FUNDAMENTALS OF
AUDIOLOGY
FOR THE SPEECH-LANGUAGE PATHOLOGIST

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I dedicate this book to my mother, Regina, and to my sister, Barbara, who inspired me to pursue audiology.
To my husband, Bill, for the days, months, and years of seeing me through this project again.
To my friends of faith, who get me through each day; and to Harissa and Isabel, who not only get me through each day but through the bumps in life as well.

Thank you for your support.

—Deborah R. Welling

I dedicate this book to Dr. Susan Rezen, the person who taught me to love audiology, and to never say “Oops!” behind an audiometer. To my family: my husband, Jim, and my children, Nyasia, John, and Elizabeth, who have afforded me the time to be away from them again to complete a Second Edition.
To my mother, Joyce, who taught me that I could do anything.

—Carol A. Ukestins

Together, we dedicate this book to Dr. Annette Zaner, mentor and friend, who brought us together more than 25 years ago, never imagining that we would still be working together 25 years later.
## Contents

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreword</td>
<td>xi</td>
</tr>
<tr>
<td>Preface</td>
<td>xiii</td>
</tr>
<tr>
<td>Acknowledgments</td>
<td>xv</td>
</tr>
<tr>
<td>About the Authors</td>
<td>xvii</td>
</tr>
<tr>
<td>Contributors</td>
<td>xix</td>
</tr>
<tr>
<td>Reviewers</td>
<td>xxi</td>
</tr>
<tr>
<td>Chapter 1: The Speech-Language Pathologist in Audiology Services: An</td>
<td>1</td>
</tr>
<tr>
<td>Interprofessional Collaboration</td>
<td>2</td>
</tr>
<tr>
<td>Introduction</td>
<td>2</td>
</tr>
<tr>
<td>Interprofessional Collaboration</td>
<td>2</td>
</tr>
<tr>
<td>Scope of Practice for the Speech-Language Pathologist</td>
<td>3</td>
</tr>
<tr>
<td>Aural (Re)habilitation</td>
<td>7</td>
</tr>
<tr>
<td>Accessing Your Friendly Neighborhood Audiolist</td>
<td>7</td>
</tr>
<tr>
<td>Getting Started</td>
<td>7</td>
</tr>
<tr>
<td>Universal Precautions</td>
<td>8</td>
</tr>
<tr>
<td>Disclosure of Cleaning Materials</td>
<td>9</td>
</tr>
<tr>
<td>A Word on Terminology</td>
<td>9</td>
</tr>
<tr>
<td>Resources for Best Practice, Evidence-Based Practice, and Response to</td>
<td>10</td>
</tr>
<tr>
<td>Intervention</td>
<td>12</td>
</tr>
<tr>
<td>Summary</td>
<td>13</td>
</tr>
<tr>
<td>Discussion Questions</td>
<td>13</td>
</tr>
<tr>
<td>References</td>
<td></td>
</tr>
<tr>
<td>Chapter 2: Sound and the Ear</td>
<td>15</td>
</tr>
<tr>
<td>Introduction</td>
<td>16</td>
</tr>
<tr>
<td>General Characteristics of Sound</td>
<td>16</td>
</tr>
<tr>
<td>Anatomy and Physiology of Hearing</td>
<td>25</td>
</tr>
<tr>
<td>Hearing Loss: An Error of Sound</td>
<td>34</td>
</tr>
<tr>
<td>Transduction</td>
<td>34</td>
</tr>
<tr>
<td>Summary</td>
<td>35</td>
</tr>
<tr>
<td>Discussion Questions</td>
<td>35</td>
</tr>
<tr>
<td>References</td>
<td>36</td>
</tr>
<tr>
<td>Recommended Readings</td>
<td>36</td>
</tr>
<tr>
<td>Chapter 3: Case History Assessment and the Process of Differential</td>
<td>37</td>
</tr>
<tr>
<td>Diagnosis</td>
<td>37</td>
</tr>
<tr>
<td>Introduction</td>
<td>38</td>
</tr>
<tr>
<td>Case History</td>
<td>38</td>
</tr>
<tr>
<td>The Process of Differential Diagnosis</td>
<td>42</td>
</tr>
<tr>
<td>Summary</td>
<td>47</td>
</tr>
<tr>
<td>Discussion Questions</td>
<td>47</td>
</tr>
<tr>
<td>References</td>
<td>48</td>
</tr>
<tr>
<td>Appendix 3-A: Speech-Language-Hearing Case History Form</td>
<td>51</td>
</tr>
<tr>
<td>Appendix 3-B: Adult Case History Form</td>
<td>57</td>
</tr>
<tr>
<td>Chapter 4: Pure Tone Audiometry and Masking</td>
<td>59</td>
</tr>
<tr>
<td>Introduction</td>
<td>60</td>
</tr>
<tr>
<td>Equipment</td>
<td>60</td>
</tr>
<tr>
<td>Earphones and Other Sound Transducers</td>
<td>62</td>
</tr>
<tr>
<td>Air Conduction Audiometry</td>
<td>64</td>
</tr>
<tr>
<td>Bone Conduction Audiometry</td>
<td>67</td>
</tr>
<tr>
<td>Masking</td>
<td>70</td>
</tr>
<tr>
<td>Sound Field (SF) Testing</td>
<td>71</td>
</tr>
<tr>
<td>Behavioral Pediatric Assessment</td>
<td>73</td>
</tr>
<tr>
<td>Behavioral Observation Audiometry (BOA)</td>
<td>73</td>
</tr>
</tbody>
</table>
Contents

Conditioned Orientation Reflex (COR); Visual Reinforcement Audiometry (VRA)/Tangible Reinforcement Operant Conditioned Audiometry (TROCA) ............................................ 74
Conditioned Play Audiometry (CPA) .................. 76
Summary .................................................. 77
Discussion Questions ................................. 77
References ............................................. 77

Chapter 5: Speech Audiometry ...................... 79
Introduction .............................................. 80
A Word About Terminology ......................... 80
Derivation of Word Lists ............................... 80
Speech Recognition Threshold/Speech Reception Threshold ............................................. 81
Speech Detection Threshold/Speech Awareness Threshold .............................................. 81
Most Comfortable Listening Level (MCL) ............ 82
Uncomfortable Listening Level/Loudness Discomfort Level/Threshold of Discomfort ............ 84
Dynamic Range ......................................... 85
Masking for Speech .................................... 87
Summary .................................................. 87
Discussion Questions ................................. 88
References ............................................. 88

Chapter 6: Otoscopy and the Middle Ear Test Battery ............................ 89
Introduction .............................................. 90
Visual Inspection ....................................... 90
Otoscopy .................................................. 91
Middle Ear Test Battery ............................... 96
Tympanometry .......................................... 97
Acoustic Reflexes ...................................... 100
Acoustic Reflex Decay Testing ....................... 102
Eustachian Tube Function ............................. 103
Summary .................................................. 103
Discussion Questions ................................. 104
References ............................................. 104

Chapter 7: Beyond the Basics ......................... 105
Introduction .............................................. 106
Electroacoustic Measures ............................ 106
Equipment ............................................. 106
Otoacoustic Emissions ................................ 107
Electrophysiologic Measures ........................ 109
Auditory Brainstem Response ....................... 110
Auditory Brainstem Response (ABR) Study ......... 110
Auditory Brainstem/Otoacoustic Emission Hybrid ........ 110
Auditory Steady-State Response (ASSR) .......... 112
Electronystagmography/Videonystagmography (ENG/VNG) ......................................... 113
Summary .................................................. 114
Discussion Questions ................................. 115
References ............................................. 115

Chapter 8: Navigating the Audiogram .......... 117
Introduction .............................................. 118
Navigating the Audiogram ......................... 118
Audiogram Symbols ................................... 119
Determining Type of Hearing Loss .................. 126
Configuration of Hearing Loss ...................... 128
Summary .................................................. 132
Discussion Questions ................................. 132
References ............................................. 133

Chapter 9: Audiogram Interpretation ........... 135
Introduction .............................................. 136
Determining Degree of Hearing Loss ............... 136
Linking Degree and Type of Hearing Loss .......... 145
Linking Degree, Type, and Configuration of Hearing Loss ............................................. 148
Progressive Hearing Loss ............................ 155
Speech Audiometry ................................... 155
Other Audiometric Data .............................. 157
<table>
<thead>
<tr>
<th>Chapter 10: Audiological Diagnoses, Etiologies, and Treatment Considerations</th>
<th>177</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>178</td>
</tr>
<tr>
<td>Diagnoses and Etiologies of the Outer Ear</td>
<td>178</td>
</tr>
<tr>
<td>Diagnoses and Etiologies of the Middle Ear</td>
<td>183</td>
</tr>
<tr>
<td>Diagnoses and Etiologies of the Inner Ear</td>
<td>188</td>
</tr>
<tr>
<td>Diagnoses and Etiologies of the Eighth Cranial Nerve</td>
<td>191</td>
</tr>
<tr>
<td>Diagnoses and Etiologies: Site of Lesion Nonspecified</td>
<td>192</td>
</tr>
<tr>
<td>Summary</td>
<td>193</td>
</tr>
<tr>
<td>Discussion Questions</td>
<td>193</td>
</tr>
<tr>
<td>References</td>
<td>194</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chapter 11: Audiologic Screening</th>
<th>197</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>198</td>
</tr>
<tr>
<td>Definitions</td>
<td>198</td>
</tr>
<tr>
<td>The Clinician's Role and Responsibility in the Screening Process</td>
<td>200</td>
</tr>
<tr>
<td>Principles of Screening</td>
<td>200</td>
</tr>
<tr>
<td>Screening Program Considerations</td>
<td>202</td>
</tr>
<tr>
<td>Visual Inspection/Otoscopy</td>
<td>204</td>
</tr>
<tr>
<td>Pure Tone Air Conduction Screening</td>
<td>207</td>
</tr>
<tr>
<td>Otoacoustic Emissions Screening</td>
<td>214</td>
</tr>
<tr>
<td>Tympanometry Screening</td>
<td>218</td>
</tr>
<tr>
<td>Screening for Handicap</td>
<td>222</td>
</tr>
<tr>
<td>Additional Screening Considerations and Questions</td>
<td>226</td>
</tr>
<tr>
<td>Summary</td>
<td>228</td>
</tr>
<tr>
<td>Discussion Questions</td>
<td>228</td>
</tr>
<tr>
<td>References</td>
<td>228</td>
</tr>
<tr>
<td>Recommended Readings</td>
<td>229</td>
</tr>
</tbody>
</table>

Appendix 11-A: Fundamentals of Audiologic Screening for the Speech-Language Pathologist | 231 |

Chapter 12: Hearing Aids and Cochlear Implants | 233 |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>234</td>
</tr>
<tr>
<td>Historical Background</td>
<td>234</td>
</tr>
<tr>
<td>Conventional Hearing Aids</td>
<td>239</td>
</tr>
<tr>
<td>External Bone Conduction Hearing Aids and Implantable Hearing Devices</td>
<td>250</td>
</tr>
<tr>
<td>Summary</td>
<td>255</td>
</tr>
<tr>
<td>Discussion Questions</td>
<td>255</td>
</tr>
<tr>
<td>References</td>
<td>256</td>
</tr>
</tbody>
</table>

Chapter 13: Hearing Assistance Technology for Children and Adults | 257 |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>258</td>
</tr>
<tr>
<td>Hearing Assistance Technology (HAT)</td>
<td>258</td>
</tr>
<tr>
<td>Remote Hearing Aid Technology</td>
<td>264</td>
</tr>
<tr>
<td>Assistive Technologies for Sound Enhancement and Alerting Devices</td>
<td>265</td>
</tr>
<tr>
<td>Summary</td>
<td>273</td>
</tr>
<tr>
<td>Discussion Questions</td>
<td>274</td>
</tr>
<tr>
<td>References</td>
<td>274</td>
</tr>
</tbody>
</table>

Chapter 14: Laws, Standards, and Guidelines | 275 |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>276</td>
</tr>
<tr>
<td>Individuals with Disabilities Education Act (IDEA)</td>
<td>276</td>
</tr>
<tr>
<td>Family Educational Rights and Privacy Act (FERPA)</td>
<td>284</td>
</tr>
<tr>
<td>Section 504 of the Rehabilitation Act</td>
<td>285</td>
</tr>
<tr>
<td>Americans with Disabilities Act (ADA)</td>
<td>288</td>
</tr>
</tbody>
</table>
Chapter 15: Understanding Auditory Development and the Child with Hearing Loss

Introduction ........................................ 296
Auditory Development in Typically Developing Children ........ 296
Auditory Development of Children with Hearing Loss ........... 297
Rationale for Teaching Language Through Audition .............. 303
A Framework for Auditory Skill Development .................. 305
Auditory Hierarchies, Checklists, and Developmental Scales .... 311
Functional Auditory Assessment .................................. 311
Summary ............................................. 316
Discussion Questions ..................................... 317
References ........................................... 317
Recommended Reading ....................................... 321

Appendix 15-A: Auditory Learning Guide ................. 323
Appendix 15-B: Auditory Skills Checklist ............ 327
Appendix 15-C: Resources ......................... 331

Chapter 16: Addressing Hearing Loss in the Early Intervention Years 

Introduction ........................................ 336
What Is EHDI? ....................................... 337
El Services for Children Who Are Deaf or Hard of Hearing: Programmatic Planning Considerations in a Perfect World ........ 349
A Word About Telepractice ................................ 355
Risk Indicator Monitoring .................................. 356
A Word About Children with Multiple Disabilities ........... 358
The Speech-Language Pathologist’s Role in the EHDI Process .... 358
Summary ............................................. 361
Discussion Questions ..................................... 361
References ........................................... 363

Appendix 16-B: Hearing Healthcare Infant/Toddler Case History Questionnaire (HHITCH-Q) .................... 367
Appendix 16-C: Early Intervention .......................... 375

Chapter 17: Audiology Services in the School System

Introduction ........................................ 378
IDEA, ADA, & 504 .................................. 379
Identification ....................................... 380
Putting Education in the Audiological Assessment: The Classroom Listening Assessment (CLA) .......... 380
Determining Signal-to-Noise Ratio ............................ 384
Determining Reverberation Time ............................ 384
Hearing Assistance Technology (HAT) ..................... 386
Parent Counseling and Training ............................ 387
Hearing Loss Prevention ............................... 387
Habilitation in the Schools for Students Who Are Deaf and Hard of Hearing .......................... 388
Auditory Habilitation ................................. 389
Counseling ......................................... 389
Self-Determination and Self-Advocacy ............ 390
Educating Children Who Are Deaf and Hard of Hearing: A Historical Perspective .......... 391
Considerations for Educational Service Provision .... 392
Communication Approaches for Children Who Are Deaf and Hard of Hearing ............... 395
Student Service and Placement Considerations ..... 397
Help! I Need an Educational Audiologist ............ 398
Resources Through the Educational Audiology Association ......................................... 400
Summary ........................................... 400
Discussion Questions ............................... 401
References ......................................... 401

Appendix 17-A: IDEA 2004 Key Regulations Pertaining to Deaf Education and Audiology ........ 405
Appendix 17-B: Classroom Acoustics Survey Worksheet .................................. 409
Appendix 17-C: Classroom Participation Questionnaire–Revised ...................... 411
Appendix 17-D: Sample Personal Amplification Monitoring Plan ...................... 415

Chapter 18: Literacy in Children with Hearing Loss: Considerations for Speech-Language Pathologists and Audiologists .......... 417
Introduction ........................................ 418
Language and Literacy ................................ 418
The Role of SLPs and AUDs in Literacy Acquisition for Children with HI ....................... 419
Children with Hearing Impairments ................. 420
Operationalizing Theories of Reading and Writing ... 422
Interventions for Reading and Writing in Children with HI ......................................... 428
Summary ........................................... 431
Note from the Author. ............................... 432
Discussion Questions ............................... 432
References ......................................... 433

Chapter 19: Diagnosis and Treatment of Auditory Processing Disorders: A Collaborative Approach ............ 439
Introduction ........................................ 440
Definition ........................................... 440
Behavioral Testing ................................ 441
Electroacoustic and Electrophysiological Testing ... 441
Who Should Be Referred for APD Testing? ........... 441
Appropriate Age and Skills for Testing ................. 442
Comorbidity of APD ................................ 443
Language Delay/Deficit ......................... 443
Attention-Deficit/Hyperactivity Disorder ............. 444
Sensory Integration ................................ 444
The Audiologist and the Speech-Language Pathologist: Working Together in Diagnosing APD .... 444
Collaborative Model ................................ 445
The AP Test Battery: What Does It Mean? ............. 447
Dichotic Listening ................................ 447
Temporal Processing/Sequencing ...................... 451
Low-Redundancy Speech ......................... 452
Binaural Interaction ................................ 453
Auditory Discrimination ............................. 453
Electrophysiological Measures ....................... 453
Interpretation ..................................... 454
Models of APD ..................................... 454
Process-Based Auditory Training Rehabilitation .... 455
Auditory Training ................................ 455
Features for Effective AT ............................. 456
Monaural Low-Redundancy Training ................ 457
Dichotic Auditory Training ......................... 457
Temporal Processing Training ....................... 458
Designing the Remediation Plan for APD ............ 458
Environmental Modifications ......................... 458
Compensatory Strategies ............................ 458
Remediation and Direct Intervention ................... 459
Formal Auditory Therapy ......................... 459
As an undergraduate student with aspirations to become a speech-language pathologist, I found my first course in audiology to be interesting but not particularly practical. I knew hearing was important for language and communication, but I thought hearing problems would be managed by the hearing professionals (audiologists) and that I would diagnose and treat the speech disorders. To a young student in the communication disorders professions, the division between audiology and speech-language pathology seemed clear. They (AuDs) did hearing tests and we (SLPs) did therapy. End of story. Except, as I advanced in my studies and began to see the connection between the classroom and the clinic, it became clear that the input (hearing) and output (speech) modes of communication were integrally linked and that any separation of those modes would negatively affect rehabilitation. While I loved learning about speech and language development—how we produce certain sounds, how children put sounds together to make words and then to make sentences—it became clear that I needed to give more than minimal attention to the role of hearing and auditory processing as a foundation for language and speech.

As a clinician, one may focus on ways to improve clients’ output; to advance the form of their language and how they use speech, communication, and social skills to effectively interact with the world around them. However, the SLP’s role in oversight and management of hearing status may seem unclear. The SLP’s responsibility to his or her client may seem limited to performing a hearing screening and creating an action plan of what to do if someone failed a screening. However, understanding one’s role beyond this referral process may be incomplete. The SLP may have the confidence to read an audiogram and identify the degree and severity of a hearing loss but is likely less able to predict the impact of that loss on communication and quality of life. The ability to partner with colleagues in audiology will become a valuable tool and resource resulting in better client outcomes.

In my work as a faculty member, I have been challenged with what to teach my students about teamwork and collaboration for patients with hearing challenges. Changes in health policy are impacting our practices. We are increasingly called upon to collaborate with our colleagues to work together to reduce cost and implement efficiencies that improve our patients’ lives. This valuable resource can provide a bridge between the professions of speech-language pathology and audiology and facilitate collegial exchange and collaboration. The publication of the first edition of this book was a welcome addition to the library of both seasoned SLPs and students of the profession. Now with this revised and expanded edition, Deborah Welling and Carol Ukstins have provided even more tools for SLPs to enable them to engage in effective interprofessional practice for individuals with hearing challenges.

As the scope of practice for SLPs has evolved and our research base has expanded, the crucial role the practicing speech and language pathologist plays in oral and written communication is better understood. Our ability to interact with our environment through the auditory sense is essential for the foundation of social interaction, for comprehension, and for language and literacy. In this text, Welling and
Ukstins, both audiologists, display a keen awareness of the role of the SLP in management of auditory issues for individuals with communication disorders. This book serves as an eminently practical guidebook to help SLPs navigate the complex world of hearing and hearing impairment.

In this revised edition, the authors have added key content across a range of subject areas. The importance of screening as a preventive measure for language and learning difficulties is emphasized and the reader is provided with comprehensive guidelines on how to establish and conduct high-quality screening programs. Strategies for measuring the impact of hearing loss on the quality of life of an individual are described, and program planning for populations across the lifespan, from early intervention to adults, is included. A major contribution is new content on language and literacy development for children with hearing loss. There have been major gains in this area, but the gap in skills remains.

Written with clarity and practicality, this text is an excellent primer for students and new clinicians and a valuable tool for the experienced SLP. We are reminded why hearing is so important and why the SLP role is so much broader than conducting a pure-tone screening test. Readers will understand the key role SLPs play in mitigating the impact of hearing loss on the quality of life for individuals with communication disorders. As is stated several times throughout the book, we will serve our patients well if we think “hearing first.”

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Introduction

Fundamentals of Audiology for the Speech-Language Pathologist is a manuscript forged as a true interdisciplinary text designed by a group of professionals with a sincere interest in training the speech-language pathologist in the essential components of audiology practices. For the student, it is our hope that this text provides a solid foundational understanding of the hearing mechanism, audiological equipment and procedures, and the diagnosis and (re)habilitation of hearing loss. For the practicing speech-language pathologist, Fundamentals of Audiology for the Speech-Language Pathologist should be viewed as a reference to use when seeking guidance in the management of hearing loss. It is not, however, intended to take the place of consulting one-on-one with colleagues in audiology, but rather to be used as a tool to aid in asking the right questions. In order to maintain a text that is equal in both breadth and depth, much of the technical jargon used throughout the field of audiology has been replaced with easy-to-understand text providing the speech-language pathologist with an adequate understanding of audiometric concepts without getting bogged down in terminology.

When considering the demands of a career as a speech-language pathologist, your role in performing measures of hearing sensitivity or working with individuals with hearing loss may or may not have crossed your mind. However, both fall (within guidelines) under the scope of practice as a speech-language pathologist. Clearly, then, in order to perform screening measures and interpret test data, a certain level of understanding must be achieved regarding a range of audilogic procedures and concepts. The purpose of this text is not to convert the speech-language pathologist into an audiologist but rather to provide the professional with the necessary information, resource tools, and understanding to competently perform the roles and responsibilities as outlined in the scope of practice.

Through this clear presentation of audiometric measures and practices, it is our goal to provide the clinician with the resources in hand to properly assist in the service provision for patients of all ages with hearing loss so that, through the therapeutic processes, families do not leave your office without a clear understanding of hearing loss; patients with hearing loss achieve the highest possible clinical/therapeutic outcomes; and, not one more child with hearing loss is misdiagnosed.

New in This Edition

As both practitioners and professors, our mutual goal is for this text to serve as a guide to the speech-language pathologist throughout his or her career. Using the text as a teaching tool ourselves, we feel that the first edition of Fundamentals of Audiology for the Speech-Language Pathologist has served our students well, but likewise has also shown us where to expand the text to provide an even more comprehensive guide to the management of hearing loss. New to this edition is a single chapter dedicated to information that you will need in order to perform a comprehensive hearing screening for your clients. Do not overlook the online materials, which include both a printable screening guide and videos to assist you in learning the proper hearing screening
procedures. An expansive chapter dedicated to etiologies of hearing loss will assist in interpreting audiometric test results to better aid in servicing your clients. Being able to link an individual’s hearing loss with its cause will assist both you and your client in having a deeper understanding of the underlying nature of their impairment. An exciting addition in the second edition of *Fundamentals of Audiology for the Speech-Language Pathologist* is a full chapter dedicated to teaching reading and writing skills to those with hearing loss. As speech-language pathologists become increasingly involved in teaching literacy skills to their clients, we hope that this chapter becomes a valuable resource for our readers.

*Fundamentals of Audiology for the Speech-Language Pathologist* is your starting point on an exciting journey. Throughout your journey, you will learn the basics of hearing science, the anatomy of the ear, and essential principles of evaluation which will lead you to the habilitation of infants and the rehabilitation of the elderly patient. At journey’s end, you will find your reward: making a difference in the lives of individuals with hearing loss.

**About This Textbook**

When considering the demands of a career as a speech-language pathologist, your role in performing measures of hearing sensitivity or working with individuals with hearing loss may or may not have crossed your mind. Further, as previously discussed, both fall (within guidelines) under the scope of practice as a speech-language pathologist. Clearly then, in order to perform screening measures and interpret audiometric test data, a certain level of understanding must be achieved regarding a range of audiological procedures and concepts. The purpose of this text is not to convert the speech-language pathologist into an audiologist, but rather to provide the professional with the necessary information, resource tools, and understanding to competently perform the roles and responsibilities. To that end, this text will address the concepts of hearing evaluation, hearing loss, technology, and rehabilitation as they pertain specifically to your needs as a communication disorders service provider. The extensive underlying mathematical and neurological processes related to the evaluation of hearing is best left to the practicing audiologist. However, you are always encouraged to research further into a concept should your specific practices necessitate such knowledge.

In order to facilitate a clear understanding of the necessary elements of audiology, the reader will find the following headings throughout much of this text as discussion of testing procedures and practices unfolds. The goal of each section is described as follows:

**What You Need To Know**

This section contains a basic overview of the particular procedure, some of the key terminology used, and a more general answer to the question “Why do we do this?” Excessive technological information is not discussed.

**How It Works**

This section provides more specific information regarding the procedure and what it is, a discussion of objective versus subjective measures, and the yield of the procedure. In some cases, the materials used are also referenced.

**Technically Speaking**

This section provides a more in-depth technical, anatomical, and/or physiological basis for each particular area discussed. Additional depth and detail are added for those with a keen interest in the particular topic.

**Methodologies**

Very simply, this section explains the process and/or procedures by which the examiner obtains the data derived, including testing instructions and steps taken for obtaining such data. As appropriate, this section also contains information regarding how the results of the given test or procedure fit in with the larger test battery.
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Prior to her role as an associate professor and director of clinical education, Dr. Welling spent many years in direct clinical service provision and supervision, with extensive experience in the behavioral assessment of the very young and difficult-to-test populations. It was during this time period that she met her coauthor, Carol Ukstins.

Dr. Welling has also had extensive involvement with interdisciplinary screening and evaluation processes in the early intervention, preschool, and school-aged populations, with an emphasis on (central) auditory processing assessment.

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With more than 25 years of experience in audiology, Ukstins has worked in hospital and community healthcare centers. Alongside her coauthor, Deborah Welling, she has worked extensively with a wide range of difficult-to-test populations, including the very young and those with multiple disabilities.

She currently works in the public school sector with deaf and hard-of-hearing students, providing support throughout the district to students with both hearing impairment and central auditory processing deficits. As the parent of two children with hearing loss, she speaks with both professional and personal knowledge on the impact of hearing loss.
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CHAPTER 1

THE SPEECH-LANGUAGE PATHOLOGIST IN AUDIOLOGY SERVICES: AN INTERPROFESSIONAL COLLABORATION

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KEY TERMS

Acquired hearing loss
Best practice
Deaf
Evidence-based practice (EBP)
Hard of hearing
Interprofessional collaboration
Response to intervention (RTI)

OBJECTIVES

• Understand the requirements of the speech-language pathologist as they relate to audiologic services.
• Review the speech-language pathology scope of practice as it pertains to audiological services and service provision to those with hearing loss.
• Discuss the concept of collaboration and understand its importance.
• Become familiar with terminology related to persons with hearing loss.
Introduction

Speech-language pathology is an exciting profession. Listed as number 28 on U.S. News & World Report’s list of “Best 100 Jobs” for 2016 (Snider, 2016), the field encompasses science, technology, and the humanities. It involves patient care from diagnosis to rehabilitation, working with all ages from infants to geriatrics. The speech-language pathologist (SLP) may find him- or herself working in a wide range of settings, including medical, educational, rehabilitative, and industry. Perhaps one of the most exciting aspects of a career in speech-language pathology is the flexibility to work in such a wide range of settings and with an even wider range of individuals and disabilities without ever having to change your field of practice. Throughout this rewarding career, it is quite likely that the speech-language pathologist will eventually have the opportunity to work with an individual who is hard of hearing or deaf. It is perhaps even more likely that the SLP will work with multiply impaired individuals with a wide variety of comorbidities, one of which may be hearing loss.

Working with such individuals requires that speech-language pathologists have a secure understanding of their own scope of practice as well as what it means to practice in an interprofessionally collaborative manner. Other elements critical to successful practice and interventions include best practice guidelines, evidence-based practice principles, and response to intervention. These topics will be addressed in this chapter.

Interprofessional Collaboration

The literature contains a variety of definitions related to interprofessional collaboration; some of them are unnecessarily extensive and complicated. At the heart of interprofessional collaboration, whether in the educational area or in clinical practice, is the concept of collaboration, which “…conveys the idea of sharing and implies collective action oriented toward a common goal, in a spirit of harmony and trust, particularly in the context of health professionals” (D’Amour, Ferrada-Videla, Rodriguez, & Beaulieu, 2005). Some of the potential benefits of interprofessional collaboration include comprehensive service provision, better outcomes for the patient, higher satisfaction on the part of the professionals, and time and cost efficiency.

Successful interaction among communication disorders service providers demonstrates the importance of having this collaborative relationship in the care of a client/patient, and devastating effects may result from its absence. If a child is referred for a speech-language evaluation because she or he is not speaking clearly and there is no communication between the speech-language pathologist and the audiologist, a hearing loss may go undiagnosed; unfortunately, this can and does happen. It is likely that many professionals who have worked in the field of communication disorders have encountered this scenario. The lack of interprofessional collaboration for this child can result in impaired speech-language development, academic progress, social interactions, vocational choices, and more.

The broader view of interprofessional collaboration sheds light on the fact that it is not only speech-language pathologists and audiologists whose professional areas are interrelated, but also those of occupational therapists, physical therapists, and recreational therapists (De Vries, 2012). As described by De Vries (2012), the skills required for effective interprofessional teamwork include understanding one’s own and others’ professions, mutual respect, cooperation, communication, coordination, assertiveness, shared responsibility, and autonomy (Banfield & Lackie, 2009; Lidskog, 2007). Although successful collaboration is clearly a complex process, fully understanding one’s own scope of practice is an integral part of this professional partnership.

We emphasize again to the reader the importance of collaborating and working as a team, striving always to improve the quality of patient care. We also strongly encourage clinicians to be cognizant of their professional roles and responsibilities, not
only in terms of their own scope of practice and the knowledge and skills acquisition (KASA) standards, but also in terms of their ethical obligations.

**Scope of Practice for the Speech-Language Pathologist**

A sound understanding of how to perform a thorough hearing screening, as well as interpret audiometric data, will become an integral part of patient care for the speech-language pathologist. When the speech-language pathologist's job responsibilities include either interpreting or performing audiological procedures, the professional is cautioned to fully understand what is and what is not within their scope of practice. This is of paramount importance when the SLP must manage the needs of a hard of hearing/deaf individual in their care.

In this section we will review the speech-language pathologist's scope of practice as it applies to audiology and hearing loss–related disorders. Your responsibilities lie beyond performing a mere air conduction screening. The American Speech-Language-Hearing Association (ASHA)’s SLP service delivery domains prove this. This is defined through the World Health Organization's International Classification of Functioning, Disability and Health (ICF).

ASHA has embraced the ICF as a whole-person framework for evaluation and intervention when providing treatment. The main elements of the ICF framework are body functions and structures, activity and participation (i.e., engagement in personally relevant settings and circumstances), environmental factors (i.e., physical as well as attitudinal environment), and personal factors (i.e., gender, ethnicity, age). In summation, ASHA encourages practitioners to no longer just assess and treat the impairment, but rather to also examine the many other factors that will play a major role in effective treatment plans. The ICF has shifted the paradigm from just treating the impairment to improving quality of life. As an example, for a school-age child with a hearing impairment, are the parents on board with consistent usage of assistive hearing devices? Does the classroom environment have optimal acoustics and amplification devices? How is the attitude of the other children in the classroom? Do the child’s classmates need education on hearing impairment in order to improve the attitudinal environment? Is the child able to actively participate in sports and clubs, despite the hearing impairment? The most recent release of ASHA’s *Scope of Practice in Speech-Language Pathology* (2016) embraces these ICF impairment factors as well as contextual factors in quality care of people with hearing impairment.

![ICF Diagram](https://example.com/ICF.png)

The following list is a synopsis of the eight SLP service delivery domains from ASHA’s *Scope of Practice in Speech-Language Pathology* (ASHA, 2016, pp. 5–18). These service domains complement the ICF (ASHA, 2016, p. 5).

1. **Collaboration**

   The SLP shares responsibility with other professionals for creating a collaborative culture. This includes joint communication and decision making using a team approach to patient care. Members of the team include both the patient
and his or her family members. The speech-language pathologist must determine whether his or her knowledge and skill is adequate regarding the breath of needs for their patient or if collaboration is necessary with other professionals to provide comprehensive patient care. Clearly, the speech-language pathologist should be collaborating with an audiologist on a patient care plan when working with an individual with hearing loss.

2. **Counseling**

Speech-language pathologists counsel by providing education, guidance, and support. Individuals, their families, and their caregivers are counseled regarding acceptance, adaptation, and decision making. This section further defines counseling as the following:

- Empowering the individual to make informed decisions
- Educating the individual and their families
- Providing support
- Promoting self-advocacy
- Discussing and evaluating emotions
- Referring to other professionals for counseling needs outside of the SLP’s scope of practice

Clearly, in cases involving individuals with hearing loss, the need for emotional support plays an important role in addressing the psycho-emotional and psychosocial impact a hearing loss may have on an individual and his or her family. Counseling in such cases may also involve discussions regarding hearing loss remediation, hearing assistance technology, and educational/programmatic decision making. These overarching issues only scratch the surface of services a patient and his or her family may need when navigating a newly identified hearing impairment.

3. **Prevention and Wellness**

The speech-language pathologist is involved in prevention and wellness activities that are geared toward reducing the incidence of a new disorder or disease, identifying disorders at an early stage, and decreasing the severity or impact disabilities associated with an existing disorder or disease.

The role early intervention plays in the overall clinical outcomes for a child with hearing loss is well documented (Ching, 2015). Considerations regarding the quality of life for an individual with hearing loss and his or her general well-being are addressed in this section of the SLP scope of practice. Prevention of hearing loss and the promotion of services available for the individual with hearing impairment, as well as the community at large, are also the responsibility of the SLP under this section. This includes educating the public at large in schools, workplaces, and communities. Always remember, “May is Better Hearing and Speech Month” and can be an important conduit to raise public awareness.

4. **Screening**

The speech-language pathologist is the expert at screening individuals for possible communication, hearing, and/or feeding and swallowing disorders in a cost-effective manner. This includes planning and conducting hearing screening programs, selecting the appropriate screening instruments, developing the screening procedures, analyzing results, and making referrals.

Specifically mentioned in this section is the role that the speech-language pathologist plays in the management of disorders, including hearing loss, in the educational realm.

5. **Assessment**

The speech-language pathologist has expertise in the differential diagnosis of disorders of communication and swallowing. Competent SLPs can diagnose communication and swallowing disorders, but do not differentially diagnose medical conditions. The speech-language pathologist may find that he or she is evaluating disorders that may include hearing loss as a primary etiology or a comorbid condition. However, this does not authorize a speech-language pathologist to evaluate or diagnose a hearing impairment. While that evaluation and diagnosis is the role of the audiologist, do not think that you have no role identifying risk factors or interpreting said audiometric results.

6. **Treatment**

Speech-language services are designed to optimize individuals’ ability to communicate and swallow, thereby improving quality of life. SLPs design their treatment according to evidence-based research and best available practice standards. Treatment plans that are designed for individuals with hearing loss are either habilitative or rehabilitative, depending on the nature of the individual case. Service provision must be both culturally and linguistically appropriate and also sensitive to the communication needs of the individual and his or her family. Again, the collaboration aspect of this portion of the SLP scope of practice holds in high regard the skill set held by an audiologist.
Speech-Language Pathology Service Delivery Areas

A comprehensive list of areas of practice for the speech-language pathologist is covered in this section. Fluency, speech production, language, cognition, voice, and resonance may all apply when servicing the individual with hearing loss. In as much as these areas are addressed, the scope of practice specifically addresses auditory habilitation and rehabilitation; speech, language, communication, and listening skills impacted by hearing loss and deafness; as well as therapeutic practices for auditory processing.

Domains of Professional Practice

In reviewing the scope of practice for the SLP as it relates to audiology practices it should now be evident that the knowledge and skills set necessary for the speech-language pathologist working with individuals with hearing loss is far greater than just knowing how to conduct a hearing screening. Moreover, the responsibility does not end there. This manuscript also elaborates on the responsibilities as they relate to advocacy and outreach, education, administration, and research; each of these areas requires a solid understanding of the normal and abnormal auditory system, and the role each plays in communication development and abilities.

The complete document can be found by going to www.asha.org/policy/SP2016-00343/.

Scope of Practice for the Audiologist

As with the speech-language pathologist, ASHA maintains the scope of practice for the audiologist as well. It is wholly important for the SLP to understand the commonalities of these practices as well as their differences. While the audiologist may be viewed as a professional dedicated to the diagnosis of hearing loss, the scope of practice describes a vocation that encompasses many similar practices to those of the speech-language pathologist.

In comparison to the “Clinical Services” portion of the SLP scope of practice, the “Professional Roles and Activities” section of the scope of practice in audiology delineates those practices for which the audiologist is responsible (ASHA, 2004). Audiologists serve a diverse population and may function in one or more of a variety of activities. The practice of audiology includes the following:

7. Modalities, Technology, and Instrumentation
SLPs use advanced instrumentation and technologies in the evaluation, management, and care of individuals. Specifically expanding on the range of technology and instrumentation listed in this section of the scope of practice, “Some examples... not limited to...” most certainly should include technology for both evaluation of and remediation for hearing impairment. State-of-the-art hearing screening instruments, hearing aids, hearing assistance technology, and the like are all covered in this section as well. While the selection and fitting of hearing aids is most certainly outside the scope of practice for the SLP, maintenance of hearing aid devices, assistive listening devices, and auditory training systems, as well as a vast array of other hearing assistance technology, does fall within the SLP’s scope of practice.

8. Population and Systems
SLPs have a role in managing populations to improve the overall health, education, and experience of the individuals they serve. SLPs also have a role in cost containment, including efficient and effective intervention. When working with an individual with hearing loss and his or her family, the SLP must assure that the intervention strategies and therapeutic goals are in alignment with the whole patient, taking into consideration his or her lifestyle and financial circumstances. The SLP must also consider the types of support provided in the classroom for teachers to ensure that the child with hearing loss has full access to the curriculum. Supporting families receiving early intervention services in making educated communication choices for their children with hearing loss is also covered in this section of the scope of practice.

SLP Scope of Practice 2016 from ASHA and AUD Scope of Practice 2016 from ASHA.
A. **Prevention**
1. Promotion of hearing wellness, as well as the prevention of hearing loss and protection of hearing function by designing, implementing, and coordinating occupational, school, and community hearing conservation and identification programs
2. Participation in noise measurements of the acoustic environment to improve accessibility and to promote hearing wellness

B. **Identification**
1. Activities that identify dysfunction in hearing, balance, and other auditory related systems
2. Supervision, implementation, and follow-up of newborn and school hearing screening programs
3. Screening for speech, orofacial myofunctional disorders, language, cognitive communication disorders, and/or preferred communication modalities that may affect education, health, development, or communication, and may result in recommendations for rescreening or comprehensive speech-language pathology assessment or in referral for other examinations or services
4. Identification of populations and individuals with or at risk for hearing loss and other auditory dysfunction, balance impairments, tinnitus, and associated communication impairments, as well as of those with normal hearing
5. In collaboration with speech-language pathologists, identification of populations and individuals at risk for developing speech-language impairments

C. **Assessment**
1. The conduct and interpretation of behavioral, electroacoustic, and/or electrophysiologic methods to assess hearing, auditory function, balance, and related systems
2. Measurement and interpretation of sensory and motor evoked potentials, electromyography, and other electodiagnostic tests for purposes of neurophysiologic intraoperative monitoring and cranial nerve assessment
3. Evaluation and management of children and adults with auditory-related processing disorders
4. Performance of otoscopy for appropriate audiological management or to provide a basis for medical referral
5. Cerumen management to prevent obstruction of the external ear canal and of amplification devices
6. Preparation of a report including interpreting data, summarizing findings, generating recommendations, and developing an audiologic treatment/management plan
7. Referrals to other professions, agencies, and/or consumer organizations

D. **Rehabilitation**
1. As part of the comprehensive audiologic (re)habilitation program, evaluates, selects, fits, and dispenses hearing assistive technology devices to include hearing aids
2. Assessment of candidacy of persons with hearing loss for cochlear implants and provision of fitting, mapping, and audiologic rehabilitation to optimize device use
3. Development of a culturally appropriate, audiologic rehabilitative management plan including, when appropriate
   a. Recommendations for fitting and dispensing, and educating the consumer and family/caregivers in the use of and adjustment to sensory aids, hearing assistive devices, alerting systems, and captioning devices
   b. Availability of counseling relating to psychosocial aspects of hearing loss, and other auditory dysfunction, and processes to enhance communication competence
   c. Skills, training, and consultation concerning environmental modifications to facilitate development of receptive and expressive communication
   d. Evaluation and modification of the audiologic management plan
4. Provision of comprehensive audiologic rehabilitation services, including management procedures for speech and language habilitation and/or rehabilitation for persons with hearing loss or other auditory dysfunction, including but not exclusive to speechreading, auditory training, and psychosocial adjustment for persons with hearing loss or other auditory dysfunction and their families/caregivers
5. Consultation and provision of vestibular and balance rehabilitation therapy to persons with vestibular and balance impairments
6. Assessment and non medical management of tinnitus using biofeedback, behavioral management, masking, hearing aids, education, and counseling
7. Provision of training for professionals of related and/or allied services when needed
8. Participation in the development of an Individual Education Program (IEP) for school-age children or an Individual Family Service Plan (IFSP) for children from birth to 36 months old
Aural (Re)habilitation

After reviewing the scope of practice in both fields, the largest overlap with our sister professions lies in providing services to those individuals with hearing loss. The term *aural rehabilitation* should be used with caution because it actually refers to the service provision to two distinctly different people groups. Correctly defined, aural habilitation refers to the delivery of services to newborns, infants, and children born with hearing loss. Congenital hearing loss—that with which a child is born—requires intensive therapeutic services by the speech-language pathologist and a close relationship with the audiologist providing listening technology. Establishing speech and language skills becomes the primary focal point of collaborative service provision.

Conversely, aural rehabilitation refers to the delivery of services to those individuals with acquired hearing loss. Acquired hearing loss occurs in individuals who are born with normal hearing sensitivity and through illness, injury, or genetics develop a hearing impairment after speech and language skills are established. In this scenario, the collaboration between the speech-language pathologist and the audiologist likewise should not be ignored as a primary relationship for the success of therapeutic outcomes (Montano, 2014).

Accessing Your Friendly Neighborhood Audiologist

With a better understanding of the scope of practice of the audiologist, one should never under estimate the power of collaboration. As sister fields, speech-language pathology and audiology both fall under the umbrella of ASHA; no matter where you find yourself practicing, you have a network of colleagues you can use as resources on a routine, daily basis. These individuals should never be hard to find in acute care medical facilities because those settings often have speech and hearing departments or otolaryngology departments where the audiologists are located. Subacute and nursing home facility employees may have a more difficult time locating the audiologist employed by the facility, possibly the result of limited hours of consultation. Within school systems there are fewer professionals employed as educational audiologists, but they can usually be accessed through local, county, regional, or state departments of education. The Educational Audiology Association (EAA) is a network of professionals working within the educational system; EAA is an invaluable repository of materials for working within the educational realm. National and state speech-language-hearing association conventions are an excellent venue for networking opportunities, as are continuing education workshops and national/international symposiums. Regardless, it is professionally beneficial that you always be able to network with an audiologist when working with an individual with hearing loss.

Getting Started

With a greater understanding of the daily scope of practice of the audiologist, there are several other guidelines that the SLP must follow when using equipment for audiological testing. Regardless of how this equipment will be used (diagnostically versus screening), one must adhere to the following
Occupational Safety and Health Administration (OSHA) regulations as well as the ASHA guidelines.

As a speech-language pathologist, the maintenance of audiometric equipment may or may not be your responsibility. However, as a professional routinely using audiometric tools, you must be aware of the maintenance requirements of the equipment in your possession. Maintaining up-to-date calibration (electroacoustic as well as daily functional) of the equipment to be used for the screening is mandatory.

**Electroacoustic Calibration**

ASHA requires that the routine electroacoustic calibration of the test equipment be completed annually by an agency or a business specifically contracted by the individual facility to do so. This agency or business typically both sells and provides services of calibration and maintenance of audiological equipment. Calibration is necessary to ensure the validity and accuracy of the results obtained and includes measurement of the background noise levels in the sound booth or other environment used for audiometric testing and calibration of the audiometric equipment itself. To ensure that proper electroacoustic calibration has been completed on the equipment in use, search for a sticker with a calibration date and agency name on each piece of equipment; the SLP merely needs to verify that the date of the last calibration is within one calendar year of the date of the screening.

**Daily Biological Calibration/Listening Checks**

In addition to annual electroacoustic calibration, daily functional (visual) inspections, performance checks, and bio-acoustic (listening) measurements must be conducted to verify the equipment performance before use (ASHA, 2005). The functional inspection, performed each day prior to use, is quickly and easily accomplished by plugging in the machine, making sure it turns on, putting on the standard earphones (or inserting the insert earphones), and performing a listening check on oneself to make certain that the equipment is subjectively functioning appropriately. A daily biometric calibration sheet should be available to record the date and initials of the staff member completing this daily responsibility.

Accurate results require equipment that is functioning appropriately. If the equipment’s electroacoustic calibration sticker is out of date or if any mechanical or functional problem is suspected as a result of the daily biological/listening check, misdiagnosis of hearing loss can occur. Equipment problems should be identified to the supervisor in charge so that repair or replacement of equipment is done in a timely manner. Any equipment suspected of malfunction should be removed from clinical use immediately.

**Universal Precautions**

Universal precautions are a set of procedures and practices designed to help protect healthcare workers and patients alike from a wide range of pathogens. Instrumentation coming into physical contact with the patient must be cleaned and disinfected after each use. According to OSHA 29 CRF standard 1910.1030, all human blood and certain human body fluids are to be treated as if they are already known to be infectious for human immunodeficiency virus (HIV), hepatitis B virus (HBV), and other bloodborne pathogens. Therefore, in agreement with the recommendations of the Centers for Disease Control and Prevention (CDC), standard precautions should be taken as the foundation for preventing transmission of infectious agents during the care of all patients, regardless of their diagnosis or presumed infection status.

The recommendations of ASHA are in agreement with these statements; the 2005 guidelines for manual pure-tone audiometry state that adherence to universal precautions and appropriate infection control procedures should be in place. The use of disposable, acoustically transparent earphone covers or disposable insert earphone tips is recommended.
Handwashing should be routine for the audiologist (or SLP) between patients (ASHA, 2005). For specific information, recommendations, and guidelines, the readers are referred to the guideline by Siegel and colleagues (2007).

**Disclosure of Cleaning Materials**

In many facilities, staff members are required to complete a Disclosure of Cleaning Materials document, sometimes known as GreenClean. The purpose of such disclosure is for the facility to manage and monitor the use of toxic chemical compounds within the confines of the agency. The speech-language pathologist is advised to become familiar with the policies of his or her place of employment regarding the completion of such forms. Liquid cleaning solutions for ultrasonic cleaners, as well as wipes and sprays used on therapy tables and equipment, may all fall under the guidelines of disclosure.

**A Word on Terminology**

As a service provider to the patient diagnosed with hearing loss, it is important not only to understand the “technical” implications of certain terms, but also to be sensitive to the fact that some of these terms might carry unpleasant connotations and may also be considered offensive to some individuals.

*“Deaf and Dumb”*

The archaic term *deaf and dumb* is considered offensive. In fact, in many European languages the term meant, as it did in English, not only “deaf and mute” but “deaf and stupid”—incapable of speech and, hence, incapable of being educated (Cooper, 2012; Power, 2006). *Deaf* individuals who choose not to use spoken language are technically considered mute. Unfortunately, a common definition of mute implies decreased mental aptitude, which is not the case for most deaf individuals. Today, deaf people find it insulting to be called “deaf and dumb” (Power, 2006).

*deaf*

The term *deaf* typically is the audiological term that refers to individuals whose hearing loss is so severe that they cannot use their sense of audition as a primary means of daily communication. This does not mean to infer that these deaf (lowercase “d”) individuals cannot use their residual hearing sensitivity as a secondary or tertiary communication modality. These individuals will frequently use some type of amplification, whether hearing aids or cochlear implants, to enhance their hearing to its maximum ability. Those who are deaf (lowercase “d”) may or may not choose to participate in the Deaf (capital “D”) culture and community.

*Deaf*

*Deaf* with a capital “D” refers to adults and children who share the use of American Sign Language and Deaf culture: common values, rules for behavior, traditions, and views of themselves and others (Padden & Humphries, 1988). Manual communication and speechreading are the primary means of communication for these individuals. Many prefer not to use amplification of any type or to only use amplification on a limited basis depending on circumstance. These individuals are rooted in a community of other Deaf individuals maintaining their own social activities and network. Deaf communities can be found throughout the country and are frequently located in areas where there are large schools for the deaf, where these individuals were educated and chose to maintain residency as adults. People who identify with Deaf culture/community are in many instances Deaf individuals, their spouses, and their families. People in the Deaf community can have a wide range in their physical degree of hearing loss (Cooper, 2012).

*Hard of Hearing*

*Hard of hearing* is the preferred terminology for a person presenting with a hearing loss who can derive benefit from hearing aids and uses aural/oral speech for communication—for example, someone
who can use a standard telephone (Zak, 1996). The term *hearing impaired* is felt to draw attention away from the person as an individual and focus directly on the disability itself.

## Putting the Person First

Current terminology supports the view of “person first” when referring to an impairment or disability. According to *The Language Used to Describe Individuals with Disabilities*, disabilities are not persons and they do not define the person, so do not replace person-nouns with disability-nouns (Folkins, 1992). Emphasis should be on the individual; this means that referring to someone as “hearing impaired,” and similarly, “aphasic” or “autistic,” should be avoided.

## Resources for Best Practice, Evidence-Based Practice, and Response to Intervention

The practicing speech-language pathologist is held to high ethical standards by ASHA to provide the best quality service possible to his or her patients. Although a job description or a policies and procedures manual will provide guidance for the speech-language pathologist in specific practice settings and situations, there are several overlying concepts that will provide guidance in the quality of your services. Whether it is in the form of a hearing screening using state-of-the-art technology or evaluating the articulation of a child with developmental disabilities, holding yourself accountable for quality service should be at the forefront of your clinical practice.

## Best Practice

Considered by many to be a buzzword, the term *best practice* describes the development of a standard of practice or process that can be used as a benchmark across a profession; best practices provide a clear expression of professional roles and responsibilities (English, 1991). Best practice refers to a clinical process or testing technique that is judged to be scientifically sound and that consistently yields results of better quality than those achieved with other procedures. Best practices are never static, but are ever-changing as improvements in therapeutic intervention and technology are discovered. Best practices are not mandated legislative regulations, but rather guidelines used as effective measures for a standard of practice.

To this end, ASHA’s practice policy documents, along with other cardinal documents of the Association, are written for and by ASHA members and approved by its governance to promulgate best practices and standards in the professions of audiology and speech-language pathology (ASHA, n.d.). As current or future members of ASHA, the vast Association resources that are available and at your disposal through the ASHA website (see www.asha.org/policy/about/) include documents in the following categories:

- **Preferred Practice Patterns**—the informational base for providing quality patient/client care and a focus for professional preparation, continuing education, and research
- **Scope of Practice**—an outline of the parameters of each of the professions
- **Guidelines**—current best practice procedures based on available evidence
- **Position Statements**—public statements of ASHA’s official stand on various issues
- **Knowledge and Skills**—the knowledge and set of skills required for a particular area of practice
- **Technical Reports**—supporting documentation and research for an ASHA position statement
- **Relevant Papers**—supporting and related professional documents
- **Standards/Quality Indicators**—documents related to certification accreditation, and professional standards
- **Ethics**—includes the Code of Ethics (by which all members and certificate holders are bound) and supporting documents
Evidence-Based Practice

Entire textbooks and courses are devoted to the study of evidence-based practice (EBP). As such, this section is not intended—in any way—to provide thorough coverage of the topic or what it entails. It is important, however, to highlight the importance of employing EBP principles to the clinician’s practice. Therefore, the purpose of this section is merely to define and describe EBP, and to provide resources for you to further investigate this topic on your own.

EBP is the foundational component of research from Dr. David Sackett, considered a pioneer in the area of evidence-based practice. Evidence-based practice can be defined as the conscientious, explicit, and judicious use of current best evidence in making decisions about the care of the individual patient. It means integrating individual clinical expertise with the best available external clinical evidence from systematic research (Sackett & Rosenberg, 1996).

For the speech-language pathologist, EBP is the integration of clinical knowledge, the value a patient places on his or her therapy session, and research evidence into the decision-making process for patient care. You might think of this similarly to that of a three-legged stool; this process will collapse if any of its legs are missing. Knowledge of clinical practice is based on the clinician’s collective experiences, education, and clinical skills. However, an integral part of EBP is also the patient. The nature of the disability, concern regarding therapeutic outcome, expectations, and values of the therapy session all play a large role in EBP. Best practices, as discussed in the previous section, are included as well because data regarding patient outcomes is usually found in clinically relevant research that has been conducted using sound methodology (Sackett, 2000).

The evidence of therapeutic progress by itself does not determine the level of therapeutic effectiveness, but it can help support the patient care process. The full integration of all three areas into clinical decisions increases the opportunity for effective clinical outcomes and quality of life. Evidence-based practice requires the clinician to constantly develop new skills, to keep abreast of and critically evaluate clinical literature, a process which will serve to hone clinical practices.

A plethora of resources for EBP are available through the ASHA website at http://www.asha.org/members/ebp/. A guide to the steps in the EBP process, EBP tutorials, and a list of evidence-based systematic reviews on a broad range of topics are only a few of the many educational tools available through the website. Students and practicing clinicians alike are encouraged to explore the information available.

Response to Intervention

The roots of response to intervention (RTI) are in the educational realm. Stemming from the release of the No Child Left Behind Act, it is a systematic methodology of providing assistance to children who are experiencing educational difficulty to prevent academic failure. The design of RTI is to provide interventions, frequent measurements of progress, and a spectrum of increasingly intensive research-based instructional interventions for those children who continue to demonstrate difficulty in a specific academic area (O’Meara, 2011). The design of RTI is based on the premise of keeping children out of the arena of special education by intervening when academic difficulties are noted, rather than waiting for the child to fail and then be referred to the Child Study Team for evaluation. RTI is viewed by many to be an alternative to the “discrepancy model,” in which cognitive ability, measured by psychological measures of intelligence (i.e., IQ testing) and their academic achievement are compared and a determination of a specific type of learning disability is made. The model of RTI is thought by many to be a better alternative to the Individualized Education Program (IEP) generated through a referral and evaluation process of special education. Its premise is that through the collaboration of all stakeholders
in the educational process, a child struggling to succeed can be provided with the appropriate interventions while remaining in the general education population. Figure 1.1 demonstrates the continuum of the RTI service provision model within the general education setting.

Although RTI is clearly and specifically written into No Child Left Behind as a process that now must take place prior to referring a child for special education and related services, much controversy surrounds the RTI model. Proponents of RTI support this multitier model of academic assistance in the general education setting focusing on the early design of interventions for those struggling in the mainstream of education. Merging special education into the general education classroom provides the least restrictive environment (LRE) for these students and allows them the best possible services. By having clear standards, useful measurements, and sound instructional practices within the classroom, academic performance is enhanced. Designing a program that exposes these students to the general education setting with their nondisabled peers will result in improvement in academic achievement and overall educational success (Batsche et al., 2005; Odom, Buysse, & Soukakou, 2011).

Opponents claim that RTI simply identifies low achieving students rather than students with learning disabilities. Poor supports in the process of RTI result in students continuing in a program that is not working to meet their needs. General education teachers cannot always provide the necessary modifications to instruction, or cannot do it systematically. Opponents claim that the main flaw in RTI is that through this intervention model we are asking the student to change when it is the instruction that must change (Batsche, Kavale, & Kovaleski, 2006; Ferri, 2012). The RTI model (Figure 1.1) assumes full cooperation of all stakeholders in the process and that the process itself is clearly defined and implemented. The devil is in the details. The success of RTI will depend on whether highly trained professionals appropriately implement it—and this is likely to be a problem.

**SUMMARY**

The role of the speech-language pathologist in servicing patients with hearing loss is clearly defined in the ASHA *Scope of Practice in Speech-Language Pathology*. Through the effective measures of hearing screening, application of best practice methods, and being proactive in interprofessional collaboration, this process can and will serve the deaf or hard of hearing individual in the most effective therapeutic ways possible. This can only be done when the speech-language pathologist is...
clear about his or her role as a professional, has a strong understanding of the premise behind the screening measure used to identify potential hearing loss, and keeps his or her professional practices current based on research and trends within the field of speech-language pathology.

**DISCUSSION QUESTIONS**

1. List three ways the roles of the SLP and the audiologist would be similar based on the ASHA scopes of practice for both fields.

2. You are asked to interpret audiological test results for a patient on your caseload. How would you access an audiologist to assist you?

3. Why are universal precautions so important?

4. What are the two types of calibration? How are they the same? How are they different?

5. Describe the differences between Deaf and deaf.

6. What are the three components to evidence-based practice (EBP)? How does the patient’s investment in their therapy play an important role in EBP?

7. What is response to intervention (RTI)? Describe a scenario in which RTI would work well for a student. Describe a scenario in which RTI would not work well for a student.

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# Chapter 2

## Sound and the Ear

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### Key Terms

<table>
<thead>
<tr>
<th>Acceleration</th>
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<td>Acoustics</td>
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<td>Auditory labyrinth</td>
<td>Inner hair cells</td>
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<td>Basilar membrane</td>
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<td>Bel</td>
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<td>Brownian motion</td>
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<td>Cochlea</td>
<td>Mixed hearing loss</td>
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<td>Compression</td>
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<td>Condensation</td>
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<td>Conductive hearing loss</td>
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<td>Decibel sensation level (dB SL)</td>
<td>Outer hair cells</td>
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<td>Decibel sound pressure level (dB SPL)</td>
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<td>Sensorineural hearing loss</td>
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<td>Simple harmonic motion (SHM)</td>
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### Objectives

- Describe the characteristics of sound.
- Define the concept of simple harmonic motion and its relationship to periodic sounds.
- Summarize the physical characteristics of sound.
- Identify the anatomy of the auditory system and trace the transmission of sound throughout.
- Differentiate the types of hearing loss an abnormality in the auditory system can cause.
Introduction
For the speech-language pathologist to work within his or her scope of practice with individuals with hearing loss, interpret audiograms, and screen for auditory disorders, one must have a firm understanding of what, how, and why we hear. The intention of this chapter is to provide an overview of the characteristics of sound, sound transmission, and the path sound takes as it is transmitted through the auditory system.

As a supplement to exhaustive coursework required by the American Speech-Language-Hearing Association, the intention of the following information is to provide the reader with a summary of acoustics and anatomy and physiology of the auditory system to reference within this text, rather than to take the place of that coursework.

General Characteristics of Sound
Sound is all around us, although it may be too faint for us to hear or too intense for us to listen to for any length of time. In the 1700s, the British philosopher George Berkeley asked the question, “If a tree falls in the forest and no one is around to hear it, does it make a sound?” Of course it does—unless it falls on another planet with little to no gaseous atmosphere, in which case there is no sound.

The study of sound is a branch of physics called **acoustics**. **Sound** itself is a physical phenomenon that is described as the movement or **propagation** of a disturbance (i.e., a vibration) through an elastic medium (e.g., air molecules) without permanent displacement of the particles.

There are three prerequisites for production of sound: (1) a source of energy (e.g., a force), (2) a vibrating object that generates an audible pressure wave, and (3) a medium of transmission (e.g., air). However, a receiver of these prerequisites of sound production is optional; that is, a listener is not required.

As human beings, we produce sound primarily in air, so let’s begin our discussion of the prerequisites with the medium of transmission we call air. Air molecules are not static; in fact, they are moving constantly in random fashion. This random movement at high speeds is called Brownian motion, named for Robert Brown (1773–1858), a Scottish botanist who described this motion, which results from the impact of molecules found within a gas or liquid. **Brownian motion** causes these air molecules to collide with each other and with whatever is in their path—walls, furniture, or people. These molecules are **elastic**—that is, the objects exhibit a tendency to resist deformity and return to their rest position—so there is no change in their shape when they bump into each other and/or other objects. These collisions produce pressure. Although we may not be able to feel that pressure, it is there. You feel this pressure whenever air is set into motion, such as on a windy day or when we speak.

A source of energy, such as a force, is the next prerequisite. **Force** is a push or a pull on an object, and is a **vector** that has both magnitude (some amount greater than zero) and direction. Force is mathematically determined to be the product of mass times acceleration ($F = ma$). Air molecules have **mass** (the quantity of matter present). Mass is not identical to weight because weight is affected by gravitational forces; however, for our purposes, mass and weight are the same. Because air molecules have mass, they obey laws of motion set forth by the great English scientist Sir Isaac Newton (1643–1727), the first of which states that all bodies remain at rest or in a state of uniform motion unless other forces act in opposition. (This property is called **inertia**.) The amount of inertia an object (e.g., an air molecule) has is directly proportional to its mass: The greater an object’s mass, the greater its inertia. An outside force must be applied to change this tendency. **Acceleration** is the speed (distance traveled per unit time) of an object per unit time, which is represented mathematically as $\frac{\text{length}}{\text{time}}$. When a force is applied to the air particles by a moving object, the air particles will travel in the direction of the force. The amount of this distance is proportional to the
magnitude of the applied force—a large force will cause the object to travel much further than a small force. Therefore, the greater the force applied to the object, the greater the distance the object travels by that force; in addition, the restoring force is proportional to the displacement (i.e., the object obeys Hooke's law, named for Robert Hooke [1635–1703], an English experimental philosopher who first described this action).

Finally, we need an object that is capable of vibrating. Air molecules happen to vibrate quite well, and can be set into vibration easily to produce a pressure wave. For example, if we strike a tuning fork on a hard surface to set its tines into vibration, the air molecules surrounding the tuning fork tines are also set into vibration, creating this pressure wave. This initial impact starts movement of the air molecules (displacement) in the same direction of the force. This pressure wave displaces air molecules near the tuning fork tines; these displaced air molecules further displace other air molecules adjacent to the pressure wave, which displace adjacent air molecules, and so on. Therefore, the wave motion is propagated, or transferred, through the air to the human ear.

When the air molecules reach the maximum point of displacement, their motion is momentarily halted because of inertia (i.e., air molecules follow Newton's first law of motion, which states that objects at rest will remain at rest unless acted upon by a force). Once the force is removed, the restoring force of elasticity returns the displaced air molecule to a resting state called equilibrium. When the air molecules return to their resting state, the void left by their former positions is filled by the adjacent air molecules, which then displace the adjacent air molecules in the opposite direction (i.e., the air molecules follow Newton's third law, which states that for any action there is an equal and opposite reaction). The elastic medium is not displaced over an appreciable distance; rather, the air molecules vibrate to and fro about their average equilibrium positions away from the source of energy.

Elasticity in the tuning fork tine allows for this displacement, but also generates a restoring force that momentarily stops the movement at the point of maximum amplitude away from the rest position. The restoring force pushes the tuning fork tines back to their rest position, but inertia carries the tines past the rest position. By overshooting the rest position, the tines then are pushed toward the opposite maximal position, at which point the restoring force builds up in the other direction and the tuning fork tines return to the rest position once again. The tuning fork tines overshoot the rest position, the restoring force builds up again, and the pattern repeats; this alternating pattern of inertia and elasticity creates one full cycle of vibration. As you can see, inertia and the restoring forces vary continuously during each cycle: Inertia is strong when the restoring force is weak, and vice versa. This interplay between the two forces enables the vibration to persist until other external forces (for example, friction, which causes a gradual decay in vibratory amplitude) overcome the tuning fork tines' mass and elasticity and the energy dissipates. Although the air molecules are displaced from their rest position at various points throughout the cycles of vibration, they continue to vibrate at the same frequency as the tuning fork.

As air molecules vibrate, waves of pressure fluctuations are created and travel through the elastic medium. (However, the molecules themselves move only a short distance.) As this vibratory disturbance (and not the air molecules themselves) propagates through the air, the atmosphere goes through alternating periods of increased and decreased air particle density and, consequently, of high and low pressure. Because air molecules can flow easily, they flow from regions of higher pressure to regions of lower pressure. The density (concentration) of these air particles alternately increases and decreases relative to their conditions at rest (i.e., when there is no vibration and the molecules are in equilibrium). For a fixed volume of vibrating air molecules, increased
concentration (density) of air particles results in increased air pressure; this is called Boyle's law (after Robert Boyle [1627–1691], British physicist and chemist), which states that the pressure and volume of a gas are inversely proportional if kept at a constant temperature (see Figure 2.1).

Because the initial force is a vector, it causes an outward movement of the tuning fork tines toward a positive displacement, which causes the surrounding air molecules to be crowded together. The force of displacement is passed from molecule to molecule; this displacement creates areas of increased pressure and density of air molecules that are called condensation (also known as compression). When the tines return toward equilibrium because of elasticity, the force on the surrounding medium is relieved, and the air molecules also return toward their position of equilibrium. This “thinning” of air molecules creates areas of decreased air pressure and density (rarefaction). The distance between two successive condensations (i.e., from a point on one wave to the same point on the next cycle of the wave) is called the wavelength of the sound wave. The wavelength represents the length of the disturbance created by the wave in a medium (see Figure 2.2). Wavelength is measured in units of length (e.g., meters) and is represented by the Greek letter lambda (λ).

Sound in air moves in the same (or opposite) direction of the force; in other words, this pressure wave moves longitudinally. In a longitudinal wave, air molecules approach and recede from each other to create variations in pressure so that the wave movement is parallel to the force. The air molecules do not move far from their rest positions; instead, they move a short distance in either direction from rest, but do not move forward with the wave itself. To demonstrate longitudinal waves at home, have a friend hold one end of a Slinky (the metal ones work best) while you hold the other end. Pinch a few of the coils together and then release them. The energy released will travel down the Slinky toward the other end and then return to you until the energy is overcome by friction and dies. In a transverse wave, on the other hand, the air molecules vibrate at right angles to the direction of wave propagation. To demonstrate transverse waves, fill a deep, wide bowl with water, and place a feather (or float a cork) on the water surface. (The fluid tension will keep the feather or the cork floating on the water’s surface because the water has greater density than either the feather or the cork.) Drop a small object (e.g., a pebble or a penny) into the bowl; the feather or cork will bob up and down, but not move very far from where it is floating. This movement is perpendicular to the direction of wave propagation.
Simple Harmonic Motion and Sound

In acoustics, when air particles are set into motion by a force to produce changes in pressure, areas of condensation and rarefaction alternate. If these areas of alternating condensation and rarefaction occur at a steady rate of change, the resultant pressure wave is said to be a pure tone (e.g., those little beeps you hear during a hearing test), which moves in simple harmonic motion (SHM) and is represented graphically by a sine wave. Although pure tones rarely occur in nature, they result when sound waves are propagated through an elastic medium and complete the same number of complete cycles of vibration per unit time. Examples of pure tones include tuning forks and pendulums, both of which produce vibrations that move in SHM (see Figure 2.3).

Characteristics of SHM

The basic attributes of a sound wave—period, frequency, amplitude, and phase—are explained through SHM. When pure tones move in SHM, they take the same amount of time to complete each cycle of vibration. In other words, pure tones are periodic. A period \( (p) \) is a physical characteristic that describes the amount of time it takes to complete one full cycle of vibration, and is measured in units of time (usually seconds \([s]\) or milliseconds \([ms]\)). Frequency \( (f) \) is the inverse of the pure tone’s period and is a physical characteristic that describes the number of complete cycles of vibration that occur per unit time (Figure 2.4). Frequency is measured in units called Hertz (Hz), in honor of Heinrich Hertz (1857–1894), a German physicist who contributed to the field of electromagnetism through his description of wave movement. Only one frequency is described in a pure tone (e.g., 1000 Hz).

Pitch and frequency are not synonymous. Because frequency is a physical characteristic, it depends on the mass of the vibrating object, its overall size, and so on; in general, the larger the vibrating object, the more slowly that object will vibrate. Pitch, on the other hand, is a percept (a psychological correlate) and is related to the listener’s perceptual response to frequency. We might also think of pitch as a relative term; that is, if you ask whether a certain sound is high pitch or low pitch, the question that would arise is: Higher or lower than what? Pitch is measured in Mels. The Mel...
scale is a psycho-physical scale of pitch perception; 1000 Mels is the pitch equal to a 1000-Hz tone at a specific intensity. Figure 2.5 shows the relationship between pitch and frequency.

As a sound wave travels through an elastic medium like air, we can calculate how far it travels through one complete cycle of vibration. This is called the wavelength (λ), and is measured in units of length (e.g., meters). We can also determine the speed (velocity) of the sound wave if we know how far it travels per unit time. The velocity of air at standard room temperature and pressure (20 degrees Celsius at sea level) is approximately 344 m/s. How fast the sound wave moves depends on the density and elastic properties of the medium through which it is moving, and is independent of pressure as long as air temperature is constant. (In gases like air, temperature plays an important part in how fast sound travels. Sounds travel faster...

**Figure 2.4** High- and low-frequency waves. The waveform at the top has twice as many cycles and its period is half as long as the wave at the bottom; therefore, the upper wave is the octave of the bottom wave.

**Figure 2.5** This graph shows the relationship between frequency (x-axis, in units of cycles per second [cps]) and pitch (y-axis, in units of Mels). At lower frequencies, frequency (dashed line) and pitch (solid line) have nearly a 1:1 relationship, but at higher frequencies, pitch differs from frequency.
through liquids and fastest along solids because the greater elasticity and density of these media increase the velocity of conduction.) Therefore, a faint sound travels at the same velocity as a loud sound. We can calculate the wavelength of a 1000-Hz sound wave very easily if we know the velocity of sound; because velocity divided by frequency equals wavelength, \( \frac{344 \text{ m/s}}{1000 \text{ cycles/s}} = 0.344 \text{ m} \) (approximately 1 foot). (Note: Do not confuse the velocity of sound wave propagation with the velocity of particle movement; particles vibrating in SHM constantly change velocity, moving with maximum velocity over their rest position.)

Amplitude (A) is another vector quantity that describes both magnitude and direction of wave displacement from rest. Amplitude is a derived unit of measurement that describes the distance from an object’s rest position by a vibrating body or the magnitude of pressure change that occurs by that object’s motion. The greater the distance caused by vibration is from the point of rest, the greater the amplitude. In general, the greater the amplitude, the louder the pure tone sounds to a listener. Amplitude can be described by both physical parameters and psychophysical percepts. Loudness is the percept of intensity and depends on how our inner ears (specifically, the cochlea) interpret how much sound pressure is presented over our tympanic membranes (eardrums). The human ear happens to be very sensitive to changes in sound pressure, so small changes in pressure (i.e., intensity) will result in either an increase or a decrease in loudness sensation. Intensity is a derived unit of measurement that describes the amount of acoustic energy (i.e., sound) that passes through a unit of area in a given time span. A pure tone’s intensity is measured by the amplitude of its sine wave, and varies with time. The human ear is capable of hearing a wide range of sound intensities.

SHM is usually depicted as a sine wave, with peaks (i.e., compressions) and troughs (i.e., rarefactions). If we were to cut that sine wave in half and move the trough directly beneath the peak, we would form a circle. If an air molecule were to move around the circumference of that circle at a constant rate, we could describe that movement as projected uniform circular motion. The air molecule’s displacement along that circumference varies with the passage of time in the same way during a cycle of movement if the frequency of the sine wave is constant. This brings us to our last characteristic of SHM: phase. Phase is that portion of a cycle that has elapsed at any instant in time, relative to some arbitrary starting point—that is, the relative timing of compressions and rarefactions of an object moving in SHM. Because of this relationship between SHM and projected uniform circular motion, phase is measured in degrees (from 0° to 360°). Figure 2.6 and Figure 2.7 depict the relationship between these concepts.

Why is phase important? If two sound waves of the exact same frequency are exactly in phase, their amplitudes add together and result in a doubling of intensity; if these sound waves are slightly out of phase, their amplitudes add together, but the resultant intensity ranges from not quite doubled to almost zero. If two sound waves are exactly out of phase, their amplitudes add together to cancel; no sound is produced because there is no change in sound pressure. This is how noise-cancellation headphones work: A sound wave exactly opposite in phase from the generating wave is produced so that their amplitudes cancel.

The Decibel: Measure of Relative Intensity

What Is a Decibel?

Earlier we noted that intensity is the physical measure of what we perceive as the loudness of a sound. A sound’s intensity is measured in acoustic (sound) pressure. Pressure is created when a force is distributed over an area; mathematically, pressure = \( \frac{\text{force}}{\text{area}} \). (Force is the product of mass and acceleration; its unit of measurement is the dyne.) When we measure sound intensity, we are measuring the force of that sound wave’s vibration over a given unit of area: The greater the change in air pressure, the greater
When we describe sound pressure using Pa, we are using what is called a linear (or integral) measuring scale (also known as an absolute scale)—there is a true zero point, each increment on the scale is equal to every other increment, and you can sum incremental units by addition. An example of a linear scale is a ruler like a yardstick; you cannot have a negative distance, and each increment (e.g., 1 inch) is equivalent. A better measurement scale to use for intensity, however, is a logarithmic (ratio) scale. A logarithmic scale is a relative scale where the intensity of sound. The unit of measurement that describes sound pressure is the Pascal (Pa), named in honor of Blaise Pascal (1623–1662), a French mathematician; 1 Pa = 10 dynes/cm². Normal human-hearing sensitivity ranges from 0.0002 dynes/cm² to 2000 dynes/cm². Although it is possible to measure sound pressure in units of dynes/cm², it would force us to use very large numbers to describe a person’s hearing sensitivity (e.g., an intensity range of 10,000,000,000,000 between softest sounds and threshold of pain).

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fractions must be used to reflect the desired accuracy of measurement of intensity (e.g., an intensity of 4.5 Bels). To minimize the use of fractions and decimals, we can use a smaller unit of measurement, the decibel (literally, one-tenth of a Bel). The **decibel (dB)** is a much more user-friendly unit of measurement of intensity, and the range of human hearing on the decibel scale becomes whole numbers that range between 0 dB and 140 dB.

The decibel expresses a logarithmic ratio between the measured sound pressure and a relative sound pressure (defined at 0.0002 dynes/cm², which happens to be the softest sound a person with normal hearing sensitivity can hear). In its simplest form, a logarithm is the same as an exponent, which indicates how many times a number is multiplied by itself. Take the equation $10 \times 10 = 100$; the number 10 is multiplied by itself. We can also express this equation as $10^2 = 100$; in this case, the number 10 is the base and the number 2 is the exponent. If we wanted to express the second equation logarithmically, we can also say $\log_{10} 100 = 2$. The number 10 is still the base, the number 2 is still the exponent, and the number 100 is still the product of the multiplication of $10 \times 10$, but we just rearranged how we expressed the multiplication problem using logarithms. To multiply logarithms with the same base number, you add their exponents; to divide logarithms with the same base number, you subtract their exponents.

We also use decibels to denote intensity for another reason: We can describe intensity either in units of power (used in acoustics) or sound pressure (**decibel sound pressure level [dB SPL]**, used in the measurement of hearing sensitivity). (Because we are primarily interested in changes in sound pressure—e.g., running speech—this discussion will be limited to audiometric applications.) In audiology, intensity level refers to the changes in sound pressure level, as measured in dynes/cm². Because decibels are based on relative differences in intensities, a reference value (standard) must be provided,

![Figure 2.8](image_url) Relationship between linear and logarithmic scales.

there is no zero point (you must define what zero is), the zero point does not represent the absence of what is being measured, and each successive unit is larger than the one preceding it; therefore, each increment is not equal and represents increasingly large numerical differences. A logarithmic scale compresses the potentially very large numbers used in a linear scale into much more manageable increments to use. See **Figure 2.8**, which illustrates the incremental differences between linear and logarithmic scales.

Why do we use a logarithmic scale for intensity? It has been known since the 19th century that the logarithmic scale corresponds nicely to how intensity differences are perceived in the human ear. Equal increases in sensation (in this case, loudness) are obtained by multiplying the stimulus by a constant factor. Although this doesn’t work for all intensities to which the ear is sensitive, it is accurate enough to be practical.

The unit of measurement used to describe human intensity differences is the **Bel** (named in honor of Alexander Graham Bell [1847–1922], the Scottish-American inventor and teacher of oral speech to individuals who are deaf). The Bel is a relative measurement of intensity that expresses the ratio of a measured sound intensity to a relative sound intensity. In other words, this very large range of human hearing (on the order of $10^{14}$ dynes/cm²) is compressed so that smaller numbers are used. By using the Bel we bring the range of intensities heard from $10^{14}$ units to a range of 0 to 14. However, this is so far to the other extreme that it is absurd! The scale of the Bel has been compressed so much that fractions must be used to reflect the desired accuracy of measurement of intensity (e.g., an intensity of 4.5 Bels). To minimize the use of fractions and decimals, we can use a smaller unit of measurement, the decibel (literally, one-tenth of a Bel). The **decibel (dB)** is a much more user-friendly unit of measurement of intensity, and the range of human hearing on the decibel scale becomes whole numbers that range between 0 dB and 140 dB.

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which is the threshold of human hearing (equal to 0.0002 dynes/cm² in units of sound pressure). We can calculate sound intensity in decibels using the following formula:

$$\text{dB SPL} = 20 \log_{10} \left( \frac{P_o}{P_r} \right)$$

where $P_o$ = measured sound pressure and $P_r$ = recognized reference point (0.0002 dynes/cm²).

To illustrate how we use this equation, let’s say that our measured sound pressure ($P_o$) is equivalent to our reference pressure ($P_r = 0.0002$ dynes/cm²). We can then substitute these values into the equation to get:

$$\text{dB SPL} = 20 \log_{10} \left( \frac{0.0002 \text{ dynes/cm}^2}{0.0002 \text{ dynes/cm}^2} \right) = 20 \log_{10} (1) = 0$$

To what power do we raise 10 to equal 1? The answer is zero (0) because $10^0 = 1$, and anything multiplied by 0 is equal to 0. Therefore, a sound stimulus that is minimally audible has an intensity of 0 dB SPL.

As you can see from Table 2.1, a tenfold increase in sound pressure (a linear measure) yields a 20-dB increase in intensity (a logarithmic measure).

### Intensity versus Loudness

Intensity, like frequency, is a physical property of an acoustic signal. The loudness—the subjective, psychological sensation of intensity—of a signal is related to its intensity; however, this relationship between loudness and intensity is not linear. At a given intensity, loudness perception varies with sound frequency because the human auditory system is designed to receive the middle frequencies with much less intensity than is needed for extremely high and low frequencies. Just as frequency has a perceptual correlate (pitch), intensity also has perceptual correlates: the phon (a unit of equal loudness) and the sone (an arbitrary unit of loudness). The phon level roughly matches intensity (in dB SPL) at a frequency of 1000 Hz. Frequencies in the range of 1000 Hz to 6000 Hz are detected at the lowest sound pressure levels, whereas very low and very high frequencies require greater sound pressure levels to pass the threshold of hearing. Figure 2.9 shows how equal loudness changes over a range of frequencies—that is, the minimum audibility needed at each frequency. (However, lower frequencies span the range of

### Figure 2.9

The heavy line on a phon curve also represents the 0 dB HL line on an audiogram. This is also known as a Fletcher–Munson curve, named for the researchers (H. Fletcher and W.A. Munson) who developed the scale.

Therefore, at each frequency, the average of the softest intensity heard by young adults is denoted as 0 dB HL (also known as audiometric zero), to which we can compare an individual’s auditory sensitivity. We denote these comparisons on a graph called an audiogram, which plots the intensity (in units of dB HL) for each test frequency (in units of Hz). Another common reference that is used audiometrically is the individual’s auditory threshold for a stimulus. A threshold is defined as the level at which a stimulus (e.g., a pure tone or speech) is so soft that it is perceived 50% of the time it is presented. The intensity in decibels above an individual’s threshold is called the sensation level (SL), and is known as the decibel sensation level (dB SL). We often use dB SL when denoting speech audiometric testing; just as we can determine speech intensity (in dB HL), we can also test speech understanding at intensity levels above threshold (in dB SL).

**Anatomy and Physiology of Hearing**

Sound is audible to us only if we have an auditory system that can utilize the physical characteristics of sound—that is, a sound’s frequency (or frequencies), intensity, and phase(s)—to understand the world around us. Our hearing is sensitive enough to hear very faint sounds (e.g., leaves rustling on the ground from a gentle breeze), yet can appreciate and identify the different instruments comprising a symphony orchestra at much higher intensities. This section will describe the different parts of the ear—the outer, middle, and inner ear—to see how sound waves travel from the ambient air into the outer ear and then are funneled through the middle and inner ears up to the brain.

The ear itself is described as a transducer—it changes one form of energy (in this case, acoustic energy) to another form (fluid/electrical) via mechanical energy of the middle ear. This transduction of sound enables the ear to analyze the various physical parameters (frequency, intensity, phase, and duration) to perceive in the brain what the ear has heard.
The Outer Ear

We most often think of our ears as just what is visible, the outer ear. The outer ear (Figure 2.10) comprises two structures, the pinna (or auricle) and the external auditory meatus (ear canal). The pinna is the visible part of the auditory system and is shaped like a funnel; it is composed of skin overlaying stiffer cartilage along with a fleshier lobe, and is attached to the cranium by ligaments. The pinna has several landmarks, such as the concha (depression in the lower center of the pinna that forms the external auditory meatus), the helix (auricular rim), the antihelix (ridge just inside the helix), the scaphoid fossa (which lies between the helix and antihelix, at the lateral aspect of the pinna), and the triangular fossa (which lies superior to the scaphoid fossa between the helix and antihelix). Other landmarks include the tragus (small flap of cartilage anterior to the opening of the external auditory meatus), the antitragus (lies just opposite the tragus and forms the inferior boundary of the concha), and the highly vascular lobe, which is inferior to the external auditory meatus. The funnel-like shape of the concha gives rise to the pinna’s basic function: to collect and send sound waves through the ear canal. The pinna also assists in sound localization and helps to protect the entrance to the external auditory canal.

The external auditory meatus is a somewhat irregularly S-shaped tube that runs from the pinna to the eardrum (tympanic membrane). It is approximately 6 mm in diameter and about 23–29 mm long in adults, is lined with epithelium (skin) and tiny hairs (cilia), and contains glands in the cartilaginous portion that produce earwax (cerumen). Cerumen is waxy and somewhat sticky, which helps to keep the ear canal moisturized and clean of debris that could accumulate. The external auditory canal has two main functions: to protect the delicate middle and inner ears from foreign bodies that could damage these structures and, with the concha, to boost (that is, increase) the amplitude of high-frequency sounds. The concha and external auditory meatus each have a natural resonant frequency to which they respond best, and each structure increases the sound pressure at its resonant frequency by approximately 10 to 15 dB for frequencies ranging from 2000 Hz through 5000 Hz. This increase in amplitude is helpful in discriminating fricative consonants such as s, z, f, and sh, all of which have acoustic energy above 2000 Hz. This boost of high-frequency sounds also enables us to localize the source of sounds, because high-frequency sounds have short wavelengths that cannot travel around the head. (In contrast, low-frequency sounds have longer wavelengths, which enable them to travel around the head.) Differences in sound wavelengths help to create timing differences between the ears and give us cues to where sounds are located.

The Middle Ear

The external auditory meatus terminates medially at the tympanic membrane, which acts as the anatomic boundary between the outer and middle ear. The tympanic membrane is a thin, concave, elastic, pearly gray to whitish translucent membrane that is made up of multiple layers of tissue—epithelial tissue (lateral layer), fibrous middle layer, and medial membranous layer—that are both concentric and radial, i.e., they fan out from a central point in a circular fashion. The membranous layer of the tympanic membrane is contiguous with the membranous lining of the external auditory meatus. The fibrous
layer maintains compliance of the membrane itself so that it can vibrate. The inner, membranous layer is contiguous with the mucous membrane lining of the middle ear space, a small cavity that links the outer ear to the fluid-filled inner ear. The tympanic membrane has a more compliant, smaller section called the **pars flaccida**, which is located superiorly, and a stiffer, larger section called the **pars tensa**, located inferiorly.

It is within the petrous portion of the temporal bone that we find the middle ear cavity, which houses the **ossicles**, muscles, and ligaments of the middle ear. This air-filled cavity is medial to the tympanic membrane and contains three very tiny bones (in fact, the smallest and hardest-working bones in the body)—the malleus, incus, and stapes—all of which can fit easily on a dime with room to spare. The ossicles are suspended in the middle ear cavity by ligaments, which permit the ossicular chain to move like a piston to push the sound waves through the middle ear to the inner ear fluids, and help the inner ear from being overdriven by excessively strong sound vibrations. The **malleus**, less than a centimeter in length, is embedded slightly into the fibrous and mucous membrane layers of the tympanic membrane at its manubrium (handle); as the tympanic membrane vibrates from sound energy impinging on it, the malleus (and incus, with which it articulates and with which forms a unit) moves at the same vibratory speed. The **incus** is the middle bone, attaching to both the malleus head (at the incudomalleolar articulation) and the stapes. It is less than a centimeter in length and has two processes: the short crus, which fits into a recess in the wall of the tympanic membrane, and the long crus, which is parallel to the manubrium of the malleus and attaches to the head of the stapes at the incudostapedial joint. The smallest of the three bones, the **stapes** looks like a stirrup, with two crura (arms) and a footplate, which fits very neatly over the oval window of the cochlear wall. The stapedial footplate helps to push the acoustic energy into the inner ear. The ossicles are suspended in the middle ear cavity by five ligaments, which permit movement of the ossicles.

The **ossicular chain** acts like an impedance-matching transformer. The middle ear compensates for loss of sound energy when going from low-impedance, air-filled medium to a high-impedance, fluid-filled medium through three primary mechanisms: the difference in area between the tympanic membrane and the oval window (the tympanic membrane is about 17 times the size of the oval window); the incudomalleolar joint between the malleus and long process of the incus, which forms a complex lever system that helps to amplify sounds traveling through the middle ear space to the inner ear; and the tympanic membrane buckling effect (Figure 2.11). Sound vibrations hitting the proportionally larger surface of the tympanic membrane must be communicated to the much smaller area of the oval window, which concentrates the energy (because it takes more energy—about 30 dB—to push against fluid than to push against air). This area difference between the tympanic membrane and oval window recovers almost 25 dB of sound energy. The difference in length between the malleus and long process of the incus, which forms a step-up function, adds another 2 dB of sound energy. Finally, the tympanic membrane buckles in response to sound, but the surface of the membrane moves a greater distance than the malleus, reducing displacement velocity of the malleus and adding about 5 dB to the sound intensity. Together, approximately 30 dB of sound energy are added to the system to compensate for the impedance mismatch between the air-filled middle ear and the fluid-filled inner ear. However, the ability of the middle ear system to amplify the sound pressure depends on the signal’s frequency; little amplification occurs for frequencies below 100 Hz or above 2500 Hz. The outer ear, however, amplifies sound energy by about 20 dB for frequencies between 2000 Hz and 5000 Hz. Taken together, this range of frequencies corresponds to the range of...
to a hearing loss caused by problems with sound conduction (i.e., a conductive hearing loss). This disorder, called otitis media (middle ear infection), is often caused by an upper respiratory infection and/or allergies and occurs most often in young children due to the immature angle of the Eustachian tube in comparison to adults (see Figure 2.12). Acute otitis media is usually caused by a bacterial infection and often presents with an elevated temperature (Rosenfeld et al., 2004). In many cases, this condition goes away on its own without treatment with antibiotics, but on occasion fluid will remain in the middle ear space because the Eustachian tube walls stick to each other and create a vacuum, which pulls the fluid from the skin cells lining the middle ear. This fluid is called effusion. The presence of effusion may result in a temporary loss of sound intensity (i.e., a conductive hearing loss). To remedy this situation, an otolaryngologist (ear–nose–throat surgeon) may surgically insert a tympanostomy (pressure-equalizing) tube into the eardrum. This tube helps to ventilate the middle ear space, thereby giving the dysfunctional Eustachian tube a chance to heal so that the middle ear cavity is once again aerated normally.

Finally, there are two muscles found in the middle ear, the stapedius muscle and the tensor tympani muscle. These muscles are specially designed for efficiency. They are (a) very tense, so that they stop vibrating instantly to limit distortion of incoming sound stimuli; (b) very elastic, to dampen

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**Figure 2.11** Schematic of the ossicular lever system and size differential between the tympanic membrane S1 and oval window S2.

**Figure 2.12** The angle difference between infant and adult Eustachian tubes.
The Inner Ear

The inner ear consists of the auditory labyrinth and vestibular labyrinth, which are intricate pathways in the petrous portion of the mastoid process of each temporal bone. The petrous portion of the temporal bone's mastoid process is the densest bone in the body, protecting the delicate organs of hearing and balance. The auditory and vestibular labyrinths are comprised of two labyrinths: the osseous labyrinth, which is a channel in the temporal bone that encases the auditory and vestibular labyrinths, and the membranous labyrinth, which consists of soft-tissue, fluid-filled channels within the osseous labyrinth containing the end-organ structures of the hearing and vestibular systems. The auditory labyrinth is called the cochlea and is the sensory end organ of hearing; the semicircular canals are the sensory end organs of balance. These two end organs are connected via the vestibule, which houses two additional organs of balance, the saccule and utricle.

The cochlea is a snail-shaped, spiral, fluid-filled canal within the temporal bone that, when straightened out, measures about 3.5 cm in length. Within each membranous duct are three chambers—the scala vestibuli (upper chamber), media (middle chamber), and tympani (lower chamber)—that are filled with fluid. The scala vestibuli and tympani are incompletely separated by the osseous spiral lamina, a bony shelf protruding from the central core, the modiolus. Circulating through the scala vestibuli and tympani is perilymph, which is secreted by the epithelial lining of the osseous labyrinth and has a higher concentration of sodium ions (Na⁺) than potassium ions (K⁺), making it chemically similar to extracellular fluid. In contrast, endolymph, which has a higher concentration of K⁺ than Na⁺, is chemically similar to intracellular fluid and is found in the scala media. This difference in ionic concentration between endolymph and perilymph gives rise to an endocochlear electrical potential (“cochlear battery”) of about 180 mV (millivolts) in the scala media, which helps to conduct neural transmission of sound. The “floor” of...
the cochlear duct is the **basilar membrane**, whereas the membranous roof is called the **vestibular membrane**. Two tissue-covered openings are found on the cochlea: The **oval window** (which is covered by the stapes footplate) is between the basilar membrane and scala vestibuli, and the **round window**, which is between the scala tympani and middle ear. The membranous portion is slightly smaller than the bony portion; the point where the scalae vestibuli and tympani communicate is called the **helicotrema**.

Within the cochlear duct is the **organ of Corti**, which contains the sensory cells of hearing and which lies on the basilar membrane. These mechano-receptor cells are shaped like hair and are called, appropriately, hair cells. The **outer hair cells**, of which there are about 15,000, form three rows shaped like a W and have their nerve fibers embedded into the **tectorial membrane**, a gel-like membrane that forms the roof of the basilar membrane. Because the basilar and tectorial membranes have different pivot points, vibration of the basilar membrane causes the cilia of the outer hair cells to bend, which alternately hyperpolarizes and depolarizes the nerve fibers of the eighth cranial nerve (CN VIII, auditory portion). Figure 2.13 shows the movement of the tectorial membrane in response to hair-cell polarization; Figure 2.14 depicts the electrochemical response of hair-cell polarization within the cochlea. The lengths of the outer hair cells increase at this point of maximum amplitude so that a vigorous electrical response is created by the incoming stimulus. The overall effect of this change of amplitude is a more precise analysis of stimulus frequency because of the different characteristic frequencies of the auditory nerve fibers, which are arranged tonotopically. Near the oval window, at the base, the nerve fibers in the hair cells are attuned to higher frequencies; at the apex, toward the central core of the cochlea, the hair cells are attuned to low-frequency sounds. Outer hair cells are tuned primarily to sound intensity; they act like transducers, changing fluid energy into electrical energy. In fact, this cochlear transduction of sound is like that of a microphone, which changes acoustic energy to electrical energy, and is often referred to as the cochlear microphonic. This transduction function is described as the shearing force and is applied to

**Figure 2.13** Shearing action of the hair cells and movement of the basilar membrane.
Hair cells are neurologically connected to the brain via nerve fibers—they preferentially encode sound clarity.

The basilar membrane is where the cochlea begins its analysis of both frequency and intensity of incoming sound signals; these incoming complex sound waves are transformed into simple sine waves similar to Fourier analyses. The stapes footplate rocks back and forth in the oval window, which establishes a transverse wave within the scala vestibuli. Inward displacement of the perilymph at the oval window is matched by the outward displacement of the fluids via the round window due to increased pressure. This perilymph wave displaces the scala media, setting up a wave on the basilar membrane, the cilia in response to the acoustic stimulation, giving rise to electrical (i.e., receptor) potentials. Fewer than 10% of the outer hair cells are neurologically connected to the brain, but they enhance the cochlear mechanical response to vibrations so that we can hear lower-intensity sounds. Outer hair cells also generate their own vibrations, both spontaneously and by using an evoking stimulus; we can measure these sounds (called otoacoustic emissions) clinically to determine cochlear function.

**Inner hair cells**, in contrast, are far fewer in number (about 3,500 altogether), and form a row stretching from base to apex in proximity of the tectorial membrane, near the modiolus (bony core) of the cochlea. However, more than 90% of these hair cells are neurologically connected to the brain via nerve fibers—they preferentially encode sound clarity.

The basilar membrane is where the cochlea begins its analysis of both frequency and intensity of incoming sound signals; these incoming complex sound waves are transformed into simple sine waves similar to Fourier analyses. The stapes footplate rocks back and forth in the oval window, which establishes a transverse wave within the scala vestibuli. Inward displacement of the perilymph at the oval window is matched by the outward displacement of the fluids via the round window due to increased pressure. This perilymph wave displaces the scala media, setting up a wave on the basilar membrane, the cilia in response to the acoustic stimulation, giving rise to electrical (i.e., receptor) potentials.
membrane that moves from the base to the apex. The vibrations of the basilar membrane progress dynamically as the incoming traveling waves move from the cochlear base toward the helicotrema at the apical end. The stiffness gradient of the basilar membrane is the primary physical feature that accounts for the direction in which the traveling wave progresses—the greater stiffness in the basal portion of the cochlea opposes displacement when stimulated by low-frequency sound, and forces the wave to travel further up the cochlea toward the apex to a region having less stiffness and less opposition to low-frequency vibration. Thus, more of the basilar membrane is stimulated by low-frequency sounds. High-frequency sounds displace the basilar membrane only near the basal end, at the oval window, and do not travel further toward the apex. This basilar membrane displacement pattern increases gradually in amplitude until the point of maximum amplitude is reached, and then decreases abruptly. There is also a stronger mechanical/electrical response to low- and moderate-intensity sounds; this is called the cochlear amplifier. Although we are uncertain how intensities are encoded in the cochlea, it is thought that the relative rate of nerve impulse spikes transmits this information to the brain (see Zemlin, 1998, pp. 486–487).

The traveling wave theory of sound transduction (proposed by Georg von Bekesy [1899–1972], and for which he received the Nobel Prize for Physiology in Medicine in 1961) through the cochlea describes how higher-frequency sounds are analyzed (Zemlin, 1998). This theory does not account for all basilar membrane mechanics, however, because the membrane itself is not displaced sharply enough to distinguish low-frequency sounds by place of stimulation. As noted in Zemlin (1998), Ernest Glen Wever hypothesized in 1937 and published in 1949 that low-frequency sounds are determined by the number of clusters of firing nerve fibers in synchrony with the low frequency; high-frequency sounds are analyzed through place theory (because neurons cannot fire at high frequencies) and/or volley theory (which describes cooperation of neurons in neural transmission of high frequencies).

Retrocochlear Pathway and Auditory Cortex

The auditory nerve fibers fire in an all-or-nothing fashion, needing only about 2 ms to rise to maximum amplitude of neural firing. They are arranged on the basilar membrane in a tonotopic fashion—nerve fibers at the apical end of the cochlea respond preferentially to low-frequency stimuli, and high-frequency sounds are encoded at the base. Similarly, the auditory nerve is tonotopically arranged so that low-frequency sounds are found in the core of the auditory nerve and high-frequency sounds are arranged around the periphery. Thus, the brain obtains information regarding frequency of the incoming sound. In addition to frequency coding, the neural fibers of the auditory nerve also encode intensity for sounds with frequencies less than 5000 Hz; neural firing approximates the period of the stimulus waveform.

Neural firing of the auditory portion of CN VIII generates action potentials; this electrical signal then travels from the cochlea to the auditory cortex in the temporal lobe. Although most of these fibers travel up to the auditory cortex to form the ascending (afferent) pathways, some neural fibers travel from either the brainstem or auditory cortex to form the descending (efferent) pathways. All auditory nerve fibers terminate at the level of the ipsilateral cochlear nucleus, where frequency and timing information about the auditory stimulus are further encoded. Although some neural pathways are ipsilateral and project into the next structure along the central auditory pathway (Figure 2.15), the superior olivary complex (in the medulla), most of these afferent pathways are contralateral (opposite side) so that the nerve fibers decussate (cross over) to the opposite superior olivary complex. Therefore, auditory information from both ears is represented in each ear, which enables us to localize sounds in space.
areas: primary, secondary, and tertiary cortices. The primary auditory cortex, the first cortical region of the auditory pathway, is tonotopically arranged in a fashion similar to that found in the cochlea and is largely responsible for discrimination of frequency and intensity of the incoming auditory stimulus. The location of a sound stimulus in space is also identified in the primary auditory cortex. The secondary and tertiary auditory cortices are largely responsible for language production, processing, and perception, and include Broca’s area (inferior frontal gyrus), where motor production of language and processing of sentence structure, grammar, and syntax are located, and Wernicke’s area (in the lower temporal lobe), where speech perception is located. In addition, other areas within the brain—the superior temporal gyrus (where morphology and syntactic processing occur in the anterior section, and integration of syntactic and semantic information in the posterior section), the inferior frontal gyrus (working memory and syntactic processing), and the middle temporal gyrus (lexical semantic processing)—contribute to language comprehension. In almost all right-handed individuals, the left hemisphere is usually dominant, with bilateral activation occurring for syntactic processing; this left hemisphere dominance is true for most left-handed individuals also. The right hemisphere is important in processing suprasegmental features like prosody and melodic contours.

Although the retrocochlear auditory pathway is primarily sensory and contains afferent pathways from the cochlea up to the auditory cortex, a complex efferent system is also present containing descending neural fibers that correspond closely to the ascending auditory fibers. These efferent fibers connect the auditory cortex to the central auditory pathway and to the cochlea, and are thought to inhibit neural activity along this pathway to increase neural activation at lower brain centers. This inhibitory feedback improves stimulus processing by decreasing background noise that may interfere with the stimulus.

Figure 2.15  The central auditory pathway.

and to improve speech perception because ipsilateral fibers are excitatory and contralateral fibers are inhibitory. In addition, low-frequency stimuli are encoded for differences in timing, whereas high-frequency stimuli are encoded for differences in latency. Other structures along the afferent auditory pathway include the lateral lemniscus (at the level of the pons), the inferior colliculus (in the midbrain, where the second decussation occurs), and the medial geniculate body (at the level of the thalamus), where all ascending fibers terminate before radiating into the appropriate cortex (in this case, the auditory cortex). Tonotopic organization of frequency to place is preserved throughout the afferent auditory pathway, which preserves the redundancy of speech.

The auditory cortex is located in the temporal lobes of the brain and is divided into three basic
and otosclerosis (fixation of the stapes footplate to the oval window of the cochlea). Disorders affecting the outer and/or middle ear are usually amenable to medical and/or surgical intervention to correct the problem. Conductive hearing loss results in the decrease of sound intensity reaching the cochlea; typically, clarity of speech is preserved in conductive hearing loss because the cochlea is usually unaffected. However, chronic conductive hearing loss can also affect speech perception because of alterations in the normal inertial mechanisms of the middle ear, which affect conduction of sound through bone.

Those individuals whose hearing loss is found in the inner ear have sensorineural hearing loss.

**Figure 2.16** An overview of the process of sound transduction through the auditory system.
**Sensorineural hearing loss** occurs due to damage to the cochlea and/or retrocochlear pathway, resulting in alterations of perception of sound frequency and intensity. In addition to a decrease of sound intensity, sensorineural hearing loss also results in a loss of speech clarity due to damage to the neural fibers located in the cochlea. Examples of sensorineural hearing loss include acoustic trauma from noise, tumors on CN VIII, ototoxic agents like loop diuretics, systemic neural diseases like diabetes mellitus, hypoxia (lack of oxygen), meningitis (both bacterial and viral, leading to inflammation of the meninges covering the brain), and Ménière’s disease (which results in an increase of endolymph fluid in the cochlea, leading to fluctuating hearing loss, aural fullness, and/or vestibular dysfunction). Sensorineural hearing loss may also result from the normal aging process (presbycusis), leading to both cochlear and retrocochlear dysfunction, and which usually results in poorer speech understanding due to damage to the cochlea and higher auditory centers.

When both conductive and sensorineural components are present in hearing loss (e.g., an individual with sensorineural hearing loss develops otitis media), a **mixed hearing loss** results. Mixed hearing loss may result from complications of middle ear surgery, otosclerosis, and the like. Medical/surgical intervention may limit the conductive portion of the hearing loss, but the sensorineural component of the loss is still present.

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**Summary**

To understand hearing and the presence of hearing loss, one must first understand what sound is. Sound is defined as the movement of a disturbance through an elastic medium (such as air molecules) without permanent displacement of the particles. There are three prerequisites for production of sound: (1) a source of energy such as a force, (2) a vibrating object that generates an audible pressure wave, and (3) a medium of transmission. Sounds may be described by their frequency, intensity, and phase, all of which are physical characteristics that are measurable. Sound moves through the human ear in stages—the outer ear (which collects sound), the middle ear (which acts as a transducer to change acoustic energy to fluid energy via mechanical energy), and then the inner ear (which sends frequency and intensity information up to the brain via the central auditory pathway). Errors in sound transduction and the location of that damage will determine the presence and type of hearing loss that results. As we journey through how a hearing loss is determined and resulting treatments, the basic understanding of sound and its transmission is crucial as the underlying concept.

**Discussion Questions**

1. List the characteristics of sound.
2. What is simple harmonic motion?
3. How are the characteristics of frequency and pitch related?
4. How are intensity and loudness related?
5. Why do we use the decibel to describe sound intensity?
6. For each part of the ear, identify the type of energy used for sound transduction.
7. What is the primary function of the middle ear?
8. In the inner ear, name the end organs of hearing and balance.
9. What does the term tonotopic organization mean regarding cochlear function?
REFERENCES


RECOMMENDED READINGS


CHAPTER 3

CASE HISTORY ASSESSMENT AND THE PROCESS OF DIFFERENTIAL DIAGNOSIS

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KEY TERMS

Comorbidity  Differential diagnosis  Look-alike diseases
Congenital  Genetic  Pseudohypacusis
Dementia  “Look, play, talk”

OBJECTIVES

• Gain an understanding of ways to obtain a thorough case history.
• Identify etiologies of hearing loss for various age categories across the lifespan.
• Understand the process of a differential diagnosis.
• Gain an understanding of conditions that may mimic or occur comorbidly with hearing loss.
Introduction
There are many components to the diagnostic process, the very first of which is to conduct a comprehensive case history. The importance of conducting a meticulous history cannot be overestimated because the keen clinician will frequently be able to establish a differential diagnosis based on the case history information. The differential diagnosis is the process by which one disorder is distinguished or differentiated from another disorder, despite presenting with many of the same symptoms and characteristics. As pointed out by Kenneth E. Sack in his compelling 2012 article “Taking Away the Diagnosis,” which was about a patient of his who had previously been misdiagnosed by a colleague, the test results can confirm or refute a diagnosis, but they rarely make the diagnosis. An individual’s test results must be considered in the context of the case history and other information, not in isolation.

This chapter will focus on the various components of the case history that relate to the collection of information regarding a patient’s hearing health history. The information gathered will assist in the development of a differential diagnosis for an individual with either suspected or known hearing loss. As we hope readers will discover for themselves, careful and systematic case history taking will frequently facilitate the diagnostic process. Remember, the watch word is thoroughness.

Case History
There are several different steps that will assist the clinician in constructing thorough background information and current patient status. In the following sections we will briefly describe each of these components.

Patient Interview
One common method is to obtain or create a form that either a patient can be asked to fill out on his or her own or the clinician can fill out interview style. Regardless of which method works best for the individual clinician, the patient and/or family member should be encouraged to describe the primary problem or complaint in his or her own words.

An example of a commercially available case history form is the Speech-Language-Hearing Case History Form created by and available through Super Duper Publications (see Appendix 3-A). Although this particular tool is geared toward children, it provides the clinician with a rather comprehensive framework with which to conduct the case history interview. Another example of a thorough case history tool, geared toward the population from birth to age 3 years, is in the appendix to the chapter Hearing Issues in the Early Intervention Years in this text.

There are many similar forms available geared toward various age ranges (from birth to geriatric) and special needs populations. Clinicians are encouraged to seek out an appropriate form to either use or modify depending on their specific needs, or they may wish to create one of their own (see Appendix 3-B). Whether using a premade form as is, modifying, or creating one’s own, the clinician needs to take many considerations into account in the process. Most notably, it is incumbent on us as professionals to explore multiple ways of asking for the same information. It has been the experience of these authors that a patient does not necessarily willfully withhold information; rather, there are times when either the person doesn’t fully understand the question being asked or we perhaps are not being clear in the way we are asking the question. As a result, the challenge for the clinician is to find multiple ways of asking certain key questions so as to elicit the necessary case history information.

In the sections that follow we present a variety of life circumstances that have the potential to cause hearing loss. It is important to recognize that what we present here is not an exhaustive listing of the etiologies of hearing loss; this is meant as a guide only. It also is important to bear in mind that the most successful approach may be a collaborative one. It behooves us as professionals to work together in a
cooperative manner by sharing our own expertise and seeking the expertise from other professionals so they may assist us in arriving at an accurate diagnosis in the most timely manner possible.

Prenatal, Perinatal, and Neonatal Complications

There are many potential complications during the prenatal, perinatal, and neonatal stages of development that can have significant deleterious effects on auditory development. These may be of genetic or nongenetic origin. According to information retrieved from the American Speech-Language-Hearing Association (ASHA), some 75% of congenital hearing loss, or hearing loss present at birth, is genetic in origin (American Speech-Language-Hearing Association [ASHA], 2015). Clearly, therefore, a familial history of hearing loss or other communication disorder is significant and important to ascertain from the patient and/or family. Additionally, late onset hearing loss also can be genetic in origin (Joint Committee on Infant Hearing [JCIH], 2007).

Some of the remaining approximately 25% of nongenetic prenatal issues may include maternal infections such as cytomegalovirus (CMV) infection, rubella (German measles), and herpes simplex virus. Other nongenetic etiologies of hearing loss include human immunodeficiency virus (HIV)/acquired immune deficiency syndrome (AIDS), Rh factor incompatibility, and fetal alcohol syndrome disorder (FASD), to name just a few. Prematurity and low birth weight are also of potential concern because these factors are well-established etiologies of congenital sensorineural hearing loss in children (Morzaria, Westerberg, & Kozak, 2004; Sarajilic et al., 2015).

Some of the perinatal complications that can affect auditory development include lack of oxygen, prolonged labor, and jaundice. The neonatal period may include complications and infections such as those that occur, for example, as a result of CMV, Rh factor incompatibility, or any other condition that requires the infant to remain hospitalized beyond the discharge time of a normal, healthy infant. Remember, any of these complications has the potential to cause hearing loss, and perhaps more importantly, the onset does not necessarily have to occur or manifest immediately. Thus, questions that are poised to ask the infant's length of stay at the hospital at birth, whether the infant went home at the same time of the birth mother, and/or if an infant was admitted soon after birth to a neonatal intensive care unit (NICU) would facilitate accurate accounts of significant pre-, peri-, and postnatal history.

The literature provides an abundance of evidence regarding potential causes of and contributors to auditory dysfunction, which in turn may result in delayed and/or disordered speech, language, communication abilities, and overall academic achievement. It bears reiteration that the keen clinician will try to pose questions in an open-ended fashion, in order to develop the fullest and most accurate differential diagnosis possible.

Toddler/Childhood Complications

If a baby has failed the newborn infant hearing screening, the absolute necessity for a full audiological evaluation is rather obvious, in order to rule out or confirm the presence of a hearing loss. What may not be quite so obvious is that if a baby passes the newborn infant hearing screening, but there is concern on the part of the parent (or primary caregiver), a full audiologic assessment is a must as well. Dismissal of concerns by a pediatrician or anyone else should not deter the family from pursuing the issue and following through with getting a complete evaluation. Again, there are numerous causes of late and progressive onset hearing loss, and a child can pass a hearing screening at one point in time yet still develop an abnormal auditory condition at a later date. As such, readers are directed to Appendix 1 of the Year 2007 Position Statement: Principles and Guidelines for Early Hearing Detection and Intervention Programs (JCIH, 2007) for a more detailed listing of risk indicators associated with permanent congenital, delayed-onset, or progressive hearing loss in childhood.
Other childhood concerns and complications are numerous. Given that otitis media is reported to be one of the most common infectious diseases of childhood (Elmorsy et al., 2010; Ghonaim, El-Edel, Basiony, & Al-Zahrani, 2011; Sheer, Swarts, & Ghadiali, 2012), a thorough otologic history is imperative. Again, stressing that the direction of questioning by the clinician is a crucial element, parents/caretakers do not always have the vast clinical knowledge to accurately describe a history of ear pathologies or describe the true severity of the medical event. For example, if a clinician asks the question, “Does your son John have a history of ear infections?” the parent may answer, “Yes.” Probing further, the clinician may ask, “How many ear infections does John have in a year?” The parent may answer, “Only one,” leading the clinician to think that the condition is an acute one, while the reality of the circumstance may be that John’s condition is chronic. He may have a single ear infection, as perceived by the parents, but despite pharmacological management it may last for 4 months without resolution. The clinician in this scenario failed to further clarify in the line of questioning, “How long does each infection last?” and “Do the infections respond to antibiotic treatment?”

In addition to the otologic history, a thorough medical history is critical. Some of the questions may include whether there is a history of allergies or other symptoms or sequelae that may be precipitous for middle ear pathology, use of medications, history of trauma, or medical or surgical treatment of any type. Should any significant medical history be reported to have occurred, it is prudent for the clinician to seek signed permission (from the patient, parent, or legal guardian) to contact the treating physician or other healthcare worker involved, in order to get a fuller understanding of the given condition. Collaborating with other healthcare providers can help the clinician better understand the patient’s condition and, as previously stated, assist in arriving at an accurate diagnosis in the timeliest manner possible. Earlier diagnosis allows for earlier intervention, and earlier intervention may lead to more successful outcomes.

Lastly, some areas of exploration for a child might include behaviors of inattentiveness, listening to the television “too loud,” any difficulty responding to questions or directions, any academic and/or reading problems in school, and whether there has been excessive noise exposure (such as MP3 use). Any area where concern is raised, obviously, should be explored further.

**Adults/Geriatrics**

An adult (as well as older children) can be asked to describe the hearing problems and other accompanying symptoms that they may be experiencing. Some questions about the hearing loss could include:

- How long has the difficulty been noticed?
- Was the onset sudden or gradual?
- Did the onset appear to have been connected with another trauma or event?
- What situations present the most and least amount of difficulty?
- If the person does experience difficulty, is it accompanied by tinnitus (ringing in the ears), dizziness, headaches, or any other abnormal symptom?
- If a known hearing loss exists, does the person now use, or have they ever used, any form of hearing aid or assistive device? If so, the device should be checked for proper functioning. Is the device worn routinely? Does the patient (or family member) think that the device is meeting amplification needs at this time?

A thorough medical and occupational history may also be useful in establishing an etiology of the presenting condition. Clients are requested to provide a complete list of current and past medications with dosages, including any over-the-counter medications and herbal supplements. Any of these types of commonly consumed substances has the potential to adversely affect hearing and/or balance function. Changes in types of medication and dosages
can also be contributory. Additionally, a synergistic effect may result from combinations of substances or a combination of a substance with another factor (such as noise exposure). Other causal and/or associated conditions include a history of diabetes, high cholesterol, hypertension, headaches, or dizziness; history of stroke, transient ischemic attack (TIA), accidents, or other trauma; a history of a serious health condition requiring ototoxic medication with long-term hospitalization; any cancer treatments; and past/present occupational or recreational history of noise exposure. Although the line of questioning for the adult and geriatric population may in some cases appear to be different from the line of questioning in the pediatric population, one should not overlook those questions related to otologic pathologies. The prudent clinician must not think that chronic middle ear infections are limited to young children. Lastly, concerns of a family member or a familial history of late onset hearing loss may be contributory for the adult client as well.

**Informal Observation**

Another component that is critically important to the evaluation process is informal observation. Where children are concerned, observation and investigation of the child’s auditory attentiveness, auditory response behaviors, and vocal quality may prove contributory. For the very young child, the quantity and quality of vocal play should be explored; deaf babies are not silent babies. What might distinguish the hearing baby from the deaf baby may not be the absence of vocal play, but rather the different characteristics that the deaf child’s vocal play may take on. Also remember that hearing is not an all-or-nothing affair. Hearing loss can vary from slight to profound, and likewise, so can its impact. Thus, significance often lies in the particular character of a baby’s utterance, rather than the presence or absence of it.

For the older child, adolescent, and adult as well, it is important to pay attention and take note of the person’s speech and language skills. Are there unusual characteristics to their speech patterns? If, for example, a client’s speech is characterized by distortions, substitutions, or omissions of high-frequency sounds or word endings, a high-frequency sensorineural hearing loss should be strongly suspected. Take note also of the vocal quality—is it very hypo- or hypernasal? How complex are their language patterns?

Informal observations can also assist in determining whether the information obtained thus far makes sense; that is, does the client’s behavior and apparent communication ability match what they report on case history, as well as the results of testing? For example, does the client respond appropriately to the tester when the tester’s face cannot be seen and no other contextual cues are available? If the client can respond appropriately under such circumstances, the likelihood of this person having sustained a severe to profound hearing loss is minimized. These are examples of ways in which the act of informally observing and making note of the client’s behaviors can assist in establishing and/or supporting a differential diagnosis.

When the client is capable of appropriately responding to and answering questions while no visual information is available, and the test results you are shown seem to indicate a profound hearing loss, suspicion (a red flag) should immediately arise. The question one might explore in such a situation is whether the outcome of testing has a monetary or other tangible motivation. If it does, the astute clinician will be on guard for this and other red flags for pseudohypacusis. Pseudohypacusis, which is a term for false, exaggerated, or psychogenically motivated hearing loss, is sometimes accompanied by telltale behaviors. Some of these behaviors include fidgeting and vague answers during case history taking, leaning in and cupping one’s ear toward a speaker, a report of sudden hearing loss with no logical medical history, excessively asking “Huh?” or “What?” and other such blatant overdramatizations of hearing loss. These behaviors are in stark contrast to what may have been obtained by
pure tone testing or reported during the case history taking, and again may help the clinician in discerning a differential diagnosis.

Lastly, it is important to consider all test results in light of the behaviors observed. Are any discrepancies observed or suspected? Do these two sets of information match? There can be many reasons for such an occurrence, ranging from pseudohypacusis to a legitimate low incidence disorder to simple test inaccuracies. If there are discrepancies and the information does not match, then further assessment is a must, regardless of the assumed cause. Careful attention to a client’s behaviors serves as an important and often informative and indispensable adjunct to the evaluation process.

The Process of Differential Diagnosis

Differential diagnosis is the method typically used to clinically distinguish or differentiate among disorders that present with many of the same or similar symptoms and characteristics. If you have gone through the case history assessment as described, and done so meticulously, you will have collected a lot of information. This information plays a key role in establishing the differential diagnosis. The importance of this cannot be overstated, as hearing loss can be the largest contributing factor to a speech and language disorder. Overlooking this component can and will have far-reaching consequences. Proper identification of hearing impairment and the concomitant difficulties is critical for establishing, preserving, and enhancing communication ability, as well as the quality of life, in all age populations across the life span.

When considering the process of differential diagnosis, two key concerns are—as just suggested—the correct diagnosis of hearing loss as opposed to another similar, though erroneous, diagnosis, and the identification of possible additional comorbidly occurring conditions. A comorbid condition is one that occurs simultaneous to the hearing loss.

Numerous conditions present with many of the same or similar symptoms and characteristics as hearing loss. The concept of look-alike diseases (also known as imitator diseases) is not restricted...
to hearing loss. In fact, when we hear about the great imitator diseases, some of the conditions that immediately come to mind may include syphilis, Lyme disease, and perhaps even multiple sclerosis or lupus. Less commonly do we hear hearing loss among the top contenders for this title. Despite this, the fact of the matter is that hearing loss is often mistaken for a number of different conditions. Misdiagnosis occurs all too often. Some of the hearing loss look-alike disorders include intellectual deficiencies, dementia, depression, behavior disorders, emotional disturbance, and attention-deficit hyperactivity disorder; the list could go on. In very young children, deafness can mimic the behaviors of autism spectrum disorder and vice versa. Clearly, the similarity of symptoms, and the possibility of these other disorders being simultaneously (comorbidly) present, causes some of the confusion and resulting errors.

It is absolutely essential that healthcare and other professionals (audiologists, speech-language pathologists [SLPs], teachers, etc.) be aware of the possibility that hearing loss may be present, but obscured by other look-alike conditions, and also that two conditions may be comorbidly present. Appropriate intervention, whether medical or (re)habilitative, cannot be put into place if an accurate diagnosis is not established. What follows is a brief discussion of some of the conditions that have been observed to complicate the diagnosis of hearing loss or that occur simultaneously with it.

**Autism Spectrum Disorder (ASD)**

Multiple studies have documented the similarities between the presenting symptoms of autism spectrum disorder (ASD) and those of other sensory deficits (Hoevenaars-van den Boom, Antonissen, Knoors, & Vervloed, 2009; Myck-Wayne, Robinson, & Henson, 2011). For example, a child with severe to profound hearing loss will not respond when called and will also have difficulty developing speech and language skills without intervention. Similarly, the psychosocial characteristics of autism often include delays in language acquisition (Syzmanski, Brice, Lam, & Hotto, 2012). A very relevant question, as pointed out by Hoevenaars-van den Boom and colleagues, is that when it is hard to distinguish characteristics of autism and other sensory impairments in controlled studies, how much harder will it then be to do so in clinical practice (Hoevenaars-van den Boom et al., 2009)? To compound this situation further, the comorbidity of hearing loss with ASD appears to be increasing; the 2009–2010 Annual Survey of Deaf and Hard of Hearing Children and Youth (Gallaudet Research Institute, 2011) indicates approximately 1.7% of 8-year olds with hearing loss also received services for autism, and the more recent 2013–2014 Annual Survey (Office of Research Support and International Affairs, 2014) shows this number to be higher, with 3% of the reported cases receiving these additional services. (It bears mentioning that the reported sample size of these latter data was much smaller than that of the earlier survey and may account for the seeming increase in comorbidity.) Regardless, other researchers have found concerning comorbidity rates as well. For example, Kancherla and colleagues (2015) reported the prevalence of hearing loss (alone) in 8-year olds to be at 1.3%, and that approximately 6% to 7% of children with hearing loss had co-occurring ASD. How, then, is the practicing clinician to confidently distinguish between the two disorders, or ascertain if there is a case of dual diagnosis?

Let us first consider hearing loss. According to the National Institutes of Health (NIH, 1993), prior to universal hearing screening, the average age of identification of hearing loss in the United States was close to 3 years of age, with lesser degrees of hearing loss going undetected for even longer. It's not surprising, then, that at the time of the NIH consensus statement it was reported that only 11 hospitals in the United States were screening more than 90% of their newborn infants prior to discharge. By the year 2005, as a result of universal newborn hearing screening (UNHS) programs, 95% of all infants in the United States were being screened prior to
hospital discharge (JCIH, 2007). The median age of diagnosis of hearing loss decreased to 2 months of age following the implementation of UNHS (Larsen, Munoz, DesGeorges, Nelson, & Kennedy, 2012).

Based on this information, it would seem reasonable to assume that if a child presenting with delayed language development was suspected of having a hearing loss, and the newborn hearing screening was completed and passed, then the risk of hearing impairment has been ruled out and the professional can move on to consider other possible etiologies. Under ideal circumstances this might actually prove to be the case; however, not only can genetic impairments occur with late onset, but also numerous other risk factors can be responsible for causing late onset and/or progressive hearing loss. (Readers are again directed to Appendix 1 of the Year 2007 Position Statement: Principles and Guidelines for Early Hearing Detection and Intervention Programs [JCIH, 2007] for a more detailed listing of risk indicators associated with permanent congenital, delayed-onset, or progressive hearing loss in childhood.) It is important, therefore, that the speech-language pathologist refer any child who has any history of these risk factors for a complete audiologic evaluation, regardless of whether a newborn infant hearing screening has been passed.

Regarding ASD, Myck-Wayne and her colleagues (2011) reported that although the median age of identification of ASD has decreased over time (Shattuck et al., 2009), reliable identification does not occur until a child is approximately 24 months of age (Baron-Cohen, Allen, & Gillberg, 1992; Moore & Goodson, 2003). Some of the reasons for this include the apparent lack of a physical test that could conclusively identify the presence or absence of ASD, and that the symptoms of autism reportedly do not occur until approximately 24 months of age (Syzmanski et al., 2012). It would appear, then, that if a child has hearing loss and ASD, the hearing loss might be identified earlier; however, the reverse can't be ruled out either.

It is at this point that we can clearly recognize the essential role that the speech-language pathologist plays in the identification, treatment, planning, and interventions of individuals with communication disorders. Let us assume a child has been identified with a hearing loss and early intervention services have been provided, yet the child's development is not progressing at the anticipated rate. The speech-language pathologist is often the professional who spends the most time with the child (more than the audiologist, social worker, etc.), and thus, is in an ideal position to observe and document the lack of progress and make appropriate referrals. It is important to remember that delayed identification of one or the other disorder will confound efforts to provide early and appropriate intervention.

Finally, it is in the best interest of our patients (and families) that we all (speech-language pathologists, audiologists, and others) work together in collaboration. Accurate differential diagnoses, appropriate treatment planning, and individualized and comprehensive therapeutic interventions are facilitated, thus giving individuals with communication disorders the best possible chance of success.

Attention-Deficit/Hyperactivity Disorder (ADHD)

There is an abundance of information in the literature regarding the comorbidity trap among the three varieties of attention-deficit/hyperactivity disorder (ADHD), the broad category of hearing loss and auditory processing, and hearing loss specifically associated with otitis media. An entire text could be written addressing how each of these conditions may or may not be related to ADHD. This section cannot hope to even scratch the surface of the broader topic and all its implications; instead, the intention of this section is merely to point out the similarity of symptoms between ADHD and hearing loss for the purposes of differential diagnosis, and provide some general guidance for the speech-language pathologist who may encounter such a case.
much of the behavior(s) observed relate to hearing ability versus another comorbid condition such as ADHD.

**Depression**

The behavioral observations and case history reports for a new patient indicate that she is withdrawn and tends to isolate; has low self-esteem; does not engage with others in conversation in social, vocational, or academic settings; appears to have trouble concentrating and paying attention; and experiences headaches, dizziness, and nausea. What do you think the most likely etiology of these symptoms could be? Would you immediately think of a hearing loss as the most likely cause? Would you think, rather, that this person is depressed? How about a dual diagnosis of hearing loss and depression?

The fact of the matter is that the diagnosis for a patient with these behaviors and complaints could be either or both of these disorders. Symptoms such as headaches, dizziness, nausea, anxiety, withdrawal and isolation, trouble concentrating, not paying attention, and poor self-esteem are well documented in both the mental health and communication disorders literature as being potential indicators of depression as well as auditory system disorders (Anderson & Matkin, 1991; Dingle et al., 2011; Grover et al., 2012; Tarhan, Bastan, Aktas, Tarhan, & Safak, 2011).

The literature documents that these two disorders can and, indeed, do occur simultaneously in all age categories. It is well documented in the adult and geriatric populations (Lee, Tong, Yuen, & Hasselt, 2010; Weinstein, 2015). Although the risk of major depressive disorder in childhood seems to be relatively small, adolescents do indeed suffer from both depression symptoms and depressive disorders. Studies have estimated that depression affects up to 2% of school-aged children and 8.3% of older adolescents in the United States (Chinawa et al., 2015). In fact, hearing-impaired children are exceedingly vulnerable to poor psychosocial development, and are reported to experience a higher prevalence of...
Dementia can be caused by a variety of conditions, and has been documented as comorbidly occurring with, or presenting as a feature of, many other diseases as well. Presbycusis is a term that refers to age-related changes in hearing, or age-related hearing loss. This type of hearing loss can impact function, or at least appear to an observer as changes in the person’s memory, cognition, language, and so on. If a person presents with these symptoms, which of these disorders is the cause—or is it both?

For many decades the literature has reflected the fact that dementia and hearing loss occur simultaneously. Weinstein (1986) found that 83% of institutionalized patients with a diagnosis of senile dementia also had some degree of hearing loss, and that the degree of hearing loss they experienced was more pronounced than in those without dementia. More recently, Lin and his colleagues (2011) concluded that hearing loss is independently associated with (incident all-cause) dementia. And finally, Lin (2012) found that individuals with mild, moderate, and severe hearing loss had a two-, three-, and five-fold risk of developing incident dementia, respectively, compared to normal hearing individuals, thus concluding that hearing loss is independently associated with incident dementia. How, then, does the clinician approach this individual?

With so many different potential reasons for decreased memory, cognition, impaired language, and even social isolation being observed in the older adult population, and the increased risk of comorbid conditions in the older adult population, it is prudent for the practicing clinician to ensure that, prior to any treatment planning and therapeutic intervention, a complete audiologic evaluation has been done and that the patient (or family) is complying with all recommendations (hearing aid fitting, etc.). Proper identification of hearing loss, with aural rehabilitative counseling and the use of hearing aids and assistive listening devices, has been found to reduce the adverse effects of hearing loss (Burkhalter, Allen, Skaar, Crittenden, & Burgio, 2009). Thus,
once the individual is able to hear and communicate as effectively as possible, the clinician is in a better position to determine whether the behaviors being observed are truly a sign of dementia, or if the individual has inadequate access to sound.

Finally, there may be times that an older adult is referred for services as the result of a stroke or other traumatic event. It is important to remember that this type of insult can also create further damage to one’s hearing. Therefore, even if your patient has a hearing aid that he or she has been using for a number of years, there is the possibility that following the traumatic event there has been further damage to the auditory system, and the device(s) may no longer be adequate. Do not assume that because an individual is wearing a hearing aid, that you need not concern yourself with their hearing status. Hearing loss can and does progress for any one of a number of reasons. The clinician must also consider that the patient’s hearing aid may be malfunctioning. Whenever there is any cause for doubt or question, remember that auditory status can change, so contact your local audiologist. Collaboration with other professionals is in the best interest of your patients.

**Summary**

An initial and very important component of the diagnostic evaluation is the process of taking a thorough case history. Many different formats can be used for this purpose; there are commercially available case history forms, or the clinician may wish to derive his or her own. Each professional will make a judgment as to the best method for his or her own purposes—dependent, of course, on the population and setting in which he or she is working. The appendices to this chapter contain one commercially available form and one sample adult form. We encourage the reader to review the information and forms available, and determine which will work best for his or her work environment.

**Discussion Questions**

1. Discuss the different components of a thorough case history regarding hearing health.
2. What kinds of information can be gathered from informal observation of a client?
3. Describe some of the complications that may occur in the prenatal, perinatal, and postnatal period.
4. What are some of the childhood risk factors for hearing loss?
5. List and describe some of the red flag behaviors that may be informally observed during the evaluation process. What might some of these behaviors indicate?
6. Discuss the process of differential diagnosis.
7. Describe the similarity in symptoms between hearing loss and other possible comorbidities.

8. With the information from this chapter and resources from the Internet, create your own adult case history form encompassing those points of hearing health that are important to patient management.

REFERENCES


APPENDIX 3-A
SPEECH-LANGUAGE-HEARING CASE HISTORY FORM

Identifying and Family Information

Child’s Name: ___________________________________ Birthdate: __________________ Sex: □ M □ F
Father’s Name: __________________________________ Daytime Phone: __________________________
Address: _______________________________________ Cell Phone: ________________________________
_____________________________________________ E-mail: _______________________________________
Mother’s Name: __________________________________ Daytime Phone: __________________________
Address: _______________________________________ Cell Phone: ________________________________
_____________________________________________ E-mail: _______________________________________
Doctor’s Name: __________________________________ Doctor’s Phone: ____________________________

Child lives with (check one):

☐ Birth Parents ☐ Foster Parents ☐ One Parent
☐ Adoptive Parents ☐ Parent and Step-Parent ☐ Other ________________

Other children in the family:

<table>
<thead>
<tr>
<th>Name</th>
<th>Age</th>
<th>Sex</th>
<th>Grade</th>
<th>Speech/Hearing Problems</th>
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Child’s race/ethnic group:

☐ White, Non-Hispanic ☐ Hispanic ☐ Black
☐ Native American ☐ Asian or Pacific Islander ☐ Other ________________

Is there a language other than English spoken in the home? ☐ Yes ☐ No

If yes, which one? ____________________________________________________________________________

Does the child speak the language? ☐ Yes ☐ No

Does the child understand the language? ☐ Yes ☐ No

Who speaks the language? ___________________________________________________________________

Which language does the child prefer to speak at home? ________________________________________
Speech-Language-Hearing

Do you feel your child has a speech problem?  □ Yes  □ No
If yes, please describe.  ____________________________________________________________

Do you feel your child has a hearing problem?  □ Yes  □ No
If yes, please describe.  ____________________________________________________________

Has he/she ever had a speech evaluation/screening?  □ Yes  □ No
If yes, where and when?  __________________________________________________________
What were you told?  _____________________________________________________________

Has he/she ever had a hearing evaluation/screening?  □ Yes  □ No
If yes, where and when?  __________________________________________________________
What were you told?  _____________________________________________________________

Has your child ever had speech therapy?  □ Yes  □ No
If yes, where and when?  __________________________________________________________
What was he/she working on?  ____________________________________________________

Has your child received any other evaluation or therapy
(physical therapy, counseling, occupational therapy, vision, etc.)?  □ Yes  □ No
If yes, please describe.  ____________________________________________________________

Is your child aware of, or frustrated by, any speech/language difficulties?  ___________________________

What do you see as your child’s most difficult problem in the home?  ______________________________

What do you see as your child’s most difficult problem in school?  ________________________________
Birth History

Was there anything unusual about the pregnancy or birth? □ Yes □ No
   If yes, please describe. _______________________________________________________________________________
   _____________________________________________________________________________________________________
   _____________________________________________________________________________________________________

How old was the mother when the child was born? __________________

Was the mother sick during the pregnancy? □ Yes □ No
   If yes, please describe. _______________________________________________________________________________
   _____________________________________________________________________________________________________
   _____________________________________________________________________________________________________

How many months was the pregnancy? __________________________

Did the child go home with his/her mother from the hospital? □ Yes □ No
   If child stayed at the hospital, please describe why and how long. _____________________________________________
   _____________________________________________________________________________________________________
   _____________________________________________________________________________________________________

Medical History

Has your child had any of the following?

☐ adenoidectomy  ☐ encephalitis  ☐ seizures
☐ allergies  ☐ flu  ☐ sinusitis
☐ breathing difficulties  ☐ head injury  ☐ sleeping difficulties
☐ chicken pox  ☐ high fevers  ☐ thumb/finger sucking habit
☐ colds  ☐ measles  ☐ tonsillectomy
☐ ear infections  ☐ meningitis  ☐ tonsillitis
   How often? ______________
☐ ear tubes  ☐ mumps  ☐ vision problems

Other serious injury/surgery: ____________________________________________________________________________

Is your child currently (or recently) under a physician’s care? □ Yes □ No
   If yes, why? ______________________________________________________________________________________
   _____________________________________________________________________________________________________
   _____________________________________________________________________________________________________

Please list any medications your child takes regularly: _______________________________________________________
   _____________________________________________________________________________________________________
   _____________________________________________________________________________________________________
   _____________________________________________________________________________________________________
Developmental History
Please tell the approximate age your child achieved the following developmental milestones:

________________ sat alone
________________ babbled
________________ put two words together
________________ walked

________________ grasped crayon/pencil
________________ said first words
________________ spoke in short sentences
________________ toilet trained

Does your child:
☐ choke on food or liquids?
☐ currently put toys/objects in his/her mouth?
☐ brush his/her teeth and/or allow brushing?

Current Speech-Language-Hearing
Does your child:
☐ repeat sounds, words, or phrases over and over?
☐ understand what you are saying?
☐ retrieve/point to common objects upon request (ball, cup, shoe)?
☐ follow simple directions (“Shut the door” or “Get your shoes”)?
☐ respond correctly to yes/no questions?
☐ respond correctly to who/what/where/when/why questions?

Your child currently communicates using:
☐ body language
☐ sounds (vowels, grunting)
☐ words (shoe, doggy, up)
☐ 2 to 4 word sentences
☐ sentences longer than four words
☐ other __________________

Behavioral characteristics:
☐ cooperative
☐ attentive
☐ willing to try new activities
☐ plays alone for reasonable length of time
☐ separation difficulties
☐ easily frustrated/impulsive
☐ stubborn
☐ restless
☐ poor eye contact
☐ easily distracted/short attention
☐ destructive/aggressive
☐ withdrawn
☐ inappropriate behavior
☐ self-abusive behavior
School History

If your child is in school, please answer the following.

Name of school and grade in school: _________________________________________
__________________________________________________________________________

Teacher’s name: __________________________________________________________
__________________________________________________________________________

Has your child repeated a grade? __________________________________________
__________________________________________________________________________

What are your child’s strengths and/or best subjects? ______________________
__________________________________________________________________________

Is your child having difficulty with any subjects? ____________________________
__________________________________________________________________________

Is your child receiving help in any subjects? _________________________________
__________________________________________________________________________

Additional Comments
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________

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Happy Ears Hearing Center
100 Main Street
Everytown, US 11000
123-555-1212
www.happyearsears.com

We want to get to know you. Please fill out this form to the best of your ability.

Name: ___________________________________________ Today’s Date: ______________________________
Address: ___________________________________________ Phone Number: ___________________________

Is this your first time here? ___Yes ___No

Referred by: ___________________________________________ Date of Referral: ___________________________
Primary Care Physician: ___________________________ Phone Number: ___________________________

Physician Address: ________________________________________________________________________________

Insurance Carrier: ___________________________________________ Policy Number: __________________________
Insurer’s Address: ________________________________________________________________________________

Does your insurance policy cover hearing aids? ___Yes ___No ___Unsure

Have you ever had your hearing tested before? ___Yes ___No

Are you experiencing hearing loss today? ___Yes ___No ___Unsure

Are you experiencing tinnitus (ringing in the ears)? ___Yes ___No ___Unsure

Are you experiencing vertigo (dizziness)? ___Yes ___No

Do you (or have you) worked around loud noise? ___Yes ___No

Is there a family history of hearing loss? ___Yes ___No ___Unknown

Do you have a history of ear infections? ___Yes ___No ___As a young child

Have you ever had surgery on your ears? ___Yes ___No

If “Yes,” list date of surgery and procedure: ________________________________________________________________________________
Please list any other medical conditions:

________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________

Please list any medications:

________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________

Do you have difficulty hearing or following a conversation in any of the following conditions?
Check all that apply.

☐ At the dinner table  ☐ Out to dinner with friends  ☐ Watching TV
☐ Listening to radio  ☐ Over the telephone  ☐ At place of worship
☐ At the workplace  ☐ In large groups of people  ☐ At the movies/theater
☐ One-on-one conversations  ☐ Hearing young children  ☐ Skype/Facetime

Do you have a preferred ear when talking on the phone?  ___Yes  ___No
If so, which ear?  ___Right  ___Left
Are you right handed or left handed?  ___Right  ___Left
Do you currently wear hearing aid(s)?  ___Yes, in one ear  ___Yes, in both ears  ___No
If yes, how old are the hearing aid(s)?
Where did you purchase your hearing aid(s)?

Do you wear your hearing aid(s) regularly?  ___Yes  ___No
If no, why not?

Do you feel your hearing aid(s) help you hear?  ___Yes  ___No  ___Unsure
CHAPTER 4

PURE TONE AUDIOMETRY AND MASKING

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KEY TERMS

<table>
<thead>
<tr>
<th>Air conduction</th>
<th>Bone conduction</th>
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<tbody>
<tr>
<td>Air conduction pathway</td>
<td>Bone conduction pathway</td>
</tr>
<tr>
<td>Auditory masking</td>
<td>Conditioned play audiometry (CPA)</td>
</tr>
<tr>
<td>Auditory threshold</td>
<td>Diagnostic</td>
</tr>
<tr>
<td>Behavioral observation audiometry (BOA)</td>
<td>Interaural attenuation</td>
</tr>
<tr>
<td>Minimum response level (MRL)</td>
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<tr>
<th>Screening</th>
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<tr>
<td>Shadow curve</td>
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<td>Visual reinforcement audiometry (VRA)</td>
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OBJECTIVES

- Understand the principles behind air and bone conduction testing, and the unique information that each contributes.
- Identify the equipment common to the audiometric test procedures described in this chapter.
- Comprehend the circumstances that necessitate masking to be performed.
- Understand the similarities and differences between diagnostic and screening air conduction testing.
- Discuss the different procedures employed during behavioral pediatric assessment and how they differ.
- Comprehend the differences between the results of earphone and sound field testing.
Introduction

“Raise your hand when you hear the sound.” You probably heard this phrase at some point in your life when you had your hearing checked as a school-aged child. At that age, pure tone audiometry was a foreign term. However, as a speech-language pathologist, pure tone audiometry is a frequently used term that defines the most common behavioral procedure used to determine both the degree and etiology of hearing loss. Although not all techniques in this chapter will be performed by a speech-language pathologist, it is important to understand the process, principles and procedures, and clinical implications of air conduction audiometry.

Equipment

Audiology Sound Booth

The testing environment in which audiometric procedures are performed is critically important. Figure 4.1A–B shows an example of a typical hearing test suite (sound booth) used for diagnostic evaluations. Routine calibrations are performed to ensure that these environments continue to meet the maximum permissible levels of noise. The presence of background noise can interfere with the client’s ability to hear and respond to sound and, therefore, must be kept to specified levels in order to ensure accuracy of the test results. In order to ensure that the background noise in a test setting is acceptable, the American National Standards Institute (ANSI) has established guidelines for these maximum levels (ANSI/ASA S3.1-1999 [R2008]) (ANSI, 1999).

Unfortunately, not all assessments have the benefit of a sound-controlled environment, as is most often the case when a speech-language pathologist (or audiologist) is required to do a hearing screening in a typical school setting. When in this situation (that is, when the environment has not been calibrated and certified as meeting ANSI specifications for background noise levels), the tester must make every effort to ensure that the test is being conducted in the quietest environment possible, using insert earphones or other noise-reducing earphones if available. When the background noise–controlled conditions cannot be met and no noise-reducing earphones are available, extreme caution must be used in the interpretation of any results.
Audiometer

The audiometer could be considered the most important piece of equipment that is used to measure hearing sensitivity. Audiometers range in complexity from a very simple portable or screening device (see Figure 4.2) to the elaborate equipment used in diagnostic and clinical settings (see Figure 4.3). Regardless of the sophistication of the machine in question or the variety of test procedures it is capable of performing, all audiometers have a few basic components in common.

All audiometers must have a frequency dial that allows the selection of each of the various frequencies used during the hearing test. The frequencies most commonly available include the octaves from 125 Hz through 8000 Hz, with some audiometers going to 12,000 Hz and higher. The output selector (either a dial or push button) allows the tester to choose the transducer (earphones, insert earphones, speaker, or bone conduction oscillator). The intensity selector (either a dial or push button), calibrated to decibels in hearing level (dB HL, in accordance with the most recent ANSI/ASA S3.6-2010 specifications for audiometers) (ANSI, 2010), potentially spans from a low of –10 dB HL through a maximum of +120 dB HL; this range will vary depending on the frequency selected, transducer used (earphones...
or bone conduction vibrator), and whether the equipment being used is of the screening or diagnostic type. Another important feature that all audiometers must have is the presentation switch, often referred to as the interrupter, which turns the test tone on so that the signal is presented to the patient. Lastly, most audiometers also have a second channel of operation in order to introduce simultaneous signals to both ears.

### Diagnostic Audiometer

A diagnostic audiometer is used in a clinical setting; it enables the audiologist to perform all basic audiometric procedures, including air conduction and bone conduction testing, basic speech audiometry, specialized speech audiometry tests (e.g., those performed during an auditory processing assessment), masking, and sound field testing.

The typical diagnostic audiometer (Figure 4.3), used for pure tone air conduction testing, has a frequency range that includes the octaves of 125, 250, 500, 1000, 2000, 4000, and 8000 Hz and the interoctave frequencies of 750, 1500, 3000, and 6000 Hz. Some specialized audiometers include the frequencies between 8000 and 20,000 Hz. The intensity range typically spans from a low of –10 dB HL through a maximum possible upper limit of approximately +120 dB HL, with the frequencies in the lower and higher ends of the frequency range having reduced upper intensity limits. As mentioned previously, frequency ranges and intensity limitations depend on the specific make and model of equipment used.

The diagnostic audiometer also has a speech circuit capable of transmitting live voice via a microphone at controlled intensity levels to the earphones of choice. Auxiliary channels provide the ability to connect to external sources, such as a CD player or other electronic components. Thus equipped, the audiologist can perform basic as well as specialized speech audiometry procedures as part of a variety of assessment types including, but not necessarily limited to, the basic audiologic evaluation, hearing aid assessment and follow-up, auditory processing evaluations, and cochlear implant candidacy evaluations.

### Earphones and Other Sound Transducers

A transducer is simply a device that transforms energy from one form to another form. An audiometer, whether screening or diagnostic, gets its power supply from an electrical socket. When we plug in the audiometer and turn it on, the power it receives is electrical. We connect sound transducers to the audiometer to change the electrical energy into sound or acoustic energy. There are several types of transducers, including standard earphones, insert earphones, noise reduction earphones, a bone conduction vibrator, and speakers. Each of these devices converts the electrical energy from the audiometer into an acoustic signal capable of being perceived by the individual. In order to assure that the right and left earphones are appropriately placed, all transducers are color-coded to “red” for “right” and “blue” for “left.”

### Standard Earphones

Standard earphones are a common type of transducer for audiometers and can be of either the supra-aural or circumaural type. Supra-aural earphones of types TDH-39, TDH-49, and TDH-50 are most common. Supra-aural earphones have some advantages when compared with circumaural earphones. They are relatively lightweight and sit on top of rather than around the ear; therefore, they tend to be more comfortable, and achieving proper placement on the client is quick and easy. This latter aspect makes them an ideal choice when performing hearing screenings with a portable audiometer. Figure 4.4 shows a pair of supra-aural earphones.

The other earphones that can be used with the audiometer are circumaural earphones. As shown in Figure 4.5, these earphones are larger, heavier, and as a result may be less comfortable than the
supra-aural type. Additionally, proper placement is not as quick and easy. The advantage, however, is that the circumaural earphones are more efficient at reducing unwanted ambient sound (Brannstrom & Lantz, 2010), and therefore they may be a good choice in screening environments where background noise is a problem and interferes with the hearing screening process.

**Insert Earphones**

A second option for sound transduction are insert earphones. These devices, shown in Figure 4.6, are not as simple, easy, or expedient to use when trying to achieve proper placement; however, there are some clear advantages to the use of insert earphones. Performing a hearing test (screening or otherwise) on a client who has a unique condition known as a collapsible ear canal is a clear case in point. With such a client, the use of standard earphones exerts pressure sufficient to cause the external auditory ear canal to close off and results in what appears to be a hearing loss; however, the observed hearing loss is an artifact and simply the result of the tragus collapsing over, and closing off, the opening to the external ear canal. When insert earphones are used instead, the ear canal is held open and reliable hearing test results can be obtained. There is also evidence (Wright & Frank, 1992) that insert earphones are better at reducing the impact of unwanted ambient noise when doing a hearing test.
in an environment that is less than the ideal sound-treated room—for example, trying to do a hearing screening in a noisy school setting.

Air Conduction Audiometry

What You Need to Know

Pure tone air conduction is an immensely practical measurement. Sound traveling through air conduction is the normal way an auditory stimulus reaches our ears during typical day-to-day activities. This is known as the air conduction pathway. For example, when someone is speaking, their words reach our ears through the air. Sound reaches our outer ear and is then sent down the ear canal to the eardrum, through the middle ear, and further on to the inner ear, where it reaches the organ of hearing. There it is converted to a neural signal that then travels up the auditory pathway to our brain for comprehension. Any break in this chain of hearing, at any point along the entire auditory pathway, can cause air conduction results to be abnormal. Abnormal results reflect the presence of a hearing loss. It is important to conclude from this that when we test hearing using air conduction audiometry, we are assessing the integrity of this entire auditory pathway; however, this determination is only part of the story. Air conduction’s limitation is that the results tell us only that there is a problem; they do not give us the entire picture. If abnormal results are obtained, air conduction results cannot tell us where the hearing problem originates in the ear.

How It Works

Pure tone air conduction audiometry is the behavioral procedure used to establish the loudness or intensity threshold in decibels (dB) at which a person just begins to hear sound via this normal mode of sound transmission. Air conduction audiometry involves putting one of two styles of transducers, standard or insert earphones, on a person’s ears and then having him or her raise a hand (or perform some other task) every time he or she hears the tonal stimulus. The air-conducted signal enters the ear and goes through the entire auditory system; hence, it represents the hearing sensitivity of the auditory system as a whole. This procedure can be done as either a screening of hearing or a part of a diagnostic assessment.

Technically Speaking

As previously stated, air conduction is the normal means of sound transmission in day-to-day situations. Pure tone air conduction audiometry is the behavioral procedure that is utilized for the purposes of establishing the loudness or intensity threshold in dB at which a person just begins to hear sound for this normal mode of sound transmission. The air-conducted signal is presented by a transducer, either supra-aural or inserts earphones, and can be performed as either a screening or diagnostic threshold procedure. As a screening, a pass/fail paradigm is employed in response to an agreed-upon intensity level (possibly 10, 15, or 20 dB, depending on the setting and population). As a diagnostic procedure, thresholds are established for individual frequencies. Regardless of whether it is done as a diagnostic or a screening procedure, air conduction testing evaluates the integrity of the entire auditory system (conductive, sensorineural, and central mechanisms), and results represent the degree of sensitivity of the entire auditory system—that is, if a hearing loss exists, we can make a statement regarding the degree of hearing loss only. As mentioned earlier, the findings cannot localize the site of damage (etiology of hearing loss). Further testing must be completed to make the determination between a conductive and a sensorineural pathology. In order to establish the etiology, bone conduction audiometry must be completed (see later in this chapter), and the results are used in conjunction with the air conduction findings.

Methodology

When you are ready to begin air conduction testing, you should first be aware that the way in which
instructions are given could have an impact on the way in which the patient responds. For example, if you merely instruct the person to raise a hand (or some other task) when a sound is heard, you may not find the very softest (threshold) level that the person is capable of hearing. **Auditory threshold** is the lowest-decibel hearing level at which responses occur in at least one half of a series of ascending trials (American Speech-Language-Hearing Association [ASHA], 2005). Instructing the patient to “listen very carefully and respond, even if you only think you hear the sound” is likely to result in a much better (more sensitive) response from the patient. In addition, ASHA’s Guidelines for Manual Pure-Tone Audiometry (2005) recommends the following:

- Indicate that the purpose of the test is to find the faintest tone that can be heard.
- Emphasize that it is necessary to sit quietly, without talking, during the test.
- Indicate that the participant is to respond whenever the tone is heard, no matter how faint it may be.
- Describe the need to respond overtly as soon as the tone comes on and to respond overtly immediately when the tone goes off.
- Indicate that each ear is to be tested separately with tones of different pitches.
- Describe inappropriate behaviors such as drinking, eating, smoking, chewing, or any additional behavior that may interfere with the test.
- Provide an opportunity for questions that the listener may have.

Proper placement of the supra-aural earphones (or insert earphones) during air conduction testing is the next critical step in the testing process. As stated previously, the red earphone must be placed on the right ear and the blue earphone must be placed on the left ear in order that the output of the earphones corresponds to the appropriate connection from the audiometer. An error of earphone placement can result in a gross misdiagnosis of hearing loss. If you are using the standard (supra-aural) earphones, make sure that the small dime-sized hole (diaphragm) that the sound comes out of lines up with the opening to the ear canal. The same holds true if you are using insert earphones; make sure that you select an appropriately sized tip and that when it is inserted, it fits flush in the ear canal and does not stick out. Inappropriately placed earphones may adversely affect hearing test results, possibly suggesting a hearing loss when one does not, in fact, exist. It is particularly important to pay attention to earphone placement when testing small children or clients with cranial-facial abnormalities because it will be evident upon initial earphone placement that transducers are fitting loose or “sloppy” on the head. In cases like these, it is important to periodically recheck earphone placement throughout the test procedure because the earphones may slip or become displaced due to natural head movement.

Pure tone air conduction audiometry is considered a behavioral test of the auditory system. Therefore, the next consideration involved in air conduction testing is how the examiner will have the client indicate that she or he has heard the sound. For example, an adult may be asked to raise a hand, press a switch, or the like. Children under the age of 5 or 6 years (chronologically or developmentally) may be trained to drop a block or participate in some other game/play type activity each time a sound is heard. Additional details regarding the testing of children will be addressed later in this chapter. Regardless of the population or the method used during testing, consistent and repeatable responses are the goal in order to obtain reliable results.

When performing diagnostic threshold testing, the frequencies of sound used typically include 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, 8000 Hz, and occasionally 125 Hz as well. When there is a significant difference between the decibel levels of the responses at two adjacent frequencies, a threshold measurement will be made at additional interoctave frequencies (750 Hz, 1500 Hz, 3000 Hz, and 6000 Hz) also.

Testing is completed one ear at a time and one frequency at a time. The clinician will typically
Degree of Hearing Loss

Hearing is not an all or nothing affair; people do not simply hear everything or hear nothing. An individual can have perfectly normal hearing, profoundly impaired hearing, or any degree of hearing loss between the two. Figure 4.8 presents an audiogram depicting various degrees of hearing loss suggested by Clark (1981), as reported and endorsed by ASHA. In the following sections we will continue the journey of interpretation with descriptions of the categories appearing on the audiogram as depicted in Figure 4.8 and the corresponding Table 4.1. It is important to point out that it is always the air conduction thresholds (sometimes collectively referred to as the air line) that we look at to determine the degree (severity) of hearing loss, not the bone conduction results (or bone line).

An important caveat to remember when reading this section is that someone’s hearing loss rarely falls neatly into only one category—that is, it is very common to see hearing loss that might be mild in

start in the right ear (or the better ear if there is a known difference) at 1000 Hz; proceed to 2000 Hz, 4000 Hz, and 8000 Hz; repeat testing at 1000 Hz as a reliability check; and then go down to 500 Hz and 250 Hz before moving on to the left (or second) ear. At each frequency, the initial intensity of the sound will be presented at a decibel level that is assumed to be higher (louder) than the level at which the person just begins to hear. In this way, the patient is familiarized with the sound stimulus. Each time the listener responds that the sound has been heard, the intensity level is decreased by 10 dB; each time the person does not hear the sound, it is increased by 5 dB. The intensity level of the sound is continually increased and decreased until the clinician finds the decibel level that the patient responds to one-half of the time, with the minimum number of responses needed to determine the threshold of hearing being two out of three responses at a single level (ANSI, 2004). The results obtained are recorded on an audiogram (see Figure 4.7).
Bone Conduction Audiometry

Equipment

Bone Conduction Oscillator

The type of sound transducer used in bone conduction audiometric testing is the bone conduction oscillator. Unlike earphones and insert earphones that convey sound to the external ear canal and use the air conduction pathway for transmission through the entire auditory system, the bone conduction oscillator uses the bone conduction pathway. With the air conduction pathway, sound enters the outer ear canal, goes through the middle ear, and then gets sent to the inner ear and beyond. In contrast, the bone conduction pathway directly stimulates the bone in which the organ of hearing is housed (the cochlea), where sound begins its journey through the inner ear, thus bypassing the outer

Table 4.1 Categories of Degree of Hearing Loss

<table>
<thead>
<tr>
<th>Decibels in Hearing Level (dB HL)</th>
<th>Degree Category</th>
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<tbody>
<tr>
<td>–10 to 15</td>
<td>Normal</td>
</tr>
<tr>
<td>16 to 25</td>
<td>Slight</td>
</tr>
<tr>
<td>26 to 40</td>
<td>Mild</td>
</tr>
<tr>
<td>41 to 55</td>
<td>Moderate</td>
</tr>
<tr>
<td>56 to 70</td>
<td>Moderately severe</td>
</tr>
<tr>
<td>71 to 90</td>
<td>Severe</td>
</tr>
<tr>
<td>91 and above</td>
<td>Profound</td>
</tr>
</tbody>
</table>
and middle ears completely. Sound then continues its journey up the auditory pathway to the brain for interpretation and processing. An example of the sensation of a bone-conducted sound is when you put your fingers over your ears and then speak—you hear yourself through bone conduction. A bone conduction oscillator is shown in Figure 4.9.

**What You Need to Know**

Bone conduction audiometry has more significance diagnostically than practically; that is to say that, unlike air conduction, **bone conduction** is not the normal way that we hear and communicate in day-to-day situations. To review, when a person speaks, the sound is transmitted through the air (air conduction) and it eventually reaches the listener at the outer ear before traveling further through the auditory system and reaching the organ of hearing (cochlea) in the inner ear. Bone conduction, on the other hand, is when sound is transmitted by vibrating the skull, a bone, and is conducted via that vibration to directly stimulate the cochlea (which is surrounded by bone) in the inner ear. We do not typically communicate with others by vibrating their skulls; at least, one would hope not. However, if you have ever experienced a car driving past with the bass control of its stereo turned up to maximum, you have experienced firsthand the vibration of sound via bone conduction. The results of this test are diagnostically significant because they can be used to help us determine the location or etiology of the hearing loss. When the results of air and bone conduction testing are used in combination, both the type of hearing loss and the severity can be established. Neither test alone can give us both pieces of information.
How It Works

Bone conduction audiometry is also considered a behavioral audiometric measure. In bone conduction audiometry, a bone conduction oscillator is placed either behind the ear (called mastoid placement) or on the forehead (called forehead placement). The client is again asked to respond in the same fashion that was established for pure tone air conduction testing—either raise a hand or perform some other task every time she or he hears a tonal stimulus.

Unlike air conduction, the bone conduction oscillator vibrates the skull; as a result, the cochlea in the inner ear (sensorineural mechanism) is stimulated directly, thus bypassing the outer and middle ears (conductive mechanism). When, for example, a client is tested by air conduction and demonstrates a moderate degree of hearing loss, the next step is to test by bone conduction. The results of air conduction testing (using supra-aural or insert earphones) are then compared to the results of bone conduction (using the bone conduction oscillator); based on a comparison of these results, we can determine how much of the (for example) moderate hearing loss is due to conductive damage, how much is due to sensorineural damage, or if some combination of damage to both pathways simultaneously is involved. Thus, the results of this test in combination with the results of air conduction testing can help the audiologist determine the type of hearing loss (conductive, sensorineural, or mixed).

In summary, bone conduction alone cannot determine the severity of the hearing loss; it can only help us determine the type of hearing loss. Air conduction alone, on the other hand, cannot determine the type of hearing loss, but it does indicate the degree. Only the combined measurements of both air and bone conduction thresholds can lead us to determine both nature (type) and severity (degree) of a hearing loss.

Methodology

In preparation for bone conduction audiometry, the clinician removes the earphones used for air conduction and places the bone conduction oscillator on the client, either on the forehead or, more frequently, on the mastoid bone behind the ear. It is noteworthy to mention that the mastoid selected for testing (right or left side) does not matter because regardless of placement, the clinician cannot be sure which cochlea is actually responding. The reason is because the bone oscillator is vibrating the entire skull, which will simultaneously stimulate both cochleas unless masking is performed. Additional details regarding the concept of masking will be addressed in the next section.

The actual procedure for obtaining bone conduction thresholds is the same as for air conduction. The clinician uses either standard hand raising or a conditioning procedure for the response pattern and then does a threshold search, as described previously. The results are plotted on the audiogram form.
Masking

Generally speaking, speech-language pathologists do not need to know how to perform masking; in fact, it is likely that they never will need to do so. However, if speech-language pathologists are to provide the best possible services for their clients, proper interpretation of the audiogram often incorporates the interpretation of masked thresholds as well. Therefore, the purpose of this section is merely to help the speech-language pathologist understand how the process of masking is carried out in order to enhance understanding of audimetric test results and the implications those findings will have on therapeutic interventions.

What You Need to Know

One of the major objectives of the basic audiological evaluation is assessment of auditory function of each ear independently (Yacullo, 1999). Unfortunately, there may be clinical circumstances where a “better ear” will, in essence, assist a “poorer ear,” yielding inaccurate results. Let’s consider a situation where a person has completely normal hearing in one ear and a profound hearing loss in the other ear. A problematic situation occurs during a routine hearing test due to the hearing sensitivity of one ear being significantly better or worse than the hearing sensitivity of the other ear. When we perform air conduction testing, using standard supra-aural earphones, testing results would reflect normal hearing in the “good” ear. However, when we switch to the “bad” ear, a complication arises. The amount of sound that will need to go into the earphone in order for the bad ear to respond will eventually become so loud that you run the risk of the good ear hearing and responding to the sound before the bad ear has a chance. In this scenario it becomes physiologically impossible for the client to listen with the bad ear and expect reliable test results. When the responses of the good ear are recorded falsely as responses of the bad ear, we call this a shadow curve. The term cross over (or cross hearing) is used when the evaluator identifies the existence of a shadow curve. When it is suspected that the stimulus used for testing is crossing over to the better hearing ear, masking is employed as a further diagnostic test procedure.

How It Works

Simply put, auditory masking is the process in which one sound is blocked out by another sound. Clinically, masking is used to prevent the test sound from being heard by the non-test ear. The process of masking can be observed in many everyday situations, such as when background noise prevents us from hearing what another person is saying. In the testing of auditory thresholds, when a significant difference in hearing ability between both ears is suspected, the audiologist needs to perform clinical masking in order to determine how the poorer ear hears when not influenced by the better ear.

During this procedure, once a shadow curve is identified, the poorer ear is retested while, at the same time, masking noise is put into the better ear to prevent it from participating in the process. In this way it is possible to determine the hearing abilities of each ear independent from the other.

Technically Speaking

Attenuation, as it refers to hearing, is the reduction or lessening in the strength of a sound. Interaural attenuation is the difference, in decibels, between the intensity of sound that was presented to the poorer ear and the amount of sound that actually reached the good ear. The mathematical difference is the amount of sound that was “lost” and got absorbed by the skull before it got loud enough to reach the other ear. This amount of sound, in decibels, is the interaural attenuation.

If a difference between the ears exists (such as a sensorineural hearing loss with one ear significantly better than the other), the responses to unmasked bone conduction testing would reflect the better cochlea, because there is essentially no interaural attenuation by bone conduction. Alternately, in the case of a bilateral conductive hearing loss, the unmasked bone conduction responses will reflect
wearing their hearing aids or other assistive device, which cannot be accomplished by using earphones.

**Visual Reinforcement Audiometry (VRA) Boxes**

Especially appropriate for testing very young (either chronologically or developmentally) children is the visual reinforcement audiometry (VRA) system arrangement in the sound field. VRA systems (see Figure 4.11) use either boxes that contain animated toys and lights, just lights, or computer monitors displaying favorite characters or animation.

**What You Need to Know**

We most frequently envision a person receiving a hearing test while wearing either supra-aural or insert earphones; however, this is not the only way a hearing test can be performed. Sound field refers to a controlled acoustic environment. Sound field testing is a term used to describe a test situation in which a client’s hearing is assessed while he or she is seated in the sound-treated room or booth. The sound stimulus is delivered through speakers mounted in the booth instead of through earphones. Many of

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**Figure 4.10** A room arrangement for sound field testing with speakers.
Although the practice of performing some of these sound field functional assessments with hearing aids and/or other assistive devices may not be standard practice in all facilities, it is the expressed opinion of these authors that such functional evaluations can yield valuable information.

Two important caveats must be addressed regarding sound field testing. First, the type of stimulus that is used cannot be a simple pure tone like that used when testing via earphones. Due to the acoustic nature of the sound field, warbled pure tones or narrow bands of noise must be used as a test stimulus. Speech stimuli may also be employed. The type of stimulus used for testing should be specifically noted on the audiogram. Secondly, when audiologic assessments are performed in this manner, with the sound coming out of speakers instead of directed to individual ears through earphones, the results only represent the hearing status of the better ear, if there is a difference between the ears (that is, one ear being significantly better than the other). For example, if a baby with normal hearing in the right ear and a profound hearing loss in the left ear is being tested behaviorally in a sound field, the responses to the sounds presented through the speakers will be observed at normal levels because the right ear has normal hearing and is the ear which is consistently responding. It is only when we use earphones that we are able to test each ear individually and determine that the left ear has a profound loss of hearing. When a behavioral audiogram is performed in the sound field and shows responses in the normal range, a conclusion of normal hearing in both ears cannot be made. Typically, a statement will be made in the written report of findings to the effect that, “these results support the hearing in the better ear, if an ear difference exists.” Again, because testing is not performed under earphones, the diagnostician cannot make a statement regarding the hearing status of both ears. A follow-up evaluation must be performed in order to obtain ear-specific information and rule out the presence of a unilateral hearing loss. Remember, any loss of hearing, even...
slight or unilateral, is cause for concern and intervention and therefore must be properly diagnosed.

In the sections that follow, you will find descriptions of various procedures that are frequently performed in a sound field with pediatric and/or difficult to test populations. It should be noted, however, that these procedures and methods of obtaining behavioral results are not limited to the sound field; that is to say that, whenever possible, they may also be performed with the use of earphones and/or a bone conduction oscillator, in order to obtain additional diagnostic and ear-specific data.

Behavioral Pediatric Assessment

A wealth of research is available supporting the use of objective procedures such as otoacoustic emission (OAE) testing and auditory brainstem response (ABR) testing in the newborn infant hearing screening process. In 2007, the Joint Committee on Infant Hearing (JCIH) of ASHA published an updated consensus statement titled Principles and Guidelines for Early Hearing Detection and Intervention (EHDI) Programs. In this position statement, the JCIH endorses early detection of and intervention for hearing loss, with the ultimate goal to maximize linguistic and communicative competence and literacy development for children who are deaf or hard of hearing. In particular, the JCIH recommends that all infants have access to a hearing screening using physiologic measures by 1 month of age (ASHA, 2007). It further recommends, however, that following failure of either the initial screening or subsequent rescreening, an audiologic evaluation be performed and behavioral measures, as developmentally appropriate and feasible, be completed as a cross-check measure. It is imperative to understand that although the objective procedures such as OAE and ABR testing are clearly important, and even indispensable, in the identification, assessment, and intervention of a hearing impairment, only behavioral tests are true and direct measures of hearing (Hicks, Tharpe, & Ashmead, 2000; Madell, 2011).

As such, behavioral measures of hearing sensitivity necessarily remain an integral part of the diagnosis and treatment of hearing loss.

With regard to behavioral pediatric assessment, whether of pediatric age chronologically or developmentally, it is important to understand that the responses observed may not actually be threshold levels for the given child. Recall that a threshold-level sound is the very softest sound that a person is capable of hearing 50% of the time. The responses that are observed and reported on during pediatric assessments are often not the softest sounds that a child is actually capable of hearing; rather, they might merely be the softest sounds that the child was willing or able to respond to on a given date. This type of measurement is often referred to as a minimum response level (MRL), in recognition of the fact that the child’s true hearing ability might be better than the results would otherwise indicate. The developmentally younger the child is, the more likely the responses are MRLs instead of actual thresholds.

The following sections on behavioral observation audiometry (BOA), the two types of COR, visual reinforcement audiometry (VRA) and tangible reinforcement operant conditioned audiometry (TROCA), and conditioned play audiometry (CPA) describe the behavioral techniques that are frequently utilized in a sound field setting (often out of necessity for a variety of reasons) with pediatric and/or difficult to test populations. As noted in the preceding section, these procedures are not limited to the sound field setting. Whenever possible they can, and should, also be employed while using earphones and/or bone conduction oscillators in order to obtain ear-specific and diagnostically useful information.

Behavioral Observation Audiometry (BOA)

What You Need to Know

Behavioral observation audiometry (BOA) is a methodology used when attempting to subjectively test the hearing of a child with a developmental age
of up to 6 or 7 months. Objective procedures (such as OAE and ABR) record physiologic activity; they do not require the active participation of the client and are measures of auditory function only. BOA is a behavioral technique that requires a subjective response from the child each time a sound is heard, and the results are a direct measure of hearing sensitivity.

**Technically Speaking**

During BOA, the responses that children typically demonstrate are reflexive ones (eye blinks, startle responses, etc.), not conditioned responses, and they are generally assumed to be representative of gross responses to sound, as opposed to threshold (the softest possible) responses. As mentioned previously, these responses are not likely to be the softest sounds that a child is actually capable of hearing; rather, they might merely be the softest sounds that the child responds to on a given date. As such, it is imperative that the results of BOA testing be viewed in conjunction with all other test results available, including electrophysiologic measures, before arriving at any diagnostic conclusions. Additionally, when behavioral pediatric assessment is warranted, it is not uncommon for multiple test sessions to be required in order for sufficient behavioral audiological information to be obtained.

**Methodology**

Hearing testing using BOA is typically accomplished in a sound field with different sounds being presented through calibrated speakers. Some of the auditory stimuli used might include warbled pure tones, noise, and unfiltered and/or filtered speech and music stimuli. The child is typically seated in the test (sound-treated) room on the parent’s lap; meanwhile, the audiologist presents the sounds through the speakers, and then observes the child’s responses to those sounds. Some of the overt responses observed may include rudimentary head turn, eye widening, changes in sucking or breathing, startle, and changes in state of arousal.

Ideally, this type of testing would be performed by two audiologists working in tandem to ensure the accuracy of the results obtained. However, in many cases when a second audiologist is not available, an available speech-language pathologist working in the same department may be called on to assist. The audiologist (or assisting speech-language pathologist) in the sound room is responsible for keeping the individual engaged and providing an extra set of eyes to help ensure validity and reliability. Simultaneously, the audiologist on the control side, in addition to observing the child’s responses, manipulates the frequency, intensity, and variety of auditory stimuli being presented to the client through the calibrated speakers. If one of the examiners judges a behavior to be a response to sound while the other examiner does not observe the same behavior as being a response, the behavior in question is not considered a response to the sound. Both examiners must be in agreement about each behavior observed for it to be considered a valid response.

**Conditioned Orientation Reflex (COR); Visual Reinforcement Audiometry (VRA)/Tangible Reinforcement Operant Conditioned Audiometry (TROCA)**

**What You Need to Know**

When a child reaches approximately 6 to 7 months of age developmentally, conditioning them to respond to sound becomes increasingly successful. At this developmental stage, which lasts through about 24 months of age, accurate behavioral hearing test results are achievable using a conditioned orientation reflex (COR) technique. One such technique is known as visual reinforcement audiometry (VRA). The basic premise underlying the VRA procedure
is not only that a child has a natural instinct to turn searchingly for an interesting sound when it is heard, but also that the child will continue to do this when "rewarded" with an appealing visual stimulus (such as lights, lighted animated toys, videos, etc.). Other types of COR may include using food or other tangible reward for a positive response. This COR technique is referred to as tangible reinforcement operant conditioned audiometry (TROCA).

**Technically Speaking**

VRA is a procedure that is frequently performed in the sound field using two audiologists, or with the assistance of an available speech-language pathologist. This type of behavioral hearing testing can be easily accomplished by again having the child sit on his or her parent’s lap. The visual reinforcers are situated on top of each of the speakers in the sound field. The reinforcing toy is typically housed in a smokey box, not visible to the child until it is illuminated. One audiologist (or assistant) is directly facing the child and will keep the child engaged during the test process. At the same time, the other audiologist on the control side of the test suite is operating the audiometer and presenting the test sounds through the speakers. These stimuli can be warbled tones, narrow bands of noise, or live or recorded speech. The child is intentionally situated between the two speakers, typically at a calibrated position (denoted on the ceiling of the sound booth), and at such an angle as to require a noticeable head turn in search of the sound, if and when the child hears the sound. This arrangement is displayed in Figure 4.12. Similarly, TROCA would provide the child with a tangible not a visual reward for a positive reinforcement.

**Methodology**

The first step in the process is to condition the child to associate the test stimulus (auditory) with the visual reinforcer (animated toy in smokey box) or tangible reward. This is easily accomplished by sending a sound through the speakers that is assumed to be “clearly loud enough” for the child to hear; the child’s attention is then directed toward the sound and the animated toy is activated. When the connection between the two has been clearly established, the audiologist (or assistant) keeps the child otherwise engaged while the audiologist on the control side systematically presents a combination of

![Figure 4.12](image.png)

**Figure 4.12** Typical audiometric test room arrangement when visual reinforcement techniques are utilized.
sounds. Some of the sounds used during this procedure may include warbled pure tones, narrow bands of noise, unfiltered and filtered speech and music, and the like. Both examiners watch for responses, and each time a response is observed the child is rewarded with the toy animation (or video, lights, or other visual stimulation) or tangible item like food as reinforcement.

An ideal test session is when the child remains interested in this activity long enough to finish getting a complete audiogram. Unfortunately, it is all too common for the child's interest to wane before completing the hearing test, thus necessitating multiple test sessions to obtain results across all frequencies. Additionally, although this test is most often performed with speakers in the sound field, it may also be done with the use of earphones, for the purposes of getting ear-specific information for difficult to test populations.

Conditioned Play Audiometry (CPA)

What You Need to Know

When children reach 2 1/2 years of age through approximately 5 years of age, either developmentally or chronologically, they can typically be engaged in conditioned play audiometry (CPA) techniques. The older children in this age range are generally able to participate in almost any game, whereas the younger children in this category need the task to be modified into a simpler form. When a simpler task is utilized, this is sometimes referred to as modified play techniques.

Technically Speaking

CPA is designed to gain audiological test results by making the evaluation process into a game. The child is conditioned to play a game—for example, drop a block into a bucket, put a ring on a stick, and so on each time a sound is heard. Almost any game will suffice, so long as it produces responses that are repeatable and consistent. A challenge that is frequently encountered during CPA is finding games that hold the child's interest throughout the evaluation process.

Methodology

CPA may be performed by one tester; however, two audiologists are useful with some of the younger children in this age range. Again, a speech-language pathologist is frequently called on to assist in this testing procedure, especially if the child being tested is on that specific speech-language pathologist's caseload. Again, familiarity with the younger child being tested is felt to be advantageous in obtaining reliable test results.

The clinician places the earphones on the child. Ideally, CPA is completed using earphones and a bone conduction oscillator, when possible, so that ear-specific information can be obtained. However, this technique may also be used in a sound field for situations where the child is unwilling or unable to accept earphones. Please refer to the previous section of this chapter regarding earphone placement on younger children.

In lieu of lengthy verbal instructions, these authors have had long-standing success conditioning children to perform the desired task by simply demonstrating and engaging the child in the play activity. A good rule of thumb is the fewer words/directions, the better. Many children who are in this situation are being tested to rule out hearing loss as contributory to developmental language issues, so extensive verbal direction can result in the child being confused or simply shutting down to the task at hand.

The clinician selects a game that is developmentally appropriate for the child and begins to engage and condition the child to the activity. The diagnostic threshold search or screening then proceeds as described previously. Results are plotted on the audiogram form, along with notes regarding the method used to obtain them and the clinician's judgment as to the reliability of the information obtained.
Summary

Pure tone air and bone conduction audiometry are the backbone of the audiologist’s behavioral testing measures. A clear understanding of the scientific basis of air conduction and bone conduction testing will aid the speech-language pathologist in thoroughly understanding not only threshold and MRL responses, but also how the responses were obtained. It is only with this clear understanding and the appropriate interpretation of air conduction and bone conduction results that a measure of both degree and type of hearing loss can be determined.

Discussion Questions

1. What type of information regarding hearing sensitivity is provided by air conduction testing?
2. What type of information regarding hearing sensitivity is provided by bone conduction testing?
3. If a child is resistant to wearing earphones, what other testing options are available to use?
4. When would you expect masking to be performed in pure tone testing? Incorporate the term interaural attenuation into your answer.
5. What type of testing technique would be used with a 5-year-old child with normal cognitive functioning to get the most reliable test results possible? Why?

References


CHAPTER 5

SPEECH AUDIOMETRY

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OBJECTIVES

• Understand the variety of speech audiometry procedures and the type of information they can provide.
• Comprehend how the results of speech audiometry relate to the pure tone findings and how they may be used as a check for response reliability.
• Describe how speech audiometry may be performed on a variety of different developmental ages and populations.
• Discuss how to incorporate the results of speech audiometry to maximize effectiveness in the therapeutic setting.

KEY TERMS

Binaural
Dynamic range (DR)
Loudness discomfort level (LDL)
Masking
Monaural
Most comfortable listening level (MCL)

Phonemically balanced (PB)
Pure tone average (PTA)
Recruitment
Speech audiometry
Speech awareness threshold (SAT)
Speech detection threshold (SDT)
Speech discrimination testing

Speech reception (recognition) threshold (SRT)
Spondee
Threshold of discomfort (TD)
Uncomfortable listening level (UCL)
Word discrimination testing (WDT)
Word recognition testing
Introduction

Speech audiometry, along with pure tone audiometry, is a critical element of a comprehensive evaluation because our daily activity of listening is not composed of a series of tones in octave and half-octave bandwidths, but is a complex neurological process called speech perception. At the forefront of this process is the detection and discrimination of a speech signal and comparing it with the levels of peripheral hearing determined through pure tone audiometry. When a hearing loss is identified, speech audiometry attempts to measure the impact the hearing loss has on the person's ability to understand and communicate using the aural/oral processes of speech and language. Speech audiometry should not be confused with the comprehensive evaluation of (central) auditory processing.

A Word About Terminology

Many of the tests in this chapter actually have several names that vary from state to state, facility to facility, or even audiologist to audiologist. This variation has its roots, in part, in regional preference, training facility (college/university), and age of the examiner (what year they graduated from school). Although the variation in terms for speech audiometry has been debated and discussed on many different levels, a single homogeneous term for each is rarely agreed upon by all. Every effort has been made to expose the reader to all terms currently in use, regardless of any underlying dispute, because the practicing speech-language pathologist will probably encounter most, if not all, of the testing terminology.

Derivation of Word Lists

Historically, the first speech tests were spoken or whispered messages presented at measured distances between the talker and the listener. These tests provided a gross estimate of an individual's ability to hear speech (American Speech-Language-Hearing Association [ASHA], 1988). Speech audiometry, as we know it today, is the result of efforts to formalize the measurement of this information. However, as a matter of point, the reader should be aware of the fact that the “Whispered Voice Screening Test,” while not a preference of those practicing audiology, is still in use today (Swan & Browning, 1985).

As with many aspects of the field of audiology, the development of speech audiometry came from the U.S. military both during and after World War II. Not exempt from this part of audiology history, formal speech audiometry came from the development of articulation testing for military communication equipment. A desire to create a clear, intelligible speech signal for radio communication precipitated the development of methodologies by which spoken English could be assessed for both minimal audible thresholds (hearing threshold for speech) and intelligibility (discrimination) when transmitted through military communication technology of the day. This spurred the creation of spondaic word lists to determine hearing thresholds for speech and phonemically balanced (PB) word lists to assess discrimination loss.

A spondee refers to a word that has two syllables with equal emphasis on both; some examples are hotdog, baseball, and toothbrush. Phonemically balanced (PB) refers to words that have been statistically analyzed for their phoneme content. This content is then compared to a sampling of spoken discourse and is again statistically analyzed for percentage of representation in that speech sample. Lists are then assembled of 25 and 50 words (referred to as half lists and full lists, respectively) that statistically represent each phoneme's occurrence in the English language using either a consonant-vowel-consonant (CVC) format or a consonant consonant-vowel-consonant consonant (CC-V-CC) format, using only monosyllabic words. The evaluation and determination of which words in the English language would be chosen for these lists is extensive, but may hold historical interest for
some. Those individuals are directed to Hirsh and colleagues (1952).

Early recordings of these words were on vinyl disks (the type used with record players), but these were determined to have too much variability and distortion of the recorded signal. After a brief period of use, recordings were transferred onto a recordable tape format called reel-to-reel. In a continued effort to create a clearer signal, recordings later evolved to cassette format, decreasing the distortion even further. Today, word lists are recorded and reproduced onto compact discs, or downloaded to tablets.

Speech Recognition Threshold/Speech Reception Threshold

What You Need to Know

A speech reception (recognition) threshold (SRT) provides a measure of a person's threshold for the recognition of speech stimuli, much in the same way as pure tone air and bone conduction testing provide thresholds for the reception of tones. The basic purpose of the SRT is to give an indication of how loud speech has to be for a person to just barely begin to hear it. Second, but no less important, the SRT serves as a reliability check or cross-check for the accuracy of the pure tone findings.

How It Works

The SRT is defined as the softest level at which a person can recognize 50% of simple speech materials (ASHA, 1988). (See American National Standards Institute [ANSI] S3.6-1969 standard or subsequent superseding standards.) The decibel level of the SRT is not a level that would be sufficient to enable the person to carry on a conversation; rather, the SRT is merely the very softest level at which sound can be detected and recognized as a speech signal. The SRT is typically performed by air conduction (using supra-aural or insert earphones), and should be in agreement with the pure tone air conduction results at 500, 1000, and 2000 Hz (this is known as the pure tone average [PTA]). For example, if someone demonstrates a severe hearing loss by pure tone air conduction testing, the SRT results should also be obtained at similarly impaired decibel levels. Thus, the SRT is a good measure of the accuracy of test results.

Technically Speaking

The SRT is the minimum hearing level for speech (see ANSI S3.6-1969 standard or subsequent superseding standards) at which an individual can recognize 50% of the speech material (ASHA, 1988). The SRT is typically obtained using spondaic words (bisyllabic words with equal emphasis on the first and second syllables), but conversational/cold running speech or the identification of body parts using a pointing task are modifications that may also be used when necessary. When a procedural variation of this type occurs, there would typically be a notation on the audiogram. In addition, there are a variety of spondaic word lists available that are geared to meet the needs of different developmental ranges, as well as picture pointing tasks for those who, for a variety of reasons, may not be capable of orally repeating words.

The SRT provides a measure of the person's threshold for the recognition of speech much in the same way as pure tone air and bone conduction testing provide thresholds for the reception of simple sound. The SRT should be in agreement with the average PTA at 500, 1000, and 2000 Hz. Although some variability between the SRT and the pure tone responses can be expected (e.g., when a steeply sloping configuration of hearing loss exists), inappropriately large differences between the SRT and the pure tone results is suggestive of pseudohypacusis, otherwise known as false hearing loss.

Methodology

Under earphones, the SRT is tested one ear at a time, beginning with the better ear using traditional
Speech Detection Threshold/Speech Awareness Threshold

What You Need To Know

The speech detection threshold (SDT) is sometimes also referred to as the speech awareness threshold (SAT). The SDT is very similar to the SRT in that it involves a patient’s responses to the presence of speech; however, whereas the SRT requires that the person detect and recognize a sound as being a speech signal, the SDT simply requires that the person indicate they are aware of a speech sound without requiring that they know what the sound is (ASHA, 1988). The response to this task is behaviorally observed (conditioned response) rather than the higher cognitive function of an SRT, which requires the listener to either repeat a word or point to a picture. As such, it is a simpler task and very useful in cases where, for whatever reason, a person is unable to repeat back words. Examples of this are when there is a significant language barrier, aphasia, autism spectrum disorder, or cognitive or developmental impairment.

How It Works

The SDT can be performed using any speech sound (for example, the tester might say “ba, ba, ba” into the microphone); it does not require spondaic words as is the case for establishing the SRT. Additionally, because the SDT requires awareness to as opposed to recognition of a signal being a speech signal, the SDT response is generally obtained at a more sensitive (lower/better) decibel level. Again, as is the case with the SRT, the results should be in agreement with the pure tone responses and serve as a check of the accuracy of the audiogram.

Technically Speaking

The SDT, or SAT, is the minimum hearing level for speech at which an individual can just detect the presence of speech stimuli. The listener does not have to identify the material as speech, but must
indicate awareness of the presence of sound (ASHA, 1988). The stimulus used for assessment of the SDT is not as important nor is it as prescribed as it is with the SRT; this is because the SDT is a detection-only task and, therefore, the content of the speech signal used as a stimulus becomes less critical. Similarly to the SRT, the results of the SDT should be in relative agreement with the pure tone findings.

**Methodology**

Under earphones, the SDT is tested one ear at a time, beginning with the better ear using traditional or insert earphones. However, the SDT can also be performed during sound field testing as well. The SDT is performed using words, connected discourse, or other such materials; the patient is simply required to raise a hand, drop a block, or use any other behavioral indication that the sound has been heard. It does not matter whether the patient knows, can identify, or understands what it is they have heard. This procedure is also performed in much the same way the air conduction thresholds are obtained—that is, the speech stimulus (this might be the spondaic word or it may also be vocalizations, such as, “ba, ba, ba”) is presented at a level that is comfortably loud for the listener. The intensity is then lowered by 10 dB each time the patient detects the sound, and raised by 5 dB each time the sound has not been detected. Just as in pure tone air conduction testing, the intensity level of the sound is continually increased and decreased until the clinician finds the decibel level that the patient responds to one-half of the time, with the minimum number of responses needed to determine the threshold of hearing being two out of three responses at a single level (ANSI, 2004).

**Most Comfortable Listening Level (MCL)**

**What You Need To Know**

The **most comfortable listening level (MCL)** is a speech audiometry measure audiologists have come to depend upon when assessing hearing and communication ability. The MCL is exactly as its name suggests—it is the decibel level that has been determined to be the most comfortable volume level at which the patient subjectively prefers to listen to speech.

**How It Works**

Subjectively, we each have a preferred level of loudness (or intensity) that we individually determine to be a comfortable level—neither too soft nor too loud for our preference. The stimulus of choice used for this test is typically conversational/cold running speech. Clinically, this level is often approximately 40 dB louder than the patient's SRT or SDT, although there is some variability from person to person. The MCL level is noted on the audiogram and may be used as the presentation level for a variety of other speech audiometry tests as well as hearing aid fitting and adjustment.

**Technically Speaking**

The MCL can be defined as the decibel level that is decided upon, by audiologist and patient together, as being the most comfortable level for the patient to listen to speech. It is neither too loud nor is it too soft, and the stimulus of choice used for this test is typically live voice conversational/cold running speech. The purpose of obtaining this measure is not only to determine the level at which the patient has the easiest time listening to speech, which typically results in the patient’s best possible speech understanding ability, but also to use it for other speech audiometry procedures and evaluations, particularly those involving the assessment and fitting of hearing aids. Large variations from a 40-dB reference to the SRT/SDT of the patient can be a clinically significant finding.

**Methodology**

The patient's MCL can be determined for each ear individually (monaural condition) or both ears together (binaural condition) using either earphones or the sound field via the speakers.
Regardless of the condition (monaural or binaural), the process is the same. The audiologist carries on a conversation with the patient, all the while manipulating the intensity level of his or her voice with the audiometer, while getting the patient's input to determine the intensity level that is “most comfortable”—that is, the level that is neither too soft nor too loud. The audiologist might ask the listener to “pretend that you are listening to the television and let me know if you would raise the volume, lower it, or leave it the same.” Ideally, the clinician will talk to the patient for several minutes so the patient will have the opportunity to listen to the way conversational speech varies over time, to help in determining an accurate MCL.

**Uncomfortable Listening Level/Loudness Discomfort Level/Threshold of Discomfort**

**What You Need To Know**

The uncomfortable listening level (UCL), also referred to as either the loudness discomfort level (LDL) or the threshold of discomfort (TD), is the limit of the acceptable amount of sound in decibels, beyond which the patient would find sound to be unacceptably loud or even painful to listen to for any significant period of time. This measure is extremely important, particularly for the assessment and fitting of hearing aids and other such amplification devices/hearing assistance technology.

**How It Works**

In normal hearing individuals, there is a wide hearing range from their threshold of hearing to their level of discomfort known as the dynamic range of hearing (discussed in detail in the next section). However, a large percentage of hard-of-hearing individuals experience the sensation of an abnormal growth in loudness—in essence, a narrowing of this range. For example, instead of a slight increase in intensity causing a slight increase in perceived loudness (as is the case with a normal hearing person), the hard-of-hearing person frequently experiences a sudden growth in the perceived loudness of that sound with only that same slight increase in the volume intensity. The term used to describe this abnormal growth of loudness is called recruitment. Unfortunately, this usually results in the hard-of-hearing listener having a lowered tolerance for loud sound. While useful in many applications of the evaluation, a low UCL is also a poor prognostic indicator for successful hearing aid use due to the fact that there is a very small dynamic range of hearing that can be amplified before sounds become intolerable.

**Technically Speaking**

The UCL is the maximum sound intensity level in decibels and it represents the upper limit of what the patient finds comfortable to listen to; beyond this level, discomfort and/or pain may be experienced. This procedure should be performed to carefully determine UCL levels (in decibels) using both speech as well as pure tone stimuli (250 Hz through 4000 Hz inclusive).

Measurement of the UCL levels should be a routine part of the audiological test battery. For adults and children with sensorineural hearing loss, it is an important aspect of the audiological profile. Less frequently, it is performed in very young children for whom the purpose of the evaluation is to rule out hearing loss. An evaluation of recruitment and/or a narrow dynamic range of hearing plays an important role in the proper evaluation and fitting of hearing aids. Should hearing aids be programmed without regard for the individual's UCLs, the patient may experience discomfort and as a result be unable or unwilling to routinely use his or her hearing aid(s).

**Methodology**

The procedure for assessing a patient's UCL is similar to that for assessing the MCL. It can be tested in both monaural and binaural conditions, either
under earphones or in the sound field through the speakers. The speech material used is again ongoing conversation between the audiologist and the patient, and the intensity level is likewise adjusted. The patient is asked to listen to the tester’s voice and indicate, in some way, when the intensity of the clinician’s voice gets to a level at which any higher would become intolerable. This acoustic level is then recorded and is extremely important in hearing aid evaluations, selection, and monitoring.

**Technically Speaking**

The DR is a simple calculation of the mathematical difference between the SRT and the UCL. For example, a typical normal hearing person might have an SRT of 10 dB and a UCL of 110 dB. Mathematically, this is represented as

$$110 \text{ dB (UCL level)} - 10 \text{ dB (SRT level)} = 100 \text{ dB}.$$  

Alternately, a hard-of-hearing person might have an SRT of 50 dB and a UCL of 90 dB, resulting in a dynamic range of 40 dB. This narrowing of the DR is an extremely common scenario, and it presents a challenge to the audiologist who is fitting hearing aids. When working with clients pursuing hearing aid use, measures of SRT, MCL, UCL, and overall dynamic range, and the accuracy of these measures, can in many cases be the determining factor of successful hearing aid use.

**Dynamic Range**

**What You Need To Know**

The **dynamic range (DR)** is the mathematical difference between the lowest level at which an individual begins to hear speech (the SRT) and the upper limit of comfort for speech (the UCL). This is sometimes also referred to as the **range of comfort loudness (RCL)** because it represents the range of loudness (from softest to loudest) that a person can hear without experiencing discomfort or pain.

**How It Works**

Normal listeners start to hear speech at a very soft (normal) level, and they do not start to experience discomfort or pain until sounds reach a very loud level. This is a wide range of loudness within which the normal listener can comfortably experience sound. The hard-of-hearing listener is likely to experience an abnormal growth of loudness (discussed in the previous section), which results in an inability to tolerate loud sounds. In a hard-of-hearing individual, the sound stimulus must be presented at a louder level before it can start to be heard; however, the threshold of discomfort may not be significantly louder than that of a normal hearing individual. Hence, the dynamic range of the hard-of-hearing individual is effectively reduced. In other cases, the UCL has decreased from that of the normal hearing individual, and in some cases significantly so. This results in an extremely narrow range of hearing from the point of detection (threshold) to the point of discomfort.


**What You Need To Know**

Word discrimination testing (WDT), also referred to as speech discrimination testing or word recognition testing, is not an assessment of sensitivity; rather, it is an assessment of clarity. This procedure is standard in most all evaluations performed. The test provides the audiologist with an estimate of how well a person is able to understand speech once it has been made comfortably loud for them. When working with clients pursuing hearing aid use, measures of SRT, MCL, UCL, and overall dynamic range, and the accuracy of these measures, can in many cases be the determining factor of successful hearing aid use.
the signal has been made loud enough, he or she will likely be very successful with hearing aids. In children, poor word discrimination scores may have a wide range of repercussions in educational planning, hearing aid use, and cochlear implant candidacy.

**How It Works**

Have you ever heard a person complain that they had no problems hearing you but just couldn't understand what you had said? This phenomenon of hearing a speech signal, yet not understanding its content, describes a large portion of the hard-of-hearing population. It brings us to some basic facts about auditory pathology: Hearing loss not only impairs the loudness of sound that reaches the person's ear, but also may include a distortional element. These are two of the most basic characteristics of hearing loss—severity and clarity. Severity refers to how loud sound must be made for a person to just barely be able to hear it; clarity refers to how intelligible the signal is once it is presented at a comfortably loud level (MCL, for example). This explains why someone may “hear” something, but not necessarily be able to discriminate the content of what they have just heard. WDT attempts to quantify a person’s ability to understand speech, once it has been made comfortably loud for the person.

**Technically Speaking**

Whereas pure tones (air and bone) allow us to establish the nature and quantify the severity of hearing impairment, and SRTs obtain threshold measures of hearing for speech, WDT focuses more on the impact the hearing loss has on communication ability by looking at a patient’s ability to understand and discriminate the content of what she or he is hearing (Brandy, 2002). Testing is accomplished using any of several different variations of PB lists available. Word discrimination testing is generally performed at the level of a person's MCL and the results are categorized as excellent, very good, good, fair, poor, and very poor. Generally speaking, the better one's WDT scores are, the less the hearing loss will impact their ability to communicate. The results obtained from the WDT are a necessary and integral part of the treatment and aural rehabilitation planning process.

**Methodology**

WDT is performed approximately 35–40 dB above the level of the SRT, or at the client’s MCL. For example, if a patient has an SRT of 20 dB HL, the presentation level of the speech stimuli used for WDT would be approximately 55–60 dB HL.

The most common speech stimuli used for WDT are PB word lists, discussed previously. The basic procedure is to present a list of words at a comfortably loud presentation level, and instruct the patient to repeat what has been said. Again, how the instructions are presented to the patient will determine the accuracy of the measured outcome; for example, “Repeat what you have heard” versus “Repeat what you have heard even if you just think you know the word” will affect patient performance on this task, yielding very different results. Once he or she has provided instructions, the examiner presents each test word item, one at a time, preceding each of the words with the phrase “Say the word . . . .” Scoring is reported as a percentage based on 25 (half list) or 50 (full list) words, at the discretion of the examiner. For example, if a list of 25 words is presented and the listener correctly repeats back 22 out of 25 words, a WDT score of 88% would be recorded.

<table>
<thead>
<tr>
<th>WDT Score (%)</th>
<th>General Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>92 to 100%</td>
<td>Excellent</td>
</tr>
<tr>
<td>84 to 90%</td>
<td>Very good</td>
</tr>
<tr>
<td>78 to 82%</td>
<td>Good</td>
</tr>
<tr>
<td>70 to 76%</td>
<td>Fair</td>
</tr>
<tr>
<td>60 to 68%</td>
<td>Poor</td>
</tr>
<tr>
<td>Less than 60%</td>
<td>Very poor</td>
</tr>
</tbody>
</table>

Table 5.1 General Guide for the Interpretation of Word Discrimination Test (WDT) Scores
Modifications of this test procedure are often necessary when assessing the very young child, special populations, or anyone who either cannot or will not comply with the request for a verbal response. An example of such modifications is the Word Intelligibility by Picture Identification (WIPI) test developed by Ross and Lerman (1970). This tool allows the clinician to assess a young child's word recognition ability by presenting the child with a series of pictures; the words are presented to the child, one at a time, and the child is asked to “Point to the . . . .” The score of these results, as indicated above, is a percentage of the words correctly identified. Similar materials are available that have been developed for use with nonverbal adults.

**Masking for Speech**

As a point of reference, if **masking** is needed for pure tone audiometry, it will probably need to be done for speech audiometry as well. The process of masking for SRT is similar to that for pure tone air conduction testing. The decibel level of the SRT in the poorer ear needs to be compared to the best (most sensitive) bone conduction threshold in the better ear; if a 40 dB or greater difference exists, the SRT needs to be retested using masking.

Similarly, if the SRT needed masking, the WDT will need masking as well. Generally speaking, the likelihood of needing masking is routinely greater for WDT than for threshold-level tests (pure tone air conduction and SRTs). This is due to the fact that the WDT is accomplished using a loudness level that is suprathreshold (louder than threshold), referencing the SRT (threshold). If a threshold or presentation level for speech audiometry testing has been masked, the audiologist will reflect those results as “masked” by placing a lower case, subscript “m” next to that specified dB level. (for example: 45dB mirrored).

Although speech-language pathologists are unlikely to be responsible for knowing how to perform effective masking, it is critically important that they understand the concept, what it represents, and the audiometric implications. Without accurately measuring and interpreting hearing test results, proper interventions and management strategies cannot be implemented accurately.

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**Summary**

Although pure tone audiometry provides us with information regarding the degree and nature of the hearing loss, it is important to know that pure tone test results only provide part of the audiometric profile of a patient. Speech audiometry is equally important for the examiner to determine the communication status of the patient and the impact a hearing loss may or in some cases may not have on daily communication. Speech reception thresholds determined for each ear serve multiple purposes in testing: first, to determine a threshold for speech; second, to serve as a reliability check for the pure tone test results; and third, to serve as a reference for word discrimination testing. Word discrimination testing then allows the examiner to determine a person's ability to clearly distinguish one word from another. Performance on word discrimination testing is a prognostic indicator for successful hearing aid use in the patient with hearing loss.

Other tests of speech audiometry play a significant role in determining quality of life factors for a patient with hearing loss. MCL, UCL, and the computation of the dynamic range of hearing are important measures to consider when working with the hard-of-hearing patient. Such measurements also play an important role in the prognosis of successful hearing aid use.


## Discussion Questions

1. Pure tone audiometry provides us with information regarding the degree and nature of the hearing loss. Why is speech audiometry also important?

2. What options for speech audiometry testing would you use when a child refuses to, or cannot, respond by repeating back a word?

3. Is it possible to apply the principle of masking to speech audiometry? If not, what principles preclude masking for speech? If yes, when would you expect to see masked thresholds for speech audiometry testing?

4. When would MCL and UCL be important information to have on a child? Incorporate the term *dynamic range* into your answer.

5. Mrs. Jones complains that her new hearing aids are “too loud” and she cannot hold a conversation with her grandson because she “does not understand a word he says.” What are the two most likely reasons for Mrs. Jones’s dissatisfaction with her new hearing aids? What measures of speech audiometry can you reference to check your suspicion? What would you recommend that Mrs. Jones do to remedy her complaints?

## References


CHAPTER 6

OTOSCOPY AND THE MIDDLE EAR TEST BATTERY

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KEY TERMS

Acoustic (stapedial) reflex
Acoustic reflex decay (ARD)
Acoustic reflex threshold (ART)
Cerumen
Conductive hearing loss
Decruitment
Ear canal volume (ECV)
Eustachian tube (ET)
External auditory canal
External auditory meatus
Middle ear
Otitis media
Otoscope
Otoscopy
Outer ear
Pinna
Recruitment
Retrocochlear pathology
Tympanic membrane
Tympanometer
Tympanometric compliance
Tympanometric pressure
Tympanometry
Universal precautions

OBJECTIVES

• Illustrate the principles and components of the middle ear test battery.
• Understand the information the middle ear test battery provides and how it relates to audiometric results.
• Discuss and explain disorders that potentially impact the results of the middle ear test battery.
• Identify the equipment necessary for performing screening and diagnostic measures.
Introduction

“Never stick anything smaller than your elbow in your ear!” is a common phrase that has been used by mothers, fathers, grandmothers, and grandfathers for years. Unfortunately, this warning goes unheeded by many, especially when faced with the annoying feeling that there is something in there, and sometimes, there is. In practice, you will never cease to be surprised at what people put in their ears. It is therefore the responsibility of the examiner to determine that sound has a clear pathway through the external auditory canal to channel itself through the peripheral auditory system. Beyond the tympanic membrane (eardrum), a host of pathologies can further impede the journey of sound to the cochlea as well.

The complete evaluation of the auditory system goes beyond measuring acuity. Using both otoscopy and the middle ear test battery, we can focus not only on in-depth evaluation of the auditory system, but also on the overall health of the ear. Otoscopy and tympanometry become an integral part of the evaluation as nonbehavioral measures used in the assessment process.

The figures referenced in this chapter are meant to provide the reader with an overview of the more common pathologies encountered in the daily practices of an audiologist or speech-language pathologist (SLP); however, they are in no way a comprehensive representation of all pathologies you may encounter. If something doesn’t look right, find an audiologist with whom you can network and consult regarding unknown or unidentified pathologies. A common clinical mistake is to think that because you are the first or perhaps only person to identify something as abnormal, that you are potentially working outside of your scope of practice. However, good clinical practice includes the willingness to question, question, question, and refer when necessary.

Visual Inspection

Most audiological procedures require highly calibrated technical tools or other equipment to evaluate. The visual inspection of the pinna and temporal area of the head requires only a trained eye, but is an integral part of the audiological evaluation that should not be overlooked. This visual inspection can yield important information used as a springboard to further diagnose auditory problems.

What You Need to Know

Many craniofacial abnormalities are strong indicators of hearing impairment. Simply stated, if there is a visible abnormality, there is probably a whole host of abnormalities that you cannot see. It is therefore important to look at and touch the pinna in order to assess its size, shape, and relative placement as compared to the patient’s other facial features. A portion of the external auditory canal (external ear canal) can also be seen without the use of any equipment. This portion of the canal should be examined for size, shape, and patency. Other aspects that should be evaluated are the presence or absence of drainage, distinct odor, cerumen (also known as ear wax), and foreign objects (American Speech-Language-Hearing Association [ASHA], 2004). This visual inspection of the ear should be performed prior to doing any tests of middle ear function and before any hearing test procedures (air conduction, bone conduction, speech audiometry, tests of otoacoustic emissions) as well. In the event that the visual inspection reveals any drainage, foul odor, and the like, tests of tympanometry should not be performed and immediate medical attention is indicated.

How It Works

Visual inspection is simply that—a visual inspection to identify any physical abnormalities that may exist. This chapter contains figures that will assist you in identifying the most common visual abnormalities of the ear; however, as previously mentioned, these should in no way be considered comprehensive. The SLP should always consult with, or refer to, an audiologist or an otolaryngologist if an abnormality is observed or suspected.
Technically Speaking

Visual inspection of the pinna, surrounding temporal area of the ear, and facial feature symmetry is important to identify craniofacial abnormalities that may have a secondary characteristic of hearing loss. Structural integrity of the cranium can be both internal and external. Therefore, visual inspection of the head is an integral part of the audiological evaluation as it can yield important information valuable in the diagnosis of the patient. Again, do not assume that if previous records do not indicate any craniofacial syndrome or other disorder that there has not been a missed diagnosis. Should any questions or concerns arise, you should immediately seek the opinion of others who work with the child.

Methodology

It is vitally important to take a comprehensive case history and create a bond with the patient prior to testing, because to visually inspect the pinna and surrounding area the examiner must touch the patient. Prior to making physical contact with a patient, it is important to adhere to policies of universal precautions. Hand washing and gloving are recommended as a precaution against transmission of pathogens.

First, the examiner should gently but firmly grasp the topmost portion of the pinna, evaluating for shape, thickness of ear cartilages, and the identification of pinna landmarks. An assessment of pain while touching the pinna should also be made at this time.

The area around the pinna should also be examined for abnormalities. Figures 6.1 through 6.5 show common, but by no means comprehensive, typical and atypical findings.

Otoscopy

Equipment

An otoscope is used to perform an otoscopic inspection (see Figure 6.6A). This device consists of a handle and a head, providing a magnifying lens and light source for visual inspection of the tympanic membrane and external ear canal. A variety

Figure 6.1 Normal pinna.

Figure 6.2 Ear tag.

Figure 6.3 Preauricular pit.
of different sizes of specula attach to the otoscope, which are designed to fit different sizes of ear canals (see Figure 6.6B).

The process of examining the external auditory meatus (also known as the external ear canal), especially the eardrum, using an instrument that magnifies and lights the area (otoscope) is known as otoscopy. The examiner inspects the external ear canal using an otoscope to identify abnormalities as compared with the known norm. Although many SLPs shy away from otoscopy, it within the scope of practice; with a small amount of training it can be completed easily and yield important results regarding your patient.

**What You Need to Know**

Performing otoscopy on a patient is an important procedure in the audiological evaluation. Results of otoscopy will allow the examiner to identify several common problems that preclude sound from entering the ear. Two quite common abnormal findings are ear canal occlusion, by either cerumen (ear wax) or foreign object, and the manifestation of middle ear pathology (otitis media or ear infection). It is important to point out that although abnormal findings on otoscopy can be identified and a patient
can be referred to a physician for follow-up, it is outside the scope of practice for either an audiologist or SLP to diagnose a medical condition based on his or her findings.

**How It Works**

With the use of an otoscope, the examiner inspects the external ear canal to identify abnormalities as compared to the known norm. The figures that follow will assist you in identifying some of the most common findings when performing otoscopy. Remember, visualization of the external auditory canal and the landmarks of the tympanic membrane should not be considered a comprehensive evaluation of the ear and hearing status. Otoscopic findings do, however, allow for the identification of significant pathologies that can impede sound from entering the ear. The SLP should always consult with, or refer to, an audiologist or an otolaryngologist if an abnormality is observed or suspected.

**Technically Speaking**

The normal pathway of sound gathered from our environment is via air conduction. In order for this sound to be gathered and channeled into the ear for the processing of what has been heard, the physical structures of the ear must be in working order. The identification of abnormalities in the external auditory canal (external ear canal) should be the precursor to any other testing completed by the examiner. Common abnormal findings are excessive cerumen (or ear wax), foreign objects, drainage from otitis media, infection of the ear canal wall, and abnormal appearance of tympanic membrane (eardrum) landmarks. The identification of such physical problems can result in the identification of a hearing loss as well. When a hearing loss is caused by a problem in the external ear canal, it is known as a hearing loss involving the conduction of sound into the ear, or a **conductive hearing loss**. Again, it should be stressed that while the audiologist or SLP is within his or her scope of practice to identify the presence of an abnormality upon otoscopic inspection of the external ear canal, a diagnosis of physical abnormality must be made by a physician.

**Methodology**

As with visual inspection of the pinna, the examiner should exercise the principles of universal precautions while performing this procedure, because it involves direct physical contact with the patient. Otoscopic inspection of the external ear canal involves using an otoscope with a speculum (see **Figure 6.7A**) chosen based on its aperture (or size of opening) as it compares to the relative size of the ear canal.
size of the patient’s ear canal on visual inspection by the examiner. (Figure 6.7B) A video otoscope (Figure 6.7C) may also be used for this procedure.

The external ear canal is normally a curvy S shape; therefore, in order to obtain a clear view of the entire canal straight down to the tympanic membrane (eardrum), the examiner must straighten the canal. This is accomplished by gently pulling up and back on the pinna (the specific direction may vary from person to person) and then inserting the otoscope speculum into the ear. The examiner looks for the normal landmarks of the tympanic membrane (see Figure 6.8) as well as physical abnormalities (see Figure 6.9 through Figure 6.12), such as perforations of the eardrum, drainage, redness, excessive wax, or the presence of pressure equalization tubes for the remediation of otitis media. Any observed abnormality should be formally documented and the patient should be referred to a physician for follow-up. It should be noted that the patient’s form of medical insurance will determine whether this referral will be to the patient’s primary care physician

Figure 6.7C Video Otoscope. Courtesy of Welch Allyn, Inc.

Figure 6.8 Normal tympanic membrane.

Figure 6.9A Cotton swab perforating the tympanic membrane (ear drum).
Figure 6.9B  Bug in the ear.

Figure 6.10  Perforated eardrum.

Figure 6.11A  Excessive wax in the external ear canal.

Figure 6.11B  Drainage from the external ear canal.
Middle Ear Test Battery

Tests of **middle ear** function play another important role in the audiological evaluation. In addition to being objective measures of the auditory system,

under a managed healthcare plan or directly to an otolaryngologist (ENT specialist). Regardless of specialty or qualifications, the need for medical follow-up should most definitely be stressed.
these tests yield important results regarding the health of the patient’s ear and also can serve to support and/or further qualify the audiometric results. Many pathologies of the ear occur in the middle ear system. Information obtained during tests of middle ear function can assist in the medical diagnosis of these pathologies by a physician. The accurate evaluation of the middle ear plays an important role in the diagnosis of conductive hearing loss as well.

**Equipment**

**Tympanometer**

A tympanometer is used to test middle ear function through a process known as tympanometry. Unlike audiometry, which allows the practitioner to make a statement regarding hearing sensitivity, tympanometry assesses the physical condition of the conductive system and helps to determine if a medical referral is necessary. Tympanometers are available as diagnostic units (see Figure 6.13A) as well as screening units (see Figure 6.13B).

**Tympanometry**

Visual inspection of both the external anatomy of the ear and structures of the external ear canal, including the tympanic membrane, are a vital part of the audiological evaluation as a whole. However, just as pure tone audiometry without speech audiometry provides us with only part of a picture, otoscopy and visual inspection of the ear provide us with only part of our assessment of a physical ear structure. In order to examine what we cannot see, tympanometry provides us with information regarding the health and functioning of the middle ear system.

**What You Need to Know**

Tympanometry is a procedure that allows us to examine the functioning of the middle ear system indirectly, by using measures of pressure and movement of the outer and middle ears as they work together as complementary systems. The results can provide an indication of any type of pathology that may prevent the efficient movement of sound from the outer ear (external ear canal) to the inner ear (cochlea). Tympanometry is also a useful procedure because it does not require a person to actively participate, thus making it one of the nonbehavioral assessments of the auditory system. Pure tone audiometry and speech audiometry procedures...
are considered behavioral audiological measures, whereas tympanometry is an objective measure and can be performed even if a patient cannot or refuses to participate in the process. It should be noted, however, that tympanometry does not tell us about hearing sensitivity per se, but only about potential physical abnormalities of the outer and/or middle ear that may be contributory in the diagnosis of a hearing loss. As with outer ear pathologies, when a hearing loss is caused by an abnormal condition in the middle ear, it is referred to as a conductive hearing loss.

How It Works

Tympanometry is based on three physical principles: pressure, compliance, and volume. Using a tympanometer, a probe tip is inserted into the external ear canal and data are collected from each ear individually. The actual readings obtained (corresponding pressure and compliance values as well as ear canal volume) are plotted on a graph known as the tympanogram, and are then classified based on established normative data. The resulting tympanogram(s), generated by the equipment based on the mathematical data, are printed out and are then interpreted by the examiner.

Tympanometry does not give us a measure of hearing; rather, it measures the mobility (compliance) of the eardrum as pressure is systematically varied in the external ear canal. Specifically, the measurements obtained indicate how the eardrum moves back and forth as pressure is first pushed in, and then pulled out of, the ear.

Technically Speaking

Tympanometry works on the principles of pressure, compliance and volume. Mathematical data points are then collected and analyzed for their content. The SLP does not need to master these mathematical principles as they relate to taking tympanometric readings; however, a brief description of each is important as background information of how these three principles articulate to generate tympanograms.

Pressure

Tympanometric pressure values are indicative of the amount of pressure in the middle ear cavity. These values are plotted on the horizontal (x) axis of the tympanogram. Pressure measurements are made in either decapascals (daPa) or millimeters of water (mmH₂O) (these units are essentially equivalent), with 0 daPa representing normal atmospheric pressure.

The normal middle ear cavity maintains a pressure that approximates normal atmospheric pressure; this is accomplished through the opening and closing of the Eustachian tube. Abnormal pressure readings on the tympanogram may be suggestive of Eustachian tube dysfunction.

Compliance

Tympanometric compliance values are indicative of the amount of mobility (movement or compliance) of the tympanic membrane; these values are plotted on the vertical (y) axis of the tympanogram. Compliance can be measured in cubic centimeters (cc or cm³) or milliliters (mL) (these units are identical).

Tympanometric compliance that is significantly lower than normal may be suggestive of tympanosclerosis (scarring of the tympanic membrane) or otosclerosis (fixation of the stapes bone in the oval window). It may also be indicative of either the early stages of or a resolving middle ear pathology. Compliance that is much higher than normal may suggest a disarticulation of the bones of the ossicular chain or a hypermobile tympanic membrane. Zero compliance (a flat line) equates to no movement of the tympanic membrane or the absence of a compliance reading. These findings can be indicative of middle ear pathology, a blockage in the external ear canal, or a puncture in the tympanic membrane itself. Abnormal compliance findings require a medical referral.

Ear Canal Volume (ECV)

The ear canal volume (ECV), also known as equivalent ear canal volume (EECV) or physical volume
test (PVT), is a middle ear test battery measure that represents the estimated volume of the external ear canal from the probe tip at the opening of the ear canal to the tympanic membrane. The range of normal values varies depending on client age and gender. Excessively large ear canal volumes may be indicative of either a perforation of the tympanic membrane or an improperly functioning pressure equalization (PE) tube, thus representing a measure of the entire outer and middle ear volumes through an opening (either pathological or surgical) of the tympanic membrane, instead of just the canal. Alternately, an abnormally small volume measure may be indicative of excessive wax buildup or a mass in the ear canal.

**Figure 6.14** shows a standard tympanogram form. The middle ear pressure is plotted on the x-axis and the compliance (eardrum mobility) is plotted along the y-axis. Along with the tympanometric finding, note that the ECV value is provided as relevant data on the tympanogram form. In every case, all three measures—compliance, pressure, and ear canal volume—are clearly represented on the print out of tympanometric finding.

**Methodology**

To prepare the patient for tympanometry as well as the other subtests in the middle ear test battery, the examiner must ensure that the patient is not talking, chewing, moving excessively, or doing anything else that will negatively impact the results. Again, as with visual inspection and otoscopy, the examiner should exercise the principles of universal precautions prior to making physical contact with the patient.

Based on a visual approximation of ear canal size and shape, a soft probe tip is selected from an assortment of sizes of tips and placed on the test probe of the tympanometer. Similarly to otoscopy, the pinna is pulled up and back, and the test probe, which is covered with the soft tip selected, is carefully positioned at the outside opening of the

**Figure 6.14** Standard tympanogram form used for the recording of results.
Figure 6.15  Side view of the placement of a probe tip into the ear.

external ear canal (see Figure 6.15). Air pressure is then systematically varied in the ear canal while the pressure response of the tympanic membrane is monitored. The patient needs only to sit still—that is, no subjective behavioral response is required of the person. The process of obtaining the tympanogram readings of pressure, compliance, and ear canal volume takes a mere 3–5 seconds to complete, but the reliability of these results is dependent on the motionlessness of the patient while the procedure is being performed. It may therefore become necessary, especially when testing young children or patients who are tactiley sensitive to objects or people in or about their ear, to otherwise distract the patient during testing.

Most tympanometers have a digital readout for the examiner to review the results and make a determination of their reliability (readability). The actual readings obtained (corresponding pressure and compliance values as well as ear canal volume) are plotted on the tympanogram, and are then classified based on established normative data. The resulting tympanogram(s) are printed out and interpreted by the examiner.

Acoustic Reflexes

Acoustic (stapedial) reflexes are involuntary contractions of the middle ear muscles—specifically, the stapedius and the tensor tympani muscles—that occur in response to high intensity sound. Testing
for the presence of acoustic reflexes is another part of the middle ear test battery. The normally functioning auditory system is expected to have reflexes present at specified levels. Similarly, there are normative acoustic reflex data for the variety of different types of hearing loss and conditions as well. As is the case with other components of the middle ear test battery, acoustic reflex testing should be viewed only in the context of the results of the complete evaluation. The results of acoustic reflex testing can potentially provide information to support, confirm, or rule out the hearing loss demonstrated by pure tones (Emanuel, Henson, & Knapp, 2012).

**What You Need to Know**

**Acoustic reflex threshold (ART)** testing would not be performed by an SLP because it is outside of his or her scope of practice. However, it is important for the SLP to understand what it is and what it represents in order to better understand and interpret the results they will find in a report from an audiologist.

**How It Works**

In a normally functioning auditory system, the muscles of the middle ear will contract in response to high-intensity sound. This involuntary contraction occurs when “too much sound” is presented to the ear (when sound becomes too intense). However, **how much sound** is too much sound depends on the patient’s hearing acuity. A normal hearing ear will react to a loud sound long before an impaired ear perceives the sound as being loud. Regardless, this muscle contraction can be measured and recorded.

The results of acoustic reflex testing have a number of potential uses. For example, if a patient is trying to fake a hearing loss, acoustic reflex testing may provide the objective data necessary to disprove such a claim. If a patient cannot or refuses to participate in behavioral testing, the presence or absence of a hearing loss might be gleaned, at least in part, from the results of acoustic reflex testing. To reiterate, tests of middle ear function are part of the nonbehavioral test procedures in the audiological test battery.

**Technically Speaking**

Acoustic reflex testing involves measuring the threshold at which the muscles of the middle ear contract. This is not a threshold of hearing sensitivity as is the case when we test pure tone air conduction thresholds. Rather, acoustic reflex threshold testing provides the threshold of when a sound becomes too intense for the person; as a result, it may serve as an indirect measure of hearing. That is to say, measurement of an acoustic reflex threshold can be a predictor of the presence or absence of a hearing loss, but the examiner should not base a diagnosis of normal hearing or hearing loss on the results of acoustic reflex thresholds alone, but on the cumulative results of the entire evaluation.

For the normal auditory system, an acoustic reflex threshold typically occurs at a level that is much louder than the level at which the person just starts to hear, or their threshold of hearing. Anticipated results vary, depending on the nature and severity of hearing loss, as well as the presence of recruitment. **ART responses characteristic of recruitment** would be generated at a lower-than-expected intensity level based on the individual’s hearing thresholds. Another finding may be the presence of decruitment. **Decruitment** is the opposite of recruitment, where the individual response is generated at a higher intensity than expected based on the peripheral hearing sensitivity. The results of acoustic reflex testing can (potentially) provide information to support, confirm, or rule out the hearing loss demonstrated by pure tones (Emanuel, Henson, & Knapp, 2012).

**Methodology**

The measurement of acoustic reflexes can be done while the probe tip is still in the person’s ear canal from performing tympanometry. Either by manual manipulation or using an automatic sequence that most tympanometers are capable of performing,
sound is presented to the ear while the examiner looks for a contraction response. Again, as with tympanometry, the contraction response required is automatic and does not require the active participation of the patient to respond in any way. The tester then searches for the acoustic reflex threshold, which represents the decibel level that is too intense (loud) for the listener; it is typically performed at 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz.

**Acoustic Reflex Decay Testing**

Acoustic reflexes have a second property that can be evaluated and clinically useful. As we have just discussed, the ear produces contractions of the middle ear muscles in response to loud sounds at predictable intensity levels. This contraction should be maintained as the loud sound is continuously presented. When the acoustic reflex is unable to appropriately sustain itself, acoustic reflex decay (ARD) has occurred. The identification of a decaying acoustic reflex is suggestive of an abnormality of the auditory system and should be followed up with further diagnostic testing.

**What You Need to Know**

Acoustic reflex decay testing would not be performed by an SLP because it is outside of his or her scope of practice; however, as with acoustic reflex threshold testing, it is important for the SLP to understand what it is and what it represents in order to better understand and interpret the results they will find in a report from an audiologist.

**How It Works**

Acoustic reflex decay testing measures how long and how well the acoustic reflex is capable of sustaining itself. In the normal auditory system, the acoustic reflex should be able to maintain its contraction for a period of time before it drops off. Alternately, the auditory system whose reflex falls off too quickly is thought to be abnormal, and is in need of additional diagnostic testing.

**Technically Speaking**

Acoustic reflex decay is a test that measures the decrease in magnitude over time of the contraction of the acoustic reflex when the patient is subjected to continuous high-intensity sound stimulation. Specifically, the reflex amplitude is expected to maintain half of the original measurement for a minimum of 10 seconds of continuous tone presentation. An auditory system in which the acoustic reflex decays to half or less of the original amplitude is demonstrating ARD, and is typically deemed in need of further diagnostic testing.

Historically, the presence of acoustic reflex decay has been associated with retrocochlear pathology, a pathological condition that occurs beyond (retro) the level of the cochlea. An example of a retrocochlear abnormality is an acoustic neuroma (tumor on the eighth cranial nerve) or a vestibular schwannoma (vestibular tumor). It should be noted, however, that in a recent study that surveyed middle ear practices for the diagnosis of retrocochlear pathology, Emanuel and her colleagues (2012) found that acoustic reflex decay testing has been on a downward trend over the past 25 years, presumably related to the availability of more sensitive measures such as magnetic resonance imaging (MRI).

**Methodology**

Once acoustic reflex thresholds have been established, the examiner can check for acoustic reflex decay, if desired. With the probe tip still in the patient’s ear from tympanometry, the examiner now measures reflex decay by raising the intensity of sound by 10 dB above the level of the acoustic reflex threshold and leaving the sound on continuously for 10 seconds. If the reflex is functioning normally it will sustain itself (within certain limits) for the 10-second period of time; if not, it will decay or decrease over time. This test can be performed either manually or as part of an automatic test sequence, and is typically performed at 500 Hz and 1000 Hz, assuming, of course, that an acoustic reflex threshold has been obtained at those frequencies in the first place.
Eustachian Tube Function

Eustachian tube function testing is another subtest of the middle ear test battery. The Eustachian tube (ET) is part of the middle ear anatomy that connects the middle ear space and the back of the throat. Normal opening and closing of the Eustachian tube equalizes the pressure of the middle ear space with the environment (normal atmospheric pressure). The persistence of otitis media is primarily due to a dysfunctional Eustachian tube (Sheer, Swarts, & Ghadiali, 2012); thus, the ET function assessment is a useful component of the middle ear test battery. A common example of Eustachian tube dysfunction is that plugged feeling one experiences when ascending or descending in an airplane.

What You Need to Know

Like the acoustic reflex threshold testing and acoustic reflex decay testing, the Eustachian tube function test is not a procedure that an SLP would be expected to perform, because it is outside of his or her scope of practice. However, as with the other tests within the middle ear test battery, it is important for the SLP to understand what it is and what it represents in order to better understand and interpret the results from an audiological evaluation.

How It Works

A properly functioning Eustachian tube serves to equalize pressure between the middle ear space and normal atmospheric pressure. As previously discussed, tympanometry is based on three principles: pressure, compliance, and volume. By using a diagnostic tympanometer, pressure (in daPa) can be manually manipulated by the examiner. During this manipulation, if the middle ear system is able to equalize the pressure manually imposed in the external ear canal, the Eustachian tube is found to be functioning appropriately. If the pressure cannot be equalized, the Eustachian tube is not functioning as it should be.

Technically Speaking

The secondary function of the Eustachian tube is to clear away and protect the middle ear space from harmful secretions from the nasopharynx. Otitis media is one of the most common infectious diseases of childhood, and the most significant causative factor is dysfunction of the Eustachian tube (Elmorsy et al., 2010), so the Eustachian tube function test provides useful information, particularly when assessing the pediatric population.

Methodology

If the results of tympanometry are abnormal, and there is a suspicion of Eustachian tube dysfunction, Eustachian tube function testing can be accomplished while the probe used for tympanometry is still in the ear canal. The examiner manually introduces pressure into the patient’s ear. During this manual manipulation of pressure, the patient is asked to swallow and yawn. If the pressure is equalized in the middle ear during this process, the Eustachian tube is functioning appropriately. In contrast, if pressure cannot be equalized, the Eustachian tube is determined to be functioning abnormally. Results are recorded accordingly.

Summary

The conductive hearing mechanism, which anatomically consists of the outer and middle ears, begins with the pinna, which collects auditory information from an individual’s environment, and connects to the external auditory canal, which in turn connects to the tympanic membrane and then the middle ear cavity. Visual inspection of the outer ear, otoscopic inspection of the external
auditory canal, and the middle ear test battery all
play a vital role in determining the overall health
of a patient’s ear. Throughout these portions of
the ear, any pathology that results in hearing loss
is considered conductive. Middle ear anomalies
(such as the common ear infection with fluid, rup-
tured eardrum, and the like) are of common and
significant concern, particularly in the pediatric
population. These conditions not only negatively
affect health, but also can have an adverse impact
on hearing ability.

Irregular findings can be determined by
completing a battery of tests of middle ear func-
tion, which may include tympanometry, acoustic
reflex thresholds, acoustic reflex decay testing,
and Eustachian tube function. Tests of middle ear
function are considered nonbehavioral or objec-
tive measures of the audiological evaluation. As
with visual inspection and otoscopy, the middle
ear test battery yields important results pertain-
ing to the health of the ear itself. The middle ear
test battery, when used in conjunction with pure
tone results, can support and/or further qualify the
audiometric findings.

Clinically, the speech-language pathologist may
be called upon to complete portions of the middle
ear test battery as part of his or her hearing screen-
ing procedures. However, a comprehensive under-
standing of all test procedures within the battery
will aid the professional in wholly understanding
the pathologies that can affect auditory sensitivity
and result in hearing loss.

**DISCUSSION QUESTIONS**

1. Pure tone audiometry and speech audiome-
try are direct measures of hearing sensitivity.
Why would we also need information regard-
ing the outer and middle ear systems?

2. What three physical principles make up
tympanometry?

3. A pediatric patient comes in for his weekly
speech and language therapy session. He is
complaining that he has not been able to hear
out of his left ear since he was playing with
beads with his younger brother on Saturday.
What problem might you suspect? How can
you evaluate your suspicion?

4. The Eustachian tube is part of which system
of the ear? What function does it perform?
Why is this important?

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Objectives

- Compare and contrast the differences between behavioral and nonbehavioral testing techniques.
- Identify the equipment necessary for performing screening and diagnostic measures.
- Understand which portion of the auditory system the otoacoustic emissions, auditory brainstem response, auditory steady-state response, and electronystagmography/videonystagmography are assessing.
- Interpret the different types of higher order responses that can be derived from neurologic testing of the auditory brainstem.
- Discuss the type and significance of information that can be obtained from these measures.
- Explain how the information from nonbehavioral tests can augment the results of behavioral audiometric tests results.
Introduction

Behavioral hearing test procedures provide information regarding the individual’s actual functional auditory abilities; clearly these procedures are necessary in the battery of tests used to diagnose hearing loss. Unfortunately, there are individuals who, for any of a number of reasons, are incapable of complying with the demands of this type of testing. What’s more, these procedures, meant to evaluate the peripheral auditory system, are simply not designed to provide us with additional data regarding the integrity of higher order functioning of the auditory system.

The development of the physiologic procedures (electroacoustic and electrophysiologic) that will be discussed in this chapter has allowed for objective assessment of the auditory system. These procedures aid in the diagnoses, treatments, and outcomes of a variety of auditory-related conditions. Some examples of the utility of these procedures include universal newborn hearing screening (UNHS) programs, diagnosis of peripheral hearing loss versus an auditory neuropathy syndrome disorder (ANSD), auditory processing disorders, balance disorders, and many others. Although these “beyond the basics” procedures are diagnostically outside of the speech-language pathologist’s (SLP’s) scope of practice, the SLP needs to have a solid understanding of the basic underlying concepts and significance that the results of these tests add to the overall diagnostic picture and the therapeutic interventions planning process. However, before you breathe a sigh of relief, tests of otoacoustic emissions are becoming increasingly popular as a screening method of choice with the young and/or difficult to test populations, and this is within the scope of practice for the speech-language pathologist.

Electroacoustic Measures

The term electroacoustic refers to the interaction or conversion of electric and acoustic energy. As it applies to the field of audiology, electroacoustic measures are, quite plainly, acoustic measurements that provide us objective information about how portions of the peripheral auditory system function. This information, in turn, helps us in establishing and/or confirming the characteristics of some forms of auditory dysfunction. The very earliest electroacoustic measurements to be used diagnostically in the field of audiology are tympanometry and acoustic reflexes (Hall & Swanepoel, 2010). Otoacoustic emission testing is not, directly, a measure of hearing sensitivity, but an indirect measure. A normal, healthy cochlea is capable of producing as well as receiving sound. The sound produced is known as otoacoustic emissions (OAEs), and their existence in a normal, healthy cochlea provides the foundation for the audiometric procedure known by the same term. Conversely, an ear which is not intact, will not generate an otoacoustic emission, hence this testing is an indirect measure of hearing. The sound that is emitted can be measured and recorded using equipment specifically designed for this purpose.

Equipment

Figure 7.1 shows a picture of the interacoustics otoacoustic emissions testing equipment, which can be used as a screening, diagnostic, or combination device.

![Figure 7.1](image_url) Interacoustics otoacoustic emissions testing equipment. 
(Courtesy of Interacoustics A/S.)
Tympanometer/Otoacoustic Emissions Hybrid

A hybrid that combines tympanometry with otoacoustic emissions is shown in Figure 7.2. Such devices are very convenient because they can facilitate a quick and reliable screening by combining the two procedures into one automatic sequence. This may be of particular interest to the speech-language pathologist or audiologist who needs to screen for hearing loss in the very young child or special needs population.

Otoacoustic Emissions

What You Need To Know

As stated previously, the normal healthy cochlea is not only able to hear sound, but also can produce sound. The sounds that the cochlea produces are known as otoacoustic emissions (OAEs). There are two types of OAEs—spontaneous and evoked.

With evoked otoacoustic emissions, a sound is sent into the ear, and in response the ear produces a sound and sends it back. By contrast, spontaneous otoacoustic emissions, as the name suggests, are spontaneously present without any sound stimulation. However, because spontaneous emissions are present in only approximately 70% of the normal hearing population (Hall, 2000), no clinical significance can be attached to them. The evoked types of emissions, on the other hand, can be recorded in nearly 100% of normal hearing ears (Chan, 2001; Kemp, 1978; Probst, 1990), and therefore have immense clinical significance and utility.

As with a tympanometry and acoustic reflexes and the role they play in the basic audiological evaluation, tests of evoked otoacoustic emissions are objectively measured, requiring no active participation on the part of the patient. Normal evoked otoacoustic emissions are typically present in only the healthy cochlea with essentially normal to near normal hearing. There are other forms of otoacoustic emissions in addition to what will be presented here for discussion. However, given the focus of this textbook, we will limit the following discussion to two types of evoked otoacoustic emissions (OAEs), i.e., transient-evoked otoacoustic emissions (TEOAEs) and distortion product otoacoustic emissions (DPOAEs).

Otoacoustic emission screenings are used as a nonbehavioral method of screening hearing in populations when a traditional pure tone screening (the kind using response patterns such as hand raising or play audiometry technique) would not yield reliable results. Another advantage to using otoacoustic emissions as a screening procedure is the time effectiveness of the measure. In the time it may take to merely condition an individual to respond to a pure tone screening, screening can be wholly completed using an OAE screening tool. As such, the speech-language pathologist must know the principles of otoacoustic emission screening, as it falls within scope of practice.
How It Works

The cochlea is a complex organ of hearing that houses both outer hair cells and inner hair cells. There have been many theories over the past century and a half to explain the workings of the cochlea and how we hear (Babbs, 2011). Although the controversy and research continue, it was documented as early as the 1940s that the ear can be more than a passive listener (Gold & Pumphrey, 1948). In fact, as later researchers discovered (Davis, 1983; Kemp, 1978), the ear is capable of producing low intensity sound called otoacoustic emissions. Current research supports the theory that these emissions are produced, most likely, by the cochlear outer hair cells as they expand and contract (see Hall, 2000). Advances in technology during the 1970s saw the creation of microphone equipment capable of measuring these responses. Thus the clinical application of measuring otoacoustic emissions as an indirect assessment of hearing ability began.

Technically Speaking

To evoke an otoacoustic emission, a sound is sent into the ear, and in response the ear produces a sound and sends it back; this response can be recorded. By contrast, the spontaneous OAEs, as the name suggests, are spontaneously present without external stimulation. However, an important caveat must be noted at this juncture. Technically speaking, otoacoustic emissions are a physical sign that the auditory system is functioning normally or near normal, up through the level of the cochlea. Because we are measuring a physical property of the ear, otoacoustic emissions are not a direct measure of hearing sensitivity, and thus do not replace behavioral hearing testing methods. The literature provides abundant data demonstrating that evoked OAEs are not present in the damaged cochlea; therefore, the presence of an evoked OAE speaks to the health of the cochlea and auditory system up to this point. However, although perhaps occurring infrequently, damage may occur to the auditory system at points beyond the level of the cochlea and still cause hearing loss. It is possible, therefore, for a patient with retrocochlear pathology to produce evoked otoacoustic emissions and still have a hearing problem.

There are two different ways to elicit an otoacoustic emissions—transient-evoked otoacoustic emissions (TEOAEs) and distortion product otoacoustic emissions (DPOAEs).

**Transient-Evoked Otoacoustic Emissions (TEOAEs)**

Clinically, a transient-evoked otoacoustic emissions (TEOAE) is an elicited or evoked a response to a transient stimulus of brief duration, such as a click or a tone burst. Generally speaking, normal TEOAE responses are associated with hearing threshold levels better than or equal to the level of a mild hearing loss of approximately 30 dB HL (Beringer & Westling, 2011).

**Distortion Product Otoacoustic Emissions (DPOAEs)**

The second type of otoacoustic emission that has clinical utility is distortion product otoacoustic emissions (DPOAE) which are obtained when the ear is simultaneously presented with two separate pure tone frequencies. A DPOAE response may be obtained with slightly more hearing loss (e.g., research suggests that DPOAEs are not diminished in ears with a mild to moderate hearing loss of up to approximately 50 to 60 dB HL [Dille et al., 2010]).

Methodology

Preparation for the otoacoustic emissions test is similar to the preparation for tympanometry; however, in addition to making sure that the patient is still, the tester must be sure to limit other sounds in the room, due to the potential negative impact ambient noise will have on obtaining reliable results. First, the clinician inspects the pinna and external ear canal to ensure that the canal is patent and unobstructed; any blockage such as wax, foreign body, etc. will interfere with the recording of OAEs. Then, the examiner pulls up and back on the patient’s pinna while
gently placing the probe tip into the outer opening to the external auditory ear canal. The probe tip in reference is the same type of soft tip that is used for tympanometry, acoustic reflex testing, and the like (refer to Figure 7.3 and Figure 7.4). Ideally, tympanometry will be performed either before or after the OAE procedure. The reason for this is because the presence of middle ear pathology will have a negative impact on OAE elicitation.

Regardless of which type of otoacoustic emission testing is being used, the probe introduces a sound stimulus into the ear canal, and the resulting cochlear emissions, if present, are picked up and recorded automatically by the equipment. No behavioral response of any type is required of the patient.

Test time for performing an OAE is very short—approximately 10 seconds for each ear for the screening procedure, and perhaps up to 1 minute for each ear for the diagnostic test. For this reason, performing hearing screenings using otoacoustic emissions—particularly when using the transient stimulus—is a quick and effective way of ruling out significantly handicapping hearing loss, especially in the very young and special needs populations. Otoacoustic emission testing is also commonly used for newborn hearing screenings in many hospitals.

Again, it must be stressed that otoacoustic emission testing is not a direct measure of hearing sensitivity, and thus does not replace behavioral hearing testing methods. Upon completion of otoacoustic emission testing, follow-up behavioral hearing evaluation should always be recommended.

Electrophysiologic Measures

The previous procedures have been measures of the auditory system up through and including the cochlea. **Electrophysiologic measures** evaluate the functional integrity of various structures along the auditory pathways beyond the cochlea, at the level of the eighth cranial nerve and brain stem. These test procedures are outside of the speech-language pathologist's scope of practice. This section should be appropriately categorized as informational, but should not be disregarded, because the interpretation of electrophysiological measures will be necessary for a comprehensive understanding of audiometric test results by the speech-language pathologist.
In this section we will limit our discussion to auditory brainstem response audiometry (ABR), auditory steady-state response (ASSR), and electronystagmography/videonystagmography (ENG/VNG). All three procedures are objective assessments of various parts of the auditory and/or vestibular (balance) system.

**Auditory Brainstem Response**

The auditory brainstem response (ABR) study is an indirect evaluation of hearing sensitivity that measures physiologic activity at the level of the eighth cranial nerve in response to an auditory stimulus. After sound travels beyond the outer, middle, and inner ear it reaches the level of the brainstem. The auditory brainstem response (ABR) refers to the physiologic activity that occurs at various structures of the auditory nervous system in response to a sound. This response can be objectively measured and recorded using a procedure known as ABR audiometry. The ABR can be completed regardless of age, cognitive level of function, or state of consciousness. In some cases, pharmacological sedation is used to make sure that myogenic activity or other behaviors (crying, fidgeting, etc.) do not contaminate the test results (Sauter, Beck, & Speidel, 2012).

**Auditory Brainstem Response (ABR) Study Equipment**

An example of the type of equipment used to record these tracings is shown in Figure 7.5. As with the OAE equipment, both screening and diagnostic systems are available.

**Auditory Brainstem/Otoacoustic Emission Hybrid**

The Early Hearing Detection and Intervention (EHDI) programs have spurred the development of hybrid devices used for newborn infant hearing screening in hospitals nationwide. Such devices combine auditory brainstem response (ABR) technology with otoacoustic emission capabilities. They allow for quick and effective objective hearing screenings. Their primary use is with infants in newborn nurseries and neonatal intensive care units (NICUs). An example is shown in Figure 7.6.

**What You Need to Know**

The ABR measures the neurological response to an auditory stimulus at the level of the brainstem. Auditory nerve fibers bundle at certain points along the eighth cranial nerve and the brainstem. Each time the nerve fibers bundle, increased neural activity is created. As a sound is introduced and travels along the eighth cranial nerve and brainstem, a waveform can be recorded as a response to the cumulative activity. This measured activity, known as the ABR response, is a useful addition to other testing methods and procedures. In a normally functioning ear, assuming no other neural complications exist, the softest intensity at which the auditory nerve responds roughly corresponds to the softest level at
which the person starts to hear. Hence, an estimation of hearing sensitivity can be made.

How It Works
As with any other test of neurological functioning, a neural response is elicited from stimulation specific to the anatomical function. As you may have experienced, physicians frequently use a reflex hammer, also called a percussion hammer, against an elbow or a knee to check deep tendon reflexes. We cannot stop our knees from flying into the air once hit. Similarly, we cannot stop our ears from responding neurologically once stimulated with sound. Although our ears do not fly up in the air as do our knees, we can measure their neural activity using electrodes placed at specific sites on the head. The waveforms or tracings elicited using a broadband click or tonal stimulus are then compared to the norm, and results are interpreted accordingly. See Figure 7.7 for an example of an ABR tracing.

Technically Speaking
The purposeful stimulation of the eighth cranial nerve and brainstem responsible for audition yields nonbehavioral (objective) results, which, although not a direct measure of hearing sensitivity, is a valuable clinical procedure. The auditory brainstem response study can also be a useful augmentation to behavioral hearing test results in the pursuit of etiological information. In terms of hearing loss, the ABR is most sensitive in distinguishing hearing levels in the normal through moderately or moderately severe range than in the profound range (Vander Werff, Brown, Gienapp, & Clay, 2002). As stated previously, it is outside of the scope of practice for the speech-language pathologist to perform ABR studies. Therefore, the technical basis behind such testing need not be extensive either.

Methodology
As discussed previously, it may be necessary to first consider the use of sedation in some patients prior to an auditory brainstem response study. The ABR test procedure then begins by having the patient sit or
lie down comfortably. After careful cleansing of the
skin, surface (noninvasive) electrodes are placed at
various locations around the ears and head for mon-
itoring and recording the neurological responses.

Testing is completed on each ear individually,
using either clicks or tonal stimuli. Sound is deliv-
ered to the test ear by either an insert earphone or
a standard earphone, and the electrodes monitor
and record the patient’s response. The ABR proce-
dure can be done as either a screening or a diag-
nostic assessment. A diagnostic ABR is typically a
more elaborate procedure than an ABR screening
and allows the audiologist to manipulate the variety
of different test parameters, such as stimulus used,
intensity presented, and so on. When performed as
a screening, an automated ABR is completed more
quickly and produces either a pass or fail/refer
response. If tones are specifically used to obtain
results, the resulting written report of findings will
typically specify “tone burst” ABR.

Auditory Steady-State
Response (ASSR)
The auditory steady-state response (ASSR) study
is very similar to the ABR just described. Like the
ABR, it is an indirect assessment of hearing sensitiv-
ity measuring the neurological response to an audi-
tory stimulus. ASSR differs from the ABR in that it
can provide frequency-specific information and can
help to differentiate between a severe and profound
hearing loss.

What You Need to Know
The populations that benefit most from ASSR stud-
ies include the young and/or difficult to test. As
such, sedation is again a consideration for those who
are unable to be calm, quiet, and still for a period of
time. Like the ABR, the ASSR is particularly use-
ful as a supplement to other behaviorally obtained
hearing test results in the pursuit of an accurate
diagnosis. Specifically, the ASSR is useful when a
severe or profound hearing loss is suspected—a dis-
tinction that is clearly meaningful and significant
with regard to aural (re)habilitation and the selec-
tion of hearing aids versus cochlear implants (Beck,
Speidel, & Gordon-Craig, 2009).

How It Works
As in the case of the ABR, the ASSR can measure the
neural activity of the eighth cranial nerve and brain-
stem using electrodes placed at specific sites on the
head. ASSR differs from the ABR, however, because
it uses a variety of stimuli that are more frequency
specific as opposed to the “click” stimulus utilized
by the ABR. The resulting waveforms or tracings are
then compared to the norm and results are inter-
preted accordingly.

Technically Speaking
The ASSR study is an objective measure that evalu-
ates the health of the structures along the auditory
nerve and the brainstem and demonstrates how the
brain “follows” certain characteristics of sound
(Hall & Swanepoel, 2010); although not being a
direct measure of hearing sensitivity, estimations
of hearing can be made based on the results. The
ASSR differs from the ABR in several ways; for
example, determining an ABR response becomes
increasingly difficult as the stimuli approach a
person’s threshold—which is when the decision
(response or no response) is most important. ASSR,
on the other hand, uses an objective, sophisticated,
statistics-based mathematical detection algorithm
to detect and define hearing thresholds (Beck,
Speidel, & Petrak, 2007). Additionally, the ASSR is
more sensitive in distinguishing hearing levels in
the profound range of hearing loss than in the nor-
mal through moderate or moderately severe range
(Vander Werff et al., 2002); thus it may be the more
appropriate choice when assessing an individual
suspected of having a significantly handicapping
hearing loss.

Methodology
Many children who fail the automated ABR screen-
ing are referred for an ASSR test. The procedures
involved in the measurement of the ASSR are very much the same as those described for the ABR procedure. Specific protocols vary; however, the general test setup again includes the placement of surface electrodes at various locations around the ears and head, following careful cleansing of the skin. Testing is accomplished one ear at a time. The earphones deliver the sound stimulus to the ear(s), and the electrodes objectively monitor and record the electrical activity. The actual test parameters may include various frequencies and intensities of tonal stimuli for the purposes of obtaining an accurate, frequency-specific estimate of hearing sensitivity. In comparison to a “tone burst” ABR, the ASSR is a more time efficient test measure.

Electronystagmography/Videonystagmography (ENG/VNG)

A symptom of an abnormal balance (vestibular) system is the presence of involuntary eye movement, which is known as nystagmus. The vestibular system which encompasses the semicircular canals is anatomically a portion of the inner ear. As such, the evaluation of the proper function of the inner ear balance system falls within the scope of practice for the clinical audiologist. Again, however, it is outside the scope of practice for the speech-language pathologist. Therefore, this section provides only a brief overview of electrophysiological evaluation of the vestibular system. The procedures of choice to establish the cause of balance disorders are electronystagmography (ENG) and videonystagmography (VNG). The difference between these two is that the ENG makes its recordings from surface electrodes placed around the eyes, whereas the VNG uses an infrared video system.

Equipment

Examples of ENG and VNG recording systems can be seen in Figure 7.8 and Figure 7.9. Notice that Figure 7.8 shows surface electrodes placed around the eyes, while Figure 7.9 instead makes use of video goggles.

The electrophysiological assessment of vestibular function (whether using ENG or VNG) records a symptom known as nystagmus, which is an involuntary rhythmic oscillating movement of the eyes, either horizontally, vertically, or torsional (rotary). The eyes work in connection with the organs of the vestibular system within the inner ear as part of proprioception to establish our sense of balance...
and position in space. The measurement of nystagmus is important because it can be a symptom of pathology of the peripheral and/or central auditory mechanism. Both ENG and VNG consist of a series of procedures that allow us to measure the nystagmus, which in turns gives an indication of the health of the vestibular system. To reiterate, the difference between the ENG and the VNG is, quite simply, the means by which the eye movements are recorded.

The ENG records the eye movements with the placement of surface (noninvasive) electrodes near and around the eyes, whereas the VNG uses video goggles that incorporate a camera to record and measure the person’s eye movements. Results are then compared to the norm and interpreted for significant abnormalities, which may result in higher order testing like magnetic resonance imaging (MRI).

**Summary**

Beyond the basic principles of behavioral audiometry and tympanometry are several tests based on the acoustic principals of the physical properties of the auditory system. Although not considered true tests of hearing, the conclusions that can be drawn from their accurate interpretation provide us insight into a patient’s auditory abilities that may not be readily obtainable by conventional behavioral measures.

Distortion product otoacoustic emissions (DPOAEs) and transient-evoked otoacoustic emissions (TEOAEs) provide information regarding the physical health of the ear that allows conclusions to be drawn about gross approximations of auditory sensitivity. Likewise, auditory brainstem response (ABR) studies and auditory steady-state response (ASSR) studies yield electrophysiologic results from the eighth cranial nerve and brainstem regarding the auditory pathways. Results of these tests also provide an indirect assessment of hearing, valuable for the course of (re)habilitation in those patients that would otherwise be unavailable via other behavioral measures of auditory sensitivity. However, with each of these tests, behavioral testing must be completed in order to substantiate the objective results.

Electronystagmography/videonystagmography (ENG/VNG) evaluate the balance system located within the semicircular canals of the inner ear. Measuring the eyes’ involuntary response to changes imposed on the semicircular canals can provide valuable information regarding the inner ear’s role in the balance system.

In practice, the speech-language pathologist will find that the screening measures of otoacoustic emissions will be useful under many circumstances. We hope to have made some sense of the alphabet soup of the other nonbehavioral tests performed clinically by audiologists. ENGs, VNGs, ABRs, ASSRs, DPOAEs, and TEOAEs performed as diagnostic measures are outside the scope of practice for the speech-language pathologist, but should now be familiar terms, allowing for a more thorough understanding of results provided to you by the clinical audiologist.
**Discussion Questions**

1. Why must we interpret otoacoustic emission testing with caution?
2. What pathologies may result in inaccurate or invalid results of otoacoustic emission testing?
3. What are the commonalities between tests of otoacoustic emissions and electrophysiological measures of hearing? How do they differ?
4. Which of the procedures discussed in this chapter are within the scope of practice for the speech-language pathologist? When should you defer to an audiologist to assist in interpreting test results?

**References**


CHAPTER 8

Navigating the Audiogram

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Key Terms

- Air–bone gap
- Audiogram
- Audiometric zero
- Asymmetrical hearing loss
- Conductive hearing loss
- Cookie bite
- Decibel (dB)
- Frequency
- Hertz (Hz)
- High-frequency sensorineural hearing loss (HF SNHL)
- Intensity
- Loudness
- Mixed hearing loss
- Noise notch
- Pitch
- Reverse curve
- Sensorineural hearing loss
- Ski slope
- Threshold
- Unilateral hearing loss
- Upwardly sloping

Objectives

- Describe the differences between frequency and intensity, pitch, and loudness.
- Explain the parts of an audiogram graph, notations, and symbols.
- Differentiate between masked and unmasked air conduction and bone conduction thresholds for right and left ears.
- Interpret audiometric data to determine a conductive, mixed, and sensorineural hearing loss.
- Identify the common configurations of air conduction results.
- Recognize the various components of the audiogram and determine what type of testing was completed at the time of evaluation.
Introduction

Interpreting the audiogram itself is a skill that every speech-language pathologist must develop in order to determine the type and degree of hearing loss and its impact on speech and language development. It is the most important aspect of developing appropriate accommodations and modification for an individual with hearing loss and will become the steering wheel for interventions and therapeutic goals.

The previous chapters introduced some of the basics of terminology, procedure definitions, and methodologies of the audiological evaluation. With this understanding, it will now be possible to look at the results that you will have in front of you, what they mean, and how to, in some cases critically, interpret the results. We emphasize that the reader use Chapters 3 through 9 together as a cohesive unit or receive other instruction regarding air and bone conduction testing, masking, speech audiometry, otoscopy and middle ear testing procedures. Our journey of interpretation will begin with how to read an audiogram.

Navigating the Audiogram

As we begin to interpret the information on the audiogram graph, we must first address the tone itself. To each tone generated, there are two critical components: frequency and intensity. Frequency is the number of cycles of vibration per one second unit of time and is measured in units of Hertz (Hz). The perception of frequency is pitch, and while many times we use the terms frequency and pitch interchangeably, in fact their definitions do reflect two different aspects of sound. The graph displayed in Figure 8.1 reflects the frequencies on a standard audiogram. Beginning on the left side of the graph along the horizontal axis with 125 Hertz, full octave frequencies (like musical octaves on a piano) are the solid lines from 125 Hz through 8000 Hz; the broken lines in between mark the interoctave frequencies (750 Hz, 1500 Hz, 3000 Hz, and 6000 Hz).

The second critical component is intensity. The intensity of a sound is a measure of its pressure per unit area, the unit for which is the decibel (dB). The perception of intensity is loudness. Similarly related as frequency is to pitch, loudness is the perception of intensity. We now look at the vertical axis of the audiogram graph displayed in Figure 8.2. Units of Intensity are broken down into 10-dB segments and span the range from –10 dB HL through 140 dB HL. The decibel scale can be further defined as decibels hearing level (dB HL) and decibel sound pressure level (dB SPL) and reflect two different measurements of sound intensity. The solid black line corresponding to 0 dB HL across the entire frequency range is also known as audiometric zero, which represents the lowest hearing level at which normal hearing people begin to detect sound. You may recall that 0 dB on the HL scale corresponds to a different amount of dB on the sound pressure level scale (dB SPL), and does not mean “no sound,” which explains why our graph reflects negative decibel levels as well. Negative dB on the HL scale simply means that the listener can hear sound at more sensitive levels than the average normal hearing person. Typically, the audiogram does not measure levels below –10 dB HL since levels beyond that exceed the limitation of sound generation by an audiometer.
It is important to note that because we are working on a scale of –10 to 140 dB to describe the hearing sensitivity of a person, hearing loss should never be described in percentages. That being said, frequently hearing losses are interpreted by an individual as a percentage. “Oh, I only have 50% hearing in my left ear,” you may be told by a patient. It is presumed that either the individual is mistakenly interpreting 50 dB HL as 50% hearing loss, or she or he may be attempting to use her or his word discrimination ability score as an overall interpretation of her or his hearing loss. Regardless, mathematically, this is typically an incorrect interpretation unless the person is basing the percentage on a 150% scale rather than a 100% scale. The prudent professional should discourage this type of interpretation or report of hearing loss by either related health professionals or by the patient, and encourage correct interpretation based on degree and configuration.

### Audiogram Symbols

The symbols used for recording the results are shown in Table 8.1. Although the exact symbols used might vary from clinic to clinic, the symbols

![Audiogram Symbols](image)

**Figure 8.2** Intensity displayed on a standard audiogram form.

**Table 8.1** Audiometric Response Symbols Key Recommended for Use by ASHA (1990 and 1999)

<table>
<thead>
<tr>
<th>Right Ear</th>
<th>Unspecified</th>
<th>Left Ear</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC unmasked</td>
<td>O</td>
<td>X</td>
</tr>
<tr>
<td>AC masked</td>
<td>Δ</td>
<td>□</td>
</tr>
<tr>
<td>BC unmasked (mastoid)</td>
<td>&lt;</td>
<td>&gt;</td>
</tr>
<tr>
<td>BC masked (masked)</td>
<td>[</td>
<td>]</td>
</tr>
<tr>
<td>BC unmasked (forehead)</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>BC masked (forehead)</td>
<td>Γ</td>
<td></td>
</tr>
<tr>
<td>Sound field</td>
<td>S</td>
<td></td>
</tr>
</tbody>
</table>

presented in Table 8.1 are the ones most commonly used and are those recommended by the American Speech-Language-Hearing Association (ASHA) in 1990 and 1999.

**Air Conduction Symbols**

When unmasked pure tone air conduction testing (using standard or insert earphones) is done, the results (thresholds) for the right ear are represented with an O and for the left ear with an X. **Threshold** is determined at each frequency (or perceived pitch) and represents the softest intensity (or perceived loudness) level that a patient’s response indicated. **Figure 8.3** illustrates the point of intersection for recording a threshold of 10 dB HL for the right ear at 1000 Hz. Once such a threshold is established, the “O” symbol is then drawn over the line of intersection. Moving to the left ear, **Figure 8.4** points out the intersection for a threshold of 40 dB HL at 4000 Hz. Once such a threshold is established, the “X” symbol is then drawn over the line of intersection. To complete air conduction testing we thusly move from frequency to frequency recording the thresholds across the audiogram for the right and left ears individually. As a note, on occasion, the “O” will be recorded in red pen and the “X” recorded in blue pen to match the coordinating color denotation on the earphone itself. However, this practice of using color coding to denote right and left is waning with the use of electronic transmission of test results.

When masking is applied, introduced into the non-test ear to determine the actual hearing threshold in the test ear (based on the guidelines previously discussed), the symbols used are ∆ for the right ear and □ for the left ear. **Figure 8.5** shows a right ear unmasked air conduction (AC) response at 25 dB HL and a masked air conduction response at 50 dB HL at 2000 Hz. Once such a threshold is established, the symbol is drawn over the line of intersection. Likewise, **Figure 8.6** reflects a left ear unmasked air conduction response at 60 dB HL and a masked air conduction response at 85 dB HL at

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**Figure 8.3** The point of intersection for recording a 10-dB HL threshold at 1000 Hz on a standard audiogram for the right ear.

**Figure 8.4** The point of intersection for recording a 40-dB HL threshold at 4000 Hz in the left ear.

**Figure 8.5** The point of intersection for recording a 25-dB HL threshold at 2000 Hz in the right ear and a 50-dB HL threshold at 2000 Hz in the left ear, with an unmasked air conduction response at 25 dB HL and a masked air conduction response at 50 dB HL.

**Figure 8.6** The point of intersection for recording a 60-dB HL threshold at 4000 Hz in the left ear and a 85-dB HL threshold at 2000 Hz in the right ear, with an unmasked air conduction response at 60 dB HL and a masked air conduction response at 85 dB HL.
**Figure 8.5** Audiogram illustrating a right ear unmasked air conduction response at 25 dB HL and a masked air conduction response at 50 dB HL at 2000 Hz.

**Figure 8.6** Audiogram illustrating a left ear unmasked air conduction response at 60 dB HL and a masked air conduction response at 85 dB HL at 500 Hz.
500 Hz. As with the right ear, once such a threshold is established, the symbol is drawn over the line of intersection. Some audiologists, as a standard of practice, but not all, will report both unmasked and masked thresholds on their audiograms.

**Air Conduction Symbols in the Sound Field**

When air conduction testing is done in the sound field through the speakers, the response is marked with an S on the audiogram. A further clarification may also be made to denote which type of tonal stimuli was used for testing in the sound field; either warbled tones (WT) or narrow bands of noise (NB/NBN). Either stimulus may be used at the discretion of the evaluator. Figure 8.7 reflects a warble tone response in the sound field at 20 dB for a 4000 Hz tone and a narrow band noise response at 35 dB at 500 Hz. Symbols are drawn over the line of intersection with the specific tonal stimuli used beneath the “S”.

**Bone Conduction Symbols**

The symbols used to record bone conduction (BC) vary depending on whether the bone conduction oscillator is placed on the forehead or the mastoid process behind the ear. When unmasked forehead placement is employed, the symbol used is a V. When unmasked bone conduction is conducted using mastoid placement, the < symbol is used on the left side of the line to represent the right ear, and the > symbol is used on the right side of the line to represent the left ear. (Refer back to Table 8.1.) When masking is applied for bone conduction testing, the [ symbol is used on the left side of the line to represent the right ear, and the ] symbol is used on the right side of the line to represent the left ear. (Refer again to Table 8.1). When masked bone conduction testing using forehead placement is performed, the γ symbol is used on the left side of the line for the right ear and δ is used on the right side of the line for the left ear.

This may seem a bit confusing, at least at first glance, but if you think of looking at someone face to face (see Figure 8.8A), that person's right ear is on your left and their left ear is on your right. If you look at the audiogram as though you are looking directly at the person's head, picture the symbols as the right and left ears, respectively; the symbols then make more representative sense.

Figure 8.8B reflects an unmasked right threshold at 15 dB at 1000 Hz as well as an unmasked left threshold at 15 dB for the same frequency. Symbols are drawn to the right and left of the line of intersection; again, left ear is drawn to the right and right ear to the left as the ears would correspond on the patient.

Figure 8.9 reflects a masked right threshold at 30 dB at 250 Hz as well as an unmasked right threshold at 15 dB for the same frequency. Symbols are drawn just to the left of the line of intersection. As with air conduction testing, some audiologists,
as a standard of practice, but not all, will report both unmasked and masked thresholds on their audiograms.

Figure 8.8A  An illustration of audiometric symbols with the corresponding location for testing on the head.

Figure 8.8B  Audiogram illustrating unmasked thresholds at 15 dB at 1000 Hz, for both left and right ears.

as a standard of practice, but not all, will report both unmasked and masked thresholds on their audiograms.

Figure 8.9  Audiogram illustrating a masked right threshold at 30 dB at 250 Hz and an unmasked right threshold at 15 dB for the same frequency.

Figure 8.10  Audiogram illustrating a masked left threshold at 70 dB at 2000 Hz as well as an unmasked left threshold at 25 dB for the same frequency. Symbols are drawn just to the right of the line of intersection. Again, some audiologists, as a standard of practice,
but not all, will report both unmasked and masked thresholds on their audiograms.

Other Related Symbols

Referring to Table 8.1, as well as to Table 8.2, you will notice that ASHA’s guidelines for audiometric symbols do not include any recommendations for recording the responses while a patient is wearing a hearing aid, cochlear implant, or other assistive device. Although each facility is free to use any symbol they choose, they should include a key to assist those who will be reading and interpreting their aided audiogram. The symbols used to denote such responses might include A to indicate the response with a hearing aid, AR for aided in the right ear, AL for aided in the left ear, and CI to indicate a response with a cochlear implant. Figure 8.11 shows examples of other symbols which may be used on the audiogram to denote responses obtained using hearing aid(s) (A for aided, AL for aided left ear, and AR for aided right ear), referred to as an aided response, and responses obtained by a cochlear implant (CI) recipient across a variety of frequencies and intensities.

The No Response Symbol

When there is no response to a particular sound stimulus in a particular condition, regardless of whether it is masked or unmasked air conduction, bone conduction, sound field, or aided conditions, the corresponding symbol is marked on the audiogram with a downward arrow attached to it, to indicate that the patient did not hear the sound at the maximum limit of the equipment. Figure 8.12 reflects no responses at the maximum instrument output level (the loudest intensity level of the

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**Table 8.2** Audiometric No Response Symbols Key Recommended for Use by ASHA (1990 and 1999)

<table>
<thead>
<tr>
<th>Right Ear</th>
<th>Unspecified</th>
<th>Left Ear</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC unmasked</td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>AC masked</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>BC unmasked (mastoid)</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>BC masked (masked)</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>BC unmasked (forehead)</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>BC masked (forehead)</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Sound field</td>
<td>S</td>
<td></td>
</tr>
</tbody>
</table>


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**Figure 8.11** Audiogram displaying examples of symbols for aided responses (A), aided in the right ear (AR), aided in the left ear (AL), and cochlear implant (CI).
in the direction of the patient’s test ear as facing the patient (right “no response” angles off to the left and left “no response” angles off to the right).

Another method of recording audiometric results is by using an audiometric “bar graph,” which records the actual numerical threshold. In contrast to the audiogram, which uses symbols to record results, numerical values are written into the box corresponding to the frequency tested. Figure 8.13 provides an example of this type of format. Although the use of a standard audiogram seems to be more popular, the method may vary from center to center and is a matter of preference.

Connecting the Responses

In order to better visualize the responses for the right and left ears, upon completion of the air conduction portion of the audiological evaluation, air conduction response symbols that denote threshold, either in their unmasked or masked forms, are connected by a line to distinguish right and left ear responses. This practice is done when responses are recorded manually to help better visualize the degree of hearing loss across frequencies for each ear. However, in the case of computer-generated audiograms, one may or may not see the responses connected. “No response” recordings are not connected to equipment being used) for the right and left ears denoting an absence of both air conduction and bone conduction responses. Similar to that of bone conduction symbols, the no response “arrow” points

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**Audiometric Results**

<table>
<thead>
<tr>
<th></th>
<th><strong>RIGHT EAR</strong></th>
<th><strong>LEFT EAR</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Unmasked</td>
<td>250 500 1000 1500 2000 3000 4000 6000 8000</td>
<td>250 500 1000 1500 2000 3000 4000 6000 8000</td>
</tr>
<tr>
<td>Masked</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Noise level</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th><strong>RIGHT EAR</strong></th>
<th><strong>FOREHEAD</strong></th>
<th><strong>LEFT EAR</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Unmasked</td>
<td>250 500 1000 2000 3000 4000 250 500 1000 2000 3000 4000</td>
<td>250 500 1000 2000 3000 4000</td>
<td>250 500 1000 2000 3000 4000</td>
</tr>
<tr>
<td>Masked</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Noise level</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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**Figure 8.12** Audiogram showing an example of how “no response” might be marked on an audiogram. See text for more detail.

**Figure 8.13** Audiometric results recorded numerically in bar graph format as opposed to being plotted on an audiogram (see Figure 8.1).
threshold responses, nor are bone conduction responses. Furthermore, the lines connecting the responses are drawn to, but not touching, each symbol. Figure 8.14 is an example of a completed air conduction audiogram for the right ear.

Sound field responses are also connected in the same manner. Figure 8.15 is an example of a completed sound field audiogram.

Figure 8.14 An example of a completed (response symbols connected) air conduction audiogram for the right ear.

Figure 8.15 An example of a completed (response symbols connected) sound field audiogram.

the three types of hearing loss that are revealed though obtaining bone conduction test results: conductive, sensorineural, and mixed.

Conductive Hearing Loss

You can determine what type of hearing loss a person has by looking at the relationship of the bone conduction thresholds with the air conduction thresholds. When the air conduction thresholds are outside of the normal range (exceeding 15 dB HL) but the bone conduction thresholds are completely within normal limits (less than 15 dB HL), a conductive hearing loss is present. Figure 8.16 shows an audiogram with a conductive hearing loss. Notice that the air conduction thresholds are at approximately 30 dB HL to 40 dB HL across all frequencies in both ears. The masked bone conduction thresholds, however, appear at 0 dB HL across all frequencies in both ears. This difference between the air conduction thresholds and the bone conduction thresholds is known as an air–bone gap.

Determining Type of Hearing Loss

Bone conduction test results have particular significance in navigating the audiogram. While pure tone test results (the unmasked “X” and “0” or the masked “Δ” and “□”) will indicate the degree or severity of the hearing loss itself, knowing the type of hearing loss is also an essential element. The type of hearing loss is based on the bone conduction thresholds (sometimes collectively referred to as the bone line). In the following sections we will review
Sensorineural Hearing Loss

Again, you can determine the type of hearing loss by looking at the bone conduction thresholds in relation to the air conduction thresholds. When air conduction thresholds are abnormal and bone conduction thresholds are equally abnormal, a sensorineural hearing loss is present. Figure 8.17 shows an audiogram with a sensorineural hearing loss. Notice that the air conduction thresholds are at approximately 30 dB HL to 40 dB HL across all frequencies in each ear, and the bone conduction...
thresholds appear at the same levels as the air conduction thresholds at each frequency. When air and bone conduction thresholds are at the same levels at each frequency, this is known as a sensorineural hearing loss.

**Mixed Hearing Loss**

A *mixed hearing loss* is merely a hearing loss that is a combination (or mix) of a conductive component plus a sensorineural component. The audiometric pattern in a mixed hearing loss is one in which bone conduction thresholds are outside of normal (indicating the sensorineural component) and the air conduction thresholds are even further impaired (indicating the addition of the conductive component). This difference between the air and the bone conduction thresholds is another example of an air–bone gap. However, in this case, the bone conduction test results fall outside of the range of normal hearing (greater than 15 dB HL for either one or both ears). Figure 8.18 depicts a mixed hearing loss. Note that the air and bone conduction thresholds are outside of the normal range. On further appraisal of the results air and bone conduction thresholds are also separated by an air–bone gap.

### Configuration of Hearing Loss

Now that the types of hearing loss have been established, we move on to the examination of the configuration, or shape, of the hearing loss as it appears on the audiogram once the air conduction testing is completed and the symbols are connected. Many times hearing thresholds will reveal a flat loss with very little intensity variability across frequencies (see Figure 8.19). However, there are also a number of other typical configurations of hearing loss that you may encounter. Each of these losses have distinct characteristics. It is only with an understanding of the implications of the individual hearing loss configuration can appropriate interventions be designed.

### Asymmetrical Hearing Loss

An *asymmetrical hearing loss* is, quite simply, when a person’s hearing sensitivity is significantly different in one ear versus the other. This might involve an audiogram in which one ear is completely within normal limits and the other ear has a sensorineural hearing loss (this would also be referred to as a unilateral hearing loss). Alternately, you might see

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**Figure 8.18** An audiogram illustrating a bilateral mixed hearing loss.
Figure 8.19  An audiogram illustrating a bilaterally symmetrical hearing loss.

Figure 8.20  An audiogram illustrating a bilateral asymmetrical hearing loss, with the left ear poorer than the right.

Figure 8.21  An audiogram illustrating a unilateral (asymmetrical) hearing loss. In this audiogram, the right ear is within normal limits and the left ear shows a conductive hearing loss.
High-Frequency Sensorineural Hearing Loss

The precise definition of a **high-frequency sensorineural hearing loss (HF SNHL)** seems to vary from source to source. Some researchers define HF SNHL as occurring above 2000 Hz (Roup & Noe, 2009), some define it as occurring above 3000 Hz (Hornsby & Ricketts, 2005), and still others use 4000 Hz through 8000 Hz (Robinson, Baer, & Moore, 2007). For our purposes, we will simply define it as a sensorineural hearing loss of greater severity in the higher frequencies than in the lower frequencies, where thresholds may be in the normal to near-normal range. What this means is that there may be normal or relatively normal hearing up to approximately 2000 Hz, and then a sloping sensorineural hearing loss at frequencies of 3000 Hz and above. Remember the dotted, rather than solid lines denoting frequency, are referred to as interoctaves. 3000 Hz on our audiogram is an interoctave frequency. Refer to **Figure 8.22**, which depicts an example of a high-frequency sensorineural hearing loss, again, bearing in mind audiometric variability from one individual to another, not all HF SNHL will appear the same.

Cookie Bite

Another common configuration is the **cookie bite** pattern. This loss depicts the most impaired thresholds in the mid-frequency range, with recovery noted in both the lower and higher frequencies. Again, it should be noted that the precise thresholds and frequencies of this hearing loss will vary from person to person. Not all cookie bite hearing losses will appear the same. **Figure 8.23** is an example of a cookie bite hearing loss.

Noise Notch

A **noise notch** is another common hearing loss configuration. Its cause is related to high-intensity noise exposure over time hence its name. Characteristically effecting the higher pitches of 3000 Hz to 6000 Hz, the audiological thresholds are characterized by recovery at 8000 Hz hence the connected thresholds depicting a notch. **Figure 8.24** is an example of a noise notch hearing loss. While all noise notch hearing losses will be centered around the frequencies noted above, the severity will vary from person to person. It should further be noted that noise notch hearing loss can be either bilateral, as depicted in **Figure 8.22** an audiogram illustrating a high-frequency hearing loss bilaterally.
A reverse curve hearing loss is depicted when individual thresholds are more significantly impaired in the lower frequencies than the higher frequencies. Hearing is impaired, for example, through 750 Hz or 1000 Hz, with recovery to normal or near normal in the higher frequencies of 1500 Hz to 8000 Hz. In a written report, this hearing loss can also be described as “upwardly sloping,” terminology which is also accurate in its description. As with the other losses described, there is significant person-to-person variability in this type of hearing loss, but is easily characterized by its distinct configuration. Figure 8.25 depicts a reverse curve hearing loss. Remember, the degree of this hearing loss can vary greatly and this figure is only one example of a reverse curve loss.
Ski Slope
A ski slope hearing loss, also known as a precipitously sloping hearing loss, is characterized by a rapid decrease in threshold responses after 250 Hz and 500 Hz. In many cases the lower frequency thresholds are at or near the range of normal. The remaining thresholds increase rapidly in their intensity as the frequencies get higher. However, as mentioned for the other configurations as well, there is a significant amount of variability from individual to individual. Figure 8.26 demonstrates a single example of a ski slope hearing loss. Note in this example, the hearing loss becomes so severe that the patient does not respond to the tones at maximum instrument output at 8000 Hz. As such, the “No Response” arrow is placed next to the symbol and the thresholds at 8000 Hz are not connected to the other responses with a line.

Summary
As a speech-language pathologist, you must secure the skills necessary to read an audiogram. The ability to interpret audiological data in order to design and provide appropriate intervention services for your patients/clients relies on this skill set. This ability begins with an understanding of the symbols used to build an audiogram during the diagnostic process. It is important to reiterate that the goal of this particular chapter is to assist the SLP in developing the confidence needed to accurately read an individual’s thresholds of hearing. Navigating the audiogram is only the first step in interpreting the audiological evaluation as a whole.

Discussion Questions
1. When bone conduction results are added to the air conduction results, the type of hearing loss can be established. What are those types of hearing loss? For each of those types, specify how the air and bone conduction responses relate to each other.
2. ______________ is to pitch as ______________ is to loudness.
3. Obtain a blank audiogram form and plot the following thresholds:
   a. 50 dB HL at 1000 Hz air conduction response for the right ear
   b. 25 dB HL at 8000 Hz air conduction response for the left ear
   c. 70 dB HL at 1000 Hz masked air conduction response for the right ear
   d. 40 dB HL at 500 Hz masked air conduction response for the left ear
   e. 10 dB HL at 2000 Hz bone conduction response for the right ear
   f. 20 dB HL at 250 Hz bone conduction response for the left ear
   g. 30 dB HL at 4000 Hz masked bone conduction response for the right ear
   h. 60 dB HL at 2000 Hz masked bone conduction response for the left ear
   i. No response at maximum instrument output level (90 dB HL) at 8000 Hz for the right ear
   j. No response at maximum instrument output level (105 dB *HL) at 4000 Hz for the left ear

4. Why is it important to be able to identify the overall configuration of hearing thresholds?

5. What other components of a complete audiological evaluation must accompany the audiogram information? What information does the audiogram alone not reveal regarding an individual's hearing status?

REFERENCES


CHAPTER 9

AUDIOGRAM INTERPRETATION

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KEY TERMS

| Air–bone gap | Keloids | Sensorineural hearing loss |
| Asymmetrical hearing loss | Minimal/slight hearing loss | Shadow curve |
| Conductive hearing loss | Mixed hearing loss | Speech banana audiogram |
| Familiar sounds audiogram | Otosclerosis | Tympanogram |
| Incidental learning | Presbycusis | |
| Interaural attenuation | Pseudohypacusis | |

OBJECTIVES

- Interpret the various components of the audiometric test battery, and understand how each plays a role in the diagnosis of hearing loss.
- Critically assess an audiogram for consistency and validity.
- Illustrate various ways of explaining audiometric test results to patients and their families.
- Understand how the various degrees and types of hearing impairment impact communication development and skills.
- Describe how the results of audiometric tests will impact the planning of speech-language therapeutic intervention.
Introduction
Interpreting the audiogram is a skill that follows the ability to determine left ear from right, air conduction (AC) from bone conduction (BC), and conductive from sensorineural and mixed hearing losses, as well as identifying common configurations of hearing loss. Every speech-language pathologist (SLP) must also develop the skills necessary to determine the degree of hearing loss and its impact on speech and language development. Interpreting the audiogram is, by far, the most important aspect of developing appropriate accommodations and modifications for an individual with hearing loss and will become the steering wheel for interventions and therapeutic goals.

With a fluid understanding of audiometric terminology and a secure ability to navigate the audiometric findings, it will now be possible to look at the results that you will have and make a determination if those results are accurately depicting the individual with hearing loss in front of you. “Accurately?” you ask? There will be those cases where the results do not make sense. It is important that the SLP develops a check and double check to make sure that the audiometric results are reliable and accurate. We suggest that the reader use Chapters 3 through 9 together as a cohesive unit for this understanding of test results. Our journey of interpretation began in Chapter 8 with navigating the audiogram, and we will now continue this journey of interpreting not only the audiometric graph itself, but all test results as a comprehensive evaluation of hearing status.

Table 9.1 and Table 9.2 show the audiometric symbols key recommended for use by the American Speech-Language-Hearing Association (ASHA, 1990 and 1999). However, it is worth mentioning that the specific audiometric symbols used on any given audiogram may vary from facility to facility, and, as such, you will typically see a “symbols key” appear on each audiogram to assist you in the interpretation of results. The symbols used within this chapter will adhere to ASHA’s recommendations.

Determining Degree of Hearing Loss
When the SLP is presented with an audiogram for interpretation, determining the degree of loss becomes significant in the type of interventions and their therapeutic goals that will be designed for that specific individual. Remember, there are varying degrees of hearing loss from normal to profound, and all degrees in between. We again draw our reader’s attention to Figure 9.1, which presents an audiogram depicting various degrees of hearing loss suggested by Clark (1981), as reported and endorsed by ASHA. In the following sections we will continue the journey of interpretation with descriptions of the

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<th>Table 9.1</th>
<th>Audiometric Response Symbols Key Recommended for Use by ASHA (1990 and 1999)</th>
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<tbody>
<tr>
<td><strong>Right Ear</strong></td>
<td><strong>Unspecified</strong></td>
</tr>
<tr>
<td>AC unmasked</td>
<td>O</td>
</tr>
<tr>
<td>AC masked</td>
<td>△</td>
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<tr>
<td>BC unmasked (mastoid)</td>
<td>&lt;</td>
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<tr>
<td>BC masked (masked)</td>
<td>[</td>
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<tr>
<td>BC unmasked (forehead)</td>
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<tr>
<td>BC masked (forehead)</td>
<td>ㄱ</td>
</tr>
<tr>
<td>Sound field</td>
<td>S</td>
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Table 9.2  Audiometric No-Response Symbols Key Recommended for Use by ASHA (1990 and 1999)

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<tr>
<th></th>
<th>Right Ear</th>
<th>Unspecified</th>
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<tr>
<td>AC unmasked</td>
<td>( O )</td>
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<td>( X )</td>
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<tr>
<td>AC masked</td>
<td>( A )</td>
<td></td>
<td>( D )</td>
</tr>
<tr>
<td>BC unmasked (mastoid)</td>
<td>( \langle \rangle )</td>
<td>( &lt; )</td>
<td></td>
</tr>
<tr>
<td>BC masked (masked)</td>
<td>( \langle \rangle )</td>
<td>( \langle \rangle )</td>
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<tr>
<td>BC unmasked (forehead)</td>
<td>( V )</td>
<td></td>
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<td>BC masked (forehead)</td>
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categories appearing on the audiogram as depicted in Figure 9.1 and the corresponding Table 9.3. It is important to point out that it is always the air conduction thresholds (sometimes collectively referred to as the *air line*) that we look at to determine the degree (severity) of hearing loss, not the bone conduction results (or *bone line*).

Normal Hearing

As generally accepted values, the range of normal hearing sensitivity is –10 dB HL to 15 dB HL, although many audiograms will reflect the “cut off” for normal hearing to be 20 dB HL. At one time the normal range was considered to be –10 dB HL through 25 dB HL; it is now generally accepted to be

![Figure 9.1](image-url)  An audiogram depicting the various categories for classifying the degree of hearing loss.
in the range of –10 dB HL through 15 dB HL (refer to Figure 9.1), particularly where children are concerned. One of many reasons for this shift may be related to more current research about incidental learning. Incidental learning takes place naturally and spontaneously as a result of a child being aware of and interacting with his or her environment, without the use of any formal direction or structure. Research clearly indicates that this is one of the ways children learn. In fact, although word learning in infancy may begin as a slow laborious task, during the second year of life the nature of word learning changes. Most typically developing 18- to 24-month-olds learn new words incidentally, without direct adult instruction and with only limited exposures to the words’ labels and referents (Brackenbury, Ryan, & Messenheimer, 2006). In addition to concerns about children, there is also evidence in the literature that adults continue to learn by informal incidental means (Jubas, 2011), and sensitive thresholds of no poorer than 15 dB HL are important for this population as well. Figure 9.2 depicts normal auditory thresholds across all frequencies tested, both air and bone conduction thresholds, bearing in mind audiometric variability from one individual to another, not all normal hearing results will appear the same. Likewise, if you will recall the term “audiometric zero,” which refers to 0 dB HL; thresholds do not need to reach 0 dB HL to be considered normal. Normal hearing is a range from –10 dB HL to +15 dB HL at all frequencies tested.

Thresholds of 20 dB HL are many times referred to as “borderline normal” and, depending on the individual case, may or may not be considered a significant finding. For example, a 20-dB HL threshold would be considered significant in a very young child, while it may not hold clinical significance in an elderly individual. Likewise, these authors acknowledge that there are some populations for whom an upper normal limit of 25 dB HL is sufficient, such as a geriatric individual with limited mobility or restricted to a nursing home facility.

Figure 9.3 depicts a borderline normal audiogram; again, bearing in mind audiometric variability from one individual to another, remember that not all hearing results will appear the same.

**Minimal/Slight Hearing Loss**

Air conduction thresholds that fall within the range from 16 dB HL through 25 dB HL are within the range of a minimal/slight hearing loss. There is very little distinction between the definition of borderline normal hearing and the identification of
minimal/slight hearing loss—so much so that this may vary from clinic to clinic in its distinction. Points of reference may include the three frequency pure tone average, whether the clinic uses 15 dB HL or 20 dB HL as the cut off for normal hearing thresholds, and the relative age of the individual being tested. It is because of this variability that the prudent SLP must have a working knowledge of audiogram interpretation that is tailored to the individual needs of the client he or she is servicing. You must be able to relate the audiometric results to the specific therapeutic circumstances of the individual.

Figure 9.4 is an example of a minimal/slight hearing loss, again bearing in mind audiometric variability from one individual to another. You will notice that there is very little difference between Figure 9.3 and Figure 9.4. However, upon examination, the pure tone averages in Figure 9.3 are 18 dB HL for both the right and left air conduction thresholds, while the pure tone averages in Figure 9.4 are 23 dB HL for both the right and left air conduction thresholds. This relative difference of 5 dB can have far reaching effects.

One should never equate a slight hearing loss with a “slight” problem in hearing. Hearing threshold levels that fall persistently within this range, particularly where children are concerned, can have an

Figure 9.3 An audiogram illustrating a borderline normal hearing sensitivity.

Figure 9.4 An audiogram illustrating a “slight” degree of hearing loss (between 16 dB HL and 25 dB HL). The type of hearing loss is unknown without the addition of bone conduction results.
adverse effect on communication development and performance, the degree of which can potentially be significantly greater than the terms minimal or slight would seem to suggest. The literature supports that the presence of a minimal/slight hearing loss in a child can negatively impact speech and language understanding, academic achievement, and social interactions. Although not every child suffers consequences as a result of these minimal decrements in hearing sensitivity, for a significant portion of this population, a loss of any degree appears sufficient to interrupt the normal continuum of communication development and academic skills (Yoshinaga-Itano, 2008).

One example of the potential effects of minimal hearing loss is not hearing the endings of words, which in turn can cause difficulty with the concepts of possession or plurality (missing the /s/ ending), or past tense (missing the /ed/ ending). Acoustically, these individuals may not be able to hear whispered, soft levels or distant speech; they also may have difficulty understanding the message when a speaker’s face is not visible or when in the presence of background noise or reverberant conditions. Someone who experiences any of these conditions in a classroom setting is at risk for academic difficulties and possible academic failure.

In addition to the speech, language, and academic effects, this degree of hearing decrement may hamper social and emotional growth for several reasons. A person with this hearing loss may be viewed as confused, immature, or even aloof as a result of missing out on hearing soft-level conversation or generally being unaware of subtle conversational cues. These children may act out, or they may become fatigued more easily than other children due to the extra effort they must expend during the day to listen, hear, and learn. The fact that there is a hearing loss is often not apparent. As a result, these children are sometimes erroneously believed to have behavioral problems, and they often do not receive the appropriate intervention that they so desperately need. For additional information, please refer to the Anderson and Matkin (2007).

Additionally, making educators and other professionals aware of the need for proper diagnosis of a minimal/slight hearing loss and management strategies for such losses is crucial for the achievement of effective educational outcomes for these children (Goldberg & Richburg, 2004). The determination of intervention needs and recommendations is best provided on a case-by-case basis. Likewise, active adults with such hearing losses may experience similar social and emotional behaviors, reduced social interactions, and difficulty in the work environment and in meetings. Conversely, this degree of hearing loss may go completely unnoticed in older, less-active adults.

Mild Hearing Loss
A mild hearing loss (refer to Figure 9.5) is one in which air conduction thresholds fall within the 26 dB HL to 40 dB HL range. Audiometric thresholds will vary from one individual to another, and not all mild hearing losses will appear the same. You can simulate and experience the effects of a mild hearing impairment by blocking off your ear canals, either with your fingers or with earplugs. Some of the physical and emotional reactions you may experience include surprise at the level of difficulty a “mild” loss creates and frustration when the speaker’s face cannot be seen. Either of these experiences could understandably cause you to stop paying attention. Clearly, the term mild does not accurately imply the resulting consequences and level of difficulty perceived. Similar to that of the minimal hearing loss category, the degree terminology can be very misleading to those who are uneducated about hearing loss and the concomitant effects.

Research on the effects of mild hearing loss indicate that although not all children with mild bilateral hearing loss have significantly delayed development compared with their peers with normal hearing, approximately one-third of these children evidence significant difficulties in their language, academic, and social-emotional development (Yoshinaga-Itano, 2008). The potential impact this degree of hearing loss can have on understanding speech
and language includes missing anywhere from 25% to 40% of the speech signal with a hearing loss of 30 dB HL and as much as 50% of discussion with a hearing loss of 40 dB HL (Anderson & Matkin, 2007). For a youngster, this can translate to missing half of class instruction and dialogue. Academically, it is not uncommon for delays to arise in early foundational reading skills, such as the ability to associate a sound with its corresponding letter (phoneme–grapheme correspondence). For the adult population, this degree of hearing loss and the attendant loss of speech-language understanding (word discrimination ability) will have a variety of negative consequences, whether the individual is in the higher education arena or in a work setting.

The social and emotional impact that mild hearing loss can have on children includes the tendency for the child to be seen as off in his or her own world, hearing only when it is something she or he wants to hear, daydreaming, and the like, especially because the existence of a mild hearing loss is not always apparent. As a result, feelings of low self-esteem may begin to set in, and there may be a tendency for the child to isolate. The adult population suffers the social effects of mild hearing loss as well, sometimes demonstrating depression and social isolation in addition to the functional disability experienced. Regardless of age, whether adult or child, it is common for those who suffer from mild hearing loss to experience physical symptoms such as fatigue, headaches, or other behaviors as a result of the increased amount of energy expended in an effort to hear.

### Moderate Hearing Loss

A moderate hearing loss is one in which the air conduction thresholds fall within 41 dB HL through 55 dB HL on the audiogram (refer to Figure 9.6). Regardless of age and life circumstances, this degree of hearing loss can have a significant negative impact on all aspects of communication and development and audiometric thresholds will vary from one individual to another within this range of hearing loss. The literature suggests that the amount of speech signal that an individual can miss out on ranges from 50% with a hearing loss of 40 dB HL to as much as 80% or

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**Figure 9.5** An audiogram illustrating a “mild” degree of hearing loss (between 26 dB HL and 40 dB HL). The type of hearing loss is unknown without the addition of bone conduction results.
Full auditory access is a critical factor if a child is to have the best possible chance for normal speech and language development. A moderate hearing loss is a barrier to the necessary opportunities. Without appropriate identification and intervention strategies in place, there is a likelihood that the child will sustain delayed or disordered syntax, limited vocabulary, imperfect speech production, and flat voice quality (Anderson & Matkin, 2007). Without the appropriate opportunities to learn language, these children will fall behind their hearing peers in communication, cognition, reading, and social-emotional development (Joint Committee on Infant Hearing, 2007). Even with appropriate amplification, a child is at a considerable disadvantage in most listening environments, especially the average noisy classroom. It is well documented that hearing aids alone in a classroom setting do not allow the hard-of-hearing student to overcome the deleterious effects of poor classroom acoustics. Children also may not become involved in extracurricular activities, sports, or other socially interactive events; instead, they may isolate.

An adult with a moderate hearing loss will encounter similar difficulties. Without the use of amplification, they are also likely to miss 50% to 80% of the content of speech with a hearing loss of 40 dB HL to 50 dB HL, respectively, even if they are in quiet (good) listening conditions (Anderson & Matkin, 2007). As indicated previously, even when hearing aids are worn, the presence of background noise and reverberant conditions will continue to cause difficulties; group settings, distance from a speaker, and/or not being able to see the speaker’s face will be problematic as well. It is noteworthy that an adult with moderate hearing loss, in general, has an advantage over a youngster with the same degree

![Figure 9.6](image-url)
of loss. An adult is more likely to be able to figure out pieces of a conversation when only part is heard; on the other hand, a child will not have had the life and language experience and exposure to fill in the missing bits of information.

In the adult population, the social effects might include no longer being able to enjoy going to restaurants, the theater, and other such large and/or noisy group settings because of their high degree of difficulty. In addition, difficulty hearing may cause adults with hearing loss to avoid family gatherings, which may lead to strained relationships and even depression, a symptom that is not uncommon in the elderly population.

**Moderately Severe Hearing Loss**

Air conduction thresholds that fall within the 56 dB HL to 70 dB HL range on the audiogram (refer to Figure 9.7) are categorized as a moderately severe hearing impairment. A hearing loss that falls within this range can be extremely handicapping; the individual with a moderate to severe loss can literally miss out on as much as 100% of average-level conversation. Again, audiometric thresholds will vary from one individual to another, so not all moderately severe hearing losses will appear the same. When we consider that the decibel level of average conversational speech is generally considered to be in the range of 45 dB HL to 50 dB HL (Martin & Clark, 2012), it is apparent that someone who is not aware of sound until 55 dB HL will be altogether unaware of average conversational speech if he or she is not using a hearing aid or other device. Whether it is an infant developing speech and language skills, a school-aged child trying to function academically in a classroom, or an adult attempting to function and communicate in a variety of settings, intervention strategies (hearing aids, aural rehabilitation, speech-language intervention, etc.) must be routinely in place.

Early hearing detection and intervention is critical for the young child with this degree of hearing impairment, for without it delayed and/or disordered speech-language skills can be expected. Some of the areas that are impacted, in varying degrees depending on the child, include disorders of syntax,

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**Figure 9.7** An audiogram illustrating a “moderate to severe” degree of hearing loss (between 56 dB HL and 70 dB HL). The type of hearing loss is unknown without the addition of bone conduction results.
morphology, vocabulary, and semantics, as well as speech intelligibility. For example, a child with hearing loss in this range typically has speech production errors comparable to those of normal-hearing children with articulation or phonological delays (Schow & Nerbonne, 2007). Additionally, there will be a well-documented difference in language development between the hard-of-hearing child and his or her normal-hearing peers within the educational setting. However, this difference is not always apparent to all individuals who work with children. From child care centers, early childhood education programs, and even as late as kindergarten and first grade, the SLP is often the first professional called upon to examine the child’s apparent unintelligible speech patterns.

In the average classroom setting and without hearing aids, the moderately severe hard-of-hearing child will be unable to understand and follow instruction or keep up with classroom discussions, and is likely to be unaware of much of the conversation that is going on around him or her. Frequently, these children can be identified as always receiving guidance from another student in the classroom, which draws the attention away from the child with hearing loss toward the “little classroom helper” who recognizes the need to assist the “slower” student.

Adults will experience difficulties in similar situations as well. Even with the use of hearing aids (and/or other devices), the presence of background noise or reverberation, the speaker’s face not being visible, and distance from the speaker may all prove to be especially problematic situations that greatly reduce the adult’s ability to hear and understand. In such settings, recommendations may include full-time use of hearing aids and other prescribed devices, as well as ancillary support services as needed.

Severe and Profound Hearing Loss
A hearing loss that falls within 71 dB HL to 90 dB HL is categorized as a severe hearing loss; when it falls at 91 dB HL and greater, it is known as a profound hearing loss. Refer to the audiogram in Figure 9.8 for an example of a severe and profound hearing loss.

Figure 9.8 An audiogram illustrating a “severe” degree of hearing loss (between 71 dB HL and 90 dB HL) in the right ear and a “profound” degree of hearing loss (91 dB HL and greater) in the left ear. The type of hearing loss is unknown without the addition of bone conduction results.
When we consider that a hearing loss at 56 dB HL to 70 dB HL can result in missing as much as 100% of speech, how much greater then is the impact of a hearing loss of this magnitude on speech-language development and overall communication skills?

Bearing in mind the discussion in the previous section regarding the impact of a moderately severe hearing loss, early intervention for the child with severe and profound hearing loss is that much more critical. For these youngsters, the earlier the child wears amplification consistently with concentrated efforts by parents and caregivers to provide rich language opportunities throughout everyday activities and/or provision of intensive language intervention (sign or verbal), the greater the probability that speech, language, and learning will develop at a relatively normal rate (Anderson & Matkin, 2007).

At the other end of the age spectrum, advancing age is the single most important (and nonmodifiable) risk factor for hearing loss in older adults (George, Farrell, & Griswold, 2012). However, adults may also sustain a hearing loss from birth (congenitally and prelingually), or it may be of later or progressive onset as a result of other causes. Therefore, the potential impact on speech, language, and range of overall communication skills is quite varied.

In terms of accessibility of sound, without hearing aids or other devices, individuals with severe and profound hearing loss (adults as well as children) are unaware of average-level conversational speech, and are most likely not even aware of loud-level speech. Additionally, often (although perhaps not always) there may be no access to even the loudest of environmental sounds. With appropriate amplification (or cochlear implantation) these individuals may be aware of average-level speech; however, the amount of speech that is actually understood is extremely variable and can range from reasonably good to none at all. This depends, at least in part, on the nature as well as the severity of the hearing loss. In addition to the age of onset of the hearing loss and whether it was incurred pre- or postlingually, other possible variables include age at time of identification, age at time of intervention, and the possible presence of comorbidities.

The SLP may be called upon to provide therapy to clients with profound hearing loss who may have relocated from other countries or from areas where early intervention services for children are not readily available or accessible. In such cases, even the procurement of hearing aids may be difficult. Because there is such a wide range of variables, the reader is encouraged to network with local audiologists who may have prior experience in working with these and other such challenging cases.

An important caveat to remember when reading this section is that someone’s hearing loss rarely falls neatly into only one category; that is, it is very common to see hearing loss that might be mild in degree at 250 Hz and then slopes to a profound degree by the time it gets to 8000 Hz. Hence, you may often come across an audiogram and/or evaluation report that describes a “mild sloping to severe” hearing loss. In such cases, the handicap experienced might be more severe as opposed to mild, depending on the specific pattern demonstrated.

**Linking Degree and Type of Hearing Loss**

Now that we have established the various degrees of hearing loss, we must now return to the type of hearing loss that has been established by the audiometric bone conduction thresholds.

**Conductive Hearing Loss**

As discussed elsewhere, you can determine what type of hearing loss a person has by looking at the relationship between the bone conduction thresholds and the air conduction thresholds. To review, when the air conduction thresholds are outside of the normal range but the bone conduction thresholds are completely within normal limits, a conductive hearing loss is present. Figure 9.9 depicts a mild conductive hearing loss. Notice that
the air conduction thresholds are at approximately 30 dB HL to 40 dB HL across all frequencies in both ears, in the mild range of hearing loss. The masked bone conduction thresholds, however, appear at 0 dB HL across all frequencies in both ears, which is within the range of normal hearing. This difference between the air conduction thresholds and the bone conduction thresholds is known as an **air–bone gap**. The appropriate descriptive interpretation would therefore be a bilateral (both ears) mild (degree) conductive (type) hearing loss. Conductive hearing losses can be of minimal, mild, moderate, and moderately severe degree.

A conductive hearing loss occurs as a result of damage to or pathology of the conductive mechanism. The conductive mechanism is made up of the outer and middle ears. Any physical damage, structural abnormality, or obstruction that occurs in this portion of the auditory system can prevent sound from being transported into the inner ear. The primary characteristic of this type of loss is typically a reduction in sensitivity, and not a loss of the clarity of speech. Therefore, when sound is made loud enough, the person’s ability to discern the content is usually intact, as demonstrated by the person’s characteristically excellent word discrimination scores.

Conductive pathologies, regardless of etiology, should be under the watchful care of a trained medical specialist. It is prudent for the SLP to regularly review files and determine how long the patient’s conductive condition has been present. Monitoring and follow-up medical and audiologic services are important to ensure that the patient’s healthcare and communication needs are routinely being met.

**Sensorineural Hearing Loss**

The comparison of air conduction to bone conduction thresholds is of paramount importance when determining the type of hearing loss. As a point of review, when air conduction and bone conduction thresholds are equally abnormal, a **sensorineural hearing loss** is present. **Figure 9.9** represents a bilateral (both ears) mild (degree) sensorineural (air and bone conduction thresholds are similarly equal) hearing loss. Sensorineural hearing losses can be of minimal, mild, moderate, moderately severe, severe, and profound degree.

A sensorineural hearing loss occurs as a result of damage to the sensorineural mechanism, which
is made up of the inner ear and auditory nerve. In the case of sensorineural hearing loss, sound is transmitted through the outer and middle ear unobstructed; the problem arises in either the inner ear or auditory nerve. Most sensorineural hearing loss is permanent. Sensorineural hearing loss is often remediated with the use of hearing aids, or cochlear implants if the nature and severity are sufficiently severe.

A common characteristic of sensorineural hearing loss is being able to hear low frequencies (many vowel sounds as well as background noise) better than the higher frequencies (many consonant sounds). This can lead to the frequent perception that the person with this type of hearing loss can hear, but they do not seem to understand, or that they may be choosing to ignore you. In fact, sensorineural hearing loss combines a loss of sensitivity with a diminished ability to understand speech, even when it is made louder. This characteristic of sensorineural hearing loss is why someone who suffers from it may turn the television up extremely loud, yet still not be able to understand what is being said. Other symptoms these individuals may experience include tinnitus (ringing or buzzing), an abnormal (inappropriately rapid) growth of loudness (recruitment) once they hear the sound, and vertigo (dizziness and loss of balance).

**Mixed Hearing Loss**

A mixed hearing loss combines the characteristics of both a conductive and sensorineural loss. We again draw the reader to depiction of this loss in Figure 9.11; we can see that it is a bilateral (both ears) moderate-sloping-to-severe mixed (neither bone conduction or air conduction thresholds are within the range of normal but likewise do not match each other) hearing loss. Mixed hearing losses can be of mild, moderate, moderately severe, severe, and profound degree.

A common example of a mixed hearing loss is when someone who has a preexisting sensorineural hearing loss (perhaps as a result of maternal in utero infection) then acquires otitis media (the common ear infection). There are numerous other possible causes of mixed hearing loss, all of them having one thing in common: They are a combination of a sensorineural component and a conductive...
Treatment and remediation for a mixed hearing loss varies depending on the specific etiologies involved.

A comorbid hearing loss can be of particular challenge in the educational realm. For example, a child may have a bilateral moderate sensorineural hearing loss and accommodations and modifications have been put in place in the child’s classroom to assist that child. This preexisting condition does not preclude this child from getting, for example, an ear infection. The child now presents with a bilateral severe mixed hearing loss due to the deleterious effects of the fluid in his middle ear cavity. The existing accommodations and modifications may in fact now be inadequate to meet the hearing needs for this child and may need to be further modified until such time that the ear infection has resolved.

A common complaint that may alert the SLP to this type of condition may be the report of a sudden significant decrease in the person’s ability to hear or that his or her hearing aids are suddenly not working to overcome the degree of hearing loss. Teachers may complain that the student is particularly distracted during a period of time, constantly asking for clarification of directions or “zoning out” of classroom discussions.

**Linking Degree, Type, and Configuration of Hearing Loss**

Establishing the various degrees of hearing loss and the types of hearing loss are only two of the three important aspects of determining the impact that the hearing loss will have on communication ability. We will now add the configuration, or shape, of the hearing loss as it appears on the audiogram.

**Asymmetrical Hearing Loss**

An asymmetrical hearing loss is, simply put, when a person’s hearing sensitivity is significantly different in one ear versus the other. There are two types of asymmetrical hearing loss: unilateral and bilateral. Asymmetrical hearing losses can occur in any degree, from minimal to profound. On rare occasion, an individual may even try to fake this type of hearing loss.
Let us first examine the unilateral type of asymmetrical hearing loss. Figure 9.12 demonstrates unmasked hearing test results for this hypothetical case. Notice that the air conduction thresholds for the right ear are completely normal, whereas the air conduction thresholds for the left ear are at approximately 55 dB HL to 65 dB HL. Because masking is not yet used when this person is tested for pure tones, the audiogram depicted is not accurate. These unmasked air conduction thresholds in the left ear are actually a shadow curve of the right ear, and they are due to the phenomenon of cross-over. In our example, cross-over and cross-hearing occurred because the intensity of the sound in the left earphone became so great that the sound exceeded the interaural attenuation. Interaural attenuation can be thought of as the reduction (in decibels) caused by the skull as sound travels from the test ear to the nontest ear (Brannstrom & Lantz, 2010). These unmasked thresholds in the left ear are erroneous; that is, they do not actually represent the hearing in the left ear at all. Rather, they simply indicate how loud the test sound was in the left earphone for the sound to cross over to the right (better) ear to respond. When this occurs, the audiologist must mask.

Our audiologist in this example employs the masking process, which involves putting noise into the better (right) ear to “keep it busy” while at the same time retesting the poorer (left) ear. When this is done, new thresholds for the pure tones are obtained for the left ear (now without the help of the right good ear). In Figure 9.13, the true air thresholds are presented in their masked form for the left ear. In fact, the left ear did not have a moderate to moderately severe hearing loss as depicted in Figure 9.12. It is, in fact, a severe to profound hearing loss. In contrast to the unmasked results for this patient (Figure 9.12), the masked audiogram provides a true indication of the severity of hearing loss in the left ear.

It is noteworthy that although SLPs are unlikely to be responsible for knowing how to perform effective masking, it is critically important that they understand the concepts, what they represent, and the audimetric implications. An important caveat for the SLP to keep in mind is that if the audiogram in front of you looks like the unmasked one in
Fig. 9.12, showing large gaps between the ears and no masking, the appropriate course of action is to contact the audiologist as soon as possible to request more information or clarification of your patient’s hearing status. The SLP must be able to accurately interpret the hearing test results provided, in order for proper interventions and management strategies to be routinely in place.

Fig. 9.13 correctly depicts a unilateral (left) severe-profound sensorineural hearing loss. In terms of the communication impact of such a hearing loss (regardless if it is the left ear or right), it is first important to recognize that having “one normal ear” is not sufficient. Regardless of patient age or life situation, unilateral sensorineural hearing loss can result in significant and sometimes severe difficulty. Most commonly, there are difficulties with discrimination in background noise and reduced ability to localize sounds (Pennings, Gulliver, & Morris, 2011). Individuals with this type of impairment experience difficulty understanding the message when their bad ear is directed toward the speaker, because their head—physically—interferes with the sound reaching the better ear. This is known as the head shadow effect and accounts for why noisy settings can be particularly problematic and wearisome. Moreover, this becomes an especially troublesome and challenging situation for children, whose speech-in-noise listening skills do not reach full development until the adolescent/teenage years (Finitzo-Hieber & Tillman, 1978; Neuman, Wroblewski, & Rubinstein, 2010; Rothpletz, Wightman, & Kistler, 2012). Young children who have this unilateral configuration of hearing loss are at an even further disadvantage, because children with unilateral hearing impairment require a more advantageous listening condition to perform equally as well as their normally hearing counterparts (Pennings et al., 2011; Ruscetta, Arjmand, & Pratt, 2005).

Although different age categories and life circumstances may necessitate different considerations and interventions for individuals with unilateral hearing loss, an important take-away message is that a hearing loss of any degree appears sufficient...
to interrupt the normal continuum of communication development and academic skills (Yoshinaga-Itano, 2008). Do not assume that one normal ear can do the job of two.

The etiology of such a hearing loss should always be investigated by an otorhinolaryngologist. Second-level testing to rule out retrocochlear pathology and congenital abnormalities should always be conducted.

The second type of asymmetrical hearing loss occurs when both ears present with hearing loss, but the losses do not match in their configuration one-to-the-other. Figure 9.14 depicts a bilateral asymmetrical hearing loss, of mild degree in the right ear and severe degree in the left ear. Such hearing losses pose a particularly interesting scenario. While one might conclude that the better ear would in fact assist the poorer ear in communication, patients with this type of configuration will typically encounter challenges based on the severity of the poorer ear.

Figure 9.14 An audiogram depicting a bilateral asymmetrical hearing loss, of mild degree in the right ear and severe degree in the left ear.

Once again, individuals identified with such hearing losses should always seek medical follow-up by an otorhinolaryngologist for second-level testing.

**High-Frequency Sensorineural Hearing Loss/Noise Notch**

The two most common causes of sensorineural hearing loss in adults are presbycusis (hearing loss due to aging) and noise-induced hearing loss (NIHL; National Institute on Deafness and Other Communication Disorders, 1997, 2002), both of which present as a loss in the higher frequencies of hearing thresholds. Furthermore, the American Academy of Audiology (AAA, 2008) estimates that about one in eight children (more than 5 million) suffer from NIHL as well. The two configurations of hearing loss frequently associated with these etiologies is a high-frequency hearing loss pattern. In Figure 9.15, the low frequencies are present in the normal range of hearing sensitivity while the highest frequencies fall in the severe range of hearing sensitivity. A bilateral (both ears) mild-to-severe (degree) high-frequency (configuration) sensorineural (type) hearing loss is depicted.

Likewise, Figure 9.16 also depicts a high-frequency hearing loss, but with a single difference. There is a threshold recovery at 6000 Hz and 8000 Hz as compared to the threshold obtained at 4000 Hz. This is the characteristic audiogram for an individual who has been exposed to high-intensity noise either traumatically (an accidental explosion) or over a period of long-term exposure.

The consequences of high-frequency sensorineural hearing loss (HF SNHL) can be quite significant. The contribution of high-frequency consonant sounds to our ability to understand speech and language is well documented in the literature as well as routinely observed. In the English language, many of our consonant sounds fall in the high frequencies, and consonants tend to carry most of the meaning of speech. Vowels, on the other hand, have lower frequency content. Imagine that you are hearing only the vowel sounds of a speech message; it
is unlikely that you would understand the content. Now imagine that you are hearing only the consonant sounds: You would have a much better idea of what the person was trying to say.

You can visualize the effect of a HF SNHL. If you compare the “speech banana” audiogram (depicted later in this chapter) to the hearing losses shown in Figure 9.15 and Figure 9.16 (or better yet, use your own client’s audiogram), you will be able to approximate the sounds that will be most problematic for this individual. Furthermore, you will be able to see why, as has been reported in the literature, the discrimination of consonants (such as fricatives) will be especially difficult for individuals with HF SNHL (Robinson, Baer, & Moore, 2007).

Because the individual with HF SNHL is, in essence, missing so many consonant sounds, word discrimination ability will be significantly affected. These individuals struggle immensely in the presence of background noise. Remember, a person with HF SNHL classically has much better (perhaps even normal) hearing sensitivity for low frequencies. This combination of HF SNHL and the presence
of background noise is particularly confounding. Not only does it directly mask the areas of normal hearing for the individual, but the noise will have a masking effect and physically block out the high-frequency consonant sounds as well. This is known as the “upward spread of masking.” In your practice, or perhaps with an older family member, you may have or will encounter someone whose complaint is, while they have hearing aids, they dislike them because they just do not help them understand speech. Typically, that individual has a HF SNHL.

For youngsters who have HF SNHL loss, even a small amount of hearing loss can have profound negative effects on speech, language comprehension, communication, classroom learning, and social development (Centers for Disease Control and Prevention, 2013). HF SNHL renders sound as distorted or muffled, and may lead to an uncertain grasp of many of the grammatical aspects of spoken language, including weak consonants such as fricatives (/f/, /s/, /sh/, and /h/) and stops (/p/, /t/, and /k/), along with morphemes that mark verb tense, possessives, and plurals (/ed/, /s/, and /s/; Levey, Fligor, Ginocchi, & Kagimbi, 2012).

One last issue about HF SNHL and its consequences should be pointed out. The audiometric results are expected to provide a guideline as to the degree and types of difficulties that a given individual may experience as a result of the hearing loss. However, there is evidence to suggest that some individuals in this category (high-frequency hearing loss above 2000 Hz) may experience listening difficulties not readily apparent from their word discrimination score results (Roup & Noe, 2009). For example, during the evaluation the individual may demonstrate very-good-to-excellent word discrimination ability in a controlled acoustic environment; however, in real-life listening situations they may have noticeable difficulties communicating.

**Cookie Bite**

![Figure 9.17](https://example.com/cookie-bite) depicts a mid-frequency sensorineural configuration called a cookie bite hearing loss.

**Reverse Curve**

A hearing loss that manifests itself in the lower frequencies is referred to as a reverse curve hearing loss. This type of hearing loss is very often hereditary in nature, and therefore, if such a hearing loss is identified, siblings of the individual should be tested as well (Bitner-Glindzicz, 2002). The degree of a cookie bite hearing loss can vary from minimal/mild to more severe degrees. Because hearing is normal or near normal in both the lower frequencies and higher frequencies, often these hearing losses are late identified because speech and language skills are not necessarily affected in the typically developing child. Teachers or family members may note that a child’s articulation appears “slightly off” and this accounting may be the springboard for an audiological referral and subsequent identification. It is noteworthy to mention that, using the cookie bite hearing loss referenced in Figure 9.17, a screening measure such as distortion product otoacoustic emissions may not be a sensitive enough measure to detect such a loss.
loss and can be either conductive or sensorineural in nature and vary in degree. A conductive reverse curve hearing loss is predominantly caused by the presence of middle ear effusion or a condition known as Eustachian tube dysfunction. However, sensorineural reverse curve hearing losses can also exist. Etiology of such losses is typically unknown. Depending on degree, individuals with such a hearing loss may have an easier time listening in the presence of background noise than even a normal-hearing individual. Mild distortions in the articulation of vowel sounds may be the sole indicator of a reverse curve hearing loss. However, school-aged children with reverse curve hearing loss are in need of services as much as children with greater degrees of hearing loss, and accurate diagnosis of such a loss is key to appropriate interventions (Kaf, Mohamed, and Elshafiey, 2016). Although hearing aids may be recommended as remediation of such losses, successful use of amplification in these individuals is not always achieved. Figure 9.18 is an example of a reverse curve configuration of hearing loss.

Ski Slope/Precipitously Sloping Hearing Loss

A hearing loss that begins with normal thresholds in the lowest frequencies and rapidly decreases to the point of profound or “no response” is referred to as a ski slope or precipitously sloping hearing loss. This hearing loss is typically sensorineural in nature and is illustrated in Figure 9.19. In children, such hearing losses are routinely congenital in origin. In adults, a precipitous loss may be caused by noise exposure, ototoxicity, the general aging process (known as presbycusis), or a combination of factors (Fabry, Launer, & Derleth, 2007). Due to its configuration, the impact a ski slope hearing loss has on an individual’s ability to communicate is vast. Good low-frequency hearing allows an individual the ability to “hear” speech, but the extremely poor high-frequency thresholds disallow for understanding of the words. Therefore, speech and language development is impacted in children with such hearing loss. Hearing aid fittings for such individuals are
challenging due to the normal hearing thresholds in the lower frequencies (Kuk, Keenan, Auriemmo, & Korhonen, 2009). In some, success has been obtained using a cochlear implant as the device of choice.

**Progressive Hearing Loss**

Not to be overlooked in the discussion of hearing loss configuration is the progressive hearing loss. In some, but not necessarily all, cases, the hearing status of an individual will, in fact, deteriorate based on the nature of the loss itself. This scenario cannot be discounted when working with an individual with hearing loss. Today, much weight is placed on the results of the newborn infant hearing screening results. However, those results are a screening measure at a distinct point in time, and cannot account for future changes in hearing ability. One cannot rely on those results as the sole indicator of hearing status, even a short period of time later. If a parent or caretaker expresses concern regarding hearing status, pursue those concerns, regardless of the results of the newborn infant hearing screening. Furthermore, as a service provider, the audiological records for a specific individual receiving speech and language services may not be the sole compilation of records over time. Families move or change diagnostic facilities and records do not always move with a case. It may then become the responsibility of the SLP to review the historical records for a person with hearing loss to determine if audiometric thresholds have been stable over time or have changed, either for the better or worse. The ability to navigate and interpret the audiogram does not only play a role in determine an individual's current hearing loss, but a change in that loss as well.

**Speech Audiometry**

So far in this chapter we have covered the characteristics of degree, type, and configuration of hearing impairment; however, any audiometric picture that does not include the results of speech audiometry is incomplete. It is important to understand that although there are certain general characteristics to each type of hearing loss—such as a person with conductive loss typically having very good understanding ability and a person's sensorineural loss often being accompanied by a loss of speech discrimination ability—a lot of variability is observed from etiology to etiology and from person to person. Speech audiometry measures attempt to quantify a person’s ability to recognize and understand the content of the speech signal they are hearing; the SLP must have a secure understanding of these measures, and what they mean, in order to design effective treatment plans for their clients.

**Speech Recognition Threshold/ Speech Reception Threshold (SRT)**

The speech recognition (sometimes called reception) threshold (SRT), a procedure that attempts to measure a person's threshold for speech, serves as a validity check for the results of pure tone results. Because the SRT is normally done by air conduction (using earphones), it is expected to corroborate the pure tone air conduction results. Specifically, the SRT should be in agreement with the pure tone average (PTA), which is the average of the thresholds at 500 Hz, 1000 Hz, and 2000 Hz. To calculate the PTA, you simply add together the three thresholds at those frequencies and then divide by three. For example, if a person has thresholds of 40 dB at 500 Hz, 50 dB at 1000 Hz, and 60 dB at 2000 Hz, the PTA would be calculated as follows:

$$\frac{40 + 50 + 60}{3} = \frac{150}{3} = 50$$

Therefore, the expected SRT for this individual should be approximately 50 dB HL, with an acceptable variability of 5 dB. Exceptions to this may occur when there is a very steeply (precipitously) sloping hearing loss; in those instances, the SRT might be closer to an average of the two better PTA frequency thresholds, typically, being the average of 500 Hz and 1000 Hz.
What does it mean if an SRT does not fall within these guidelines? Very simply, disagreement between the SRT and the PTA is an indication of inconsistency in test results. This inconsistency may provide an early indication of pseudohypacusis (false or exaggerated hearing loss). It may also be due to test variables such as equipment malfunction or misunderstanding of the instructions by the patient (ASHA, 1988), language or cognitive impairments, or an indication of developmental stage. If your patient’s audiogram shows an inconsistency between the SRT and the PTA, you should look for explanatory notes, either on the audiogram or within the evaluation report, providing rationale.

Speech Detection Threshold (SDT)/Speech Awareness Threshold (SAT)

The speech detection threshold (SDT) is another threshold measure for speech, but unlike the SRT, in which the person identifies the sound as being a speech signal, with the SDT the person only needs to be aware that sound is present. As such, the SDT is an easier task and is generally slightly better (lower dB level) than the SRT, typically by approximately 5 to 10 dB. Like the SRT, the SDT serves as a validity check of pure tone findings, but is more closely related to the best air conduction threshold as opposed to the three PTA frequencies (500 Hz, 1000 Hz, and 2000 Hz). In fact, if a person has a very steeply sloping hearing loss, the SDT is likely to be a great deal better than the PTA.

What does it mean if the SDT is not consistent with the pure tone air conduction findings? Similar to the previous section, if there is an unexplained discrepancy between the SDT and the pure tone findings, there is a distinct possibility of there being a case of pseudohypacusis. It is also possible, however, that an equipment malfunction or a cognitive, language, or development delay or disorder exists. These possibilities need to be explored in such cases where inconsistencies exist. You should consult the written report or your local audiologist for additional clarification.

Word Discrimination Testing

The results of word discrimination testing (WDT), whether referred to as speech recognition scores or speech discrimination scores, are a fundamental part of the audiologic evaluation. These scores represent an approximation of the person’s ability to understand what has been said when speech has been made loud enough for them to hear it. The type of speech used is typically phonetically balanced word lists, such as CID W-22s and NU-6 lists. In terms of the results, conductive hearing loss, generally speaking, is frequently associated with very good discrimination scores; a sensorineural loss, on the other hand, is typically accompanied by somewhat poorer and variable scores, as has been noted in the literature (Brandy, 2002; Penrod, 1994) as well as observed by these authors during clinical practice. However, there are cases of sensorineural hearing loss with uncharacteristically good WDT scores relative to the audiogram, and the reverse is possible as well. Therefore, it bears repeating that any report that reflects only the nature and severity is incomplete. It is critically important for the SLP to have available all information for the purpose of speech-language assessment, intervention, and remediation planning processes for all patients.

The audiogram in front of you should include, at minimum, WDT scores in the quiet condition (no competing noise) in each ear separately, if the individual being tested is capable of repeating back words reliably; sometimes the audiogram also will have WDT scores in the presence of background noise. Perhaps you may have an audiogram that includes a person’s WDT scores both with and without visual (lip reading) cues. The categorizing of the results generally follows a scale of excellent (100%) through very poor (less than 50%); Table 9.4 provides the general scoring guidelines. It is important to recognize that these are suggested guidelines only and should be interpreted with caution; as already suggested, WDT score variability may occur within hearing loss categories as well as in an individual from day to day or one test session to the next.
Table 9.4  General Guide for the Interpretation of Word Discrimination Test (WDT) Scores

<table>
<thead>
<tr>
<th>WDT Score (%)</th>
<th>General Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>92 to 100%</td>
<td>Excellent</td>
</tr>
<tr>
<td>84 to 90%</td>
<td>Very good</td>
</tr>
<tr>
<td>78 to 82%</td>
<td>Good</td>
</tr>
<tr>
<td>70 to 76%</td>
<td>Fair</td>
</tr>
<tr>
<td>60 to 68%</td>
<td>Poor</td>
</tr>
<tr>
<td>Less than 60%</td>
<td>Very poor</td>
</tr>
</tbody>
</table>

A noteworthy consideration is that standard WDT is completed in an ideal “laboratory”-type setting; that is, the sound-treated booth, a quiet environment with no noise or distractions and the patient’s attention focused—at all times—on the task at hand. Real-life listening conditions are not as ideal as this setting. Even when the WDT is done with background noise, the person is still in a somewhat ideal laboratory type of setting, with focused attention and without distraction. So again, these results need to be interpreted cautiously because they are only a “snapshot” of a person’s true word discrimination ability and likely represent a best case scenario of their ability.

Lastly, if the results of WDT do not make sense or do not seem possible, you should contact your local audiologist. For example, if the WDT scores indicate that a person repeats back 100% of words correctly at a decibel level that is softer (better) than any of the pure tone air conduction thresholds, a case of pseudohypacusis should be suspected. Refer to the “Pseudohypacusis” section later in this chapter.

Other Audiometric Data

Sound Field Unaided

Often, an audiogram will have unaided sound field data; there are several reasons why this may be the case. For example, if the patient is a young child or one who has multiple or developmental disabilities (see Figure 9.20), the individual may not have been capable of or amenable to accepting the earphones, thus necessitating the sound field test condition (refer to Figure 9.21; also, refer back to Table 9.1 for the ASHA symbols key). An instance of when sound field unaided hearing testing might specifically be desirable is for comparison purposes, as might be the case when anticipating that a patient will soon be fit with hearing aids or cochlear implants and needing those results to document device benefit.

When reviewing and interpreting the results of unaided sound field testing, for whatever reason it was performed, it is important to keep in mind that these data represent the hearing of the better ear, if there is a difference between the ears. For example, if a patient has one ear that hears normally and one ear that is profoundly impaired, the better (normal)
ear will pick up sound at normal levels. Thus, in the sound field condition we cannot rule out the possibility that someone has a unilateral hearing loss. If unaided sound field testing was performed out of necessity, as might be the case with a very young child, follow-up testing to obtain ear-specific information is always necessary and recommended, even when the results appear to be within normal limits.

**Sound Field, Aided (Hearing Aid or Cochlear Implant)**

A routine part of an audiologic assessment on a hearing-impaired patient should be the aided audiogram. Although we recognize that in some facilities the aided audiogram may have gone by the wayside in favor of some of the objective hearing aid verification options, it is the expressed opinion of these authors that aided functional data can provide very useful information. Very simply, the aided audiogram is a graph that contains a person’s responses to speech and tones while he or she is wearing some device meant to improve hearing sensitivity. These devices may include hearing aids, cochlear implants, or some combination of both. The aided audiogram provides an estimation of the amount of benefit the person is receiving while he or she is using his or her device(s); it helps to determine if the patient’s needs are being met as effectively as possible, or if a different solution should be explored. The aided audiogram is also an excellent counseling tool for those individuals who may be resistant to or fail to see the benefit of amplification.

Although ASHA does not have a specific symbol to indicate the response with either a hearing aid or cochlear implant, hearing aid results are frequently noted using the symbol A (see Figure 9.22), and a cochlear implant is often noted using the symbol CI (see Figure 9.23). The aided audiogram should clearly indicate what types of devices your patient is using, and which symbols denote specific responses.

The aided audiogram might even have symbols that indicate your patient uses a hearing aid in one ear while using a cochlear implant in the other ear. This scenario is not uncommon, particularly where a child is concerned. When this occurs, for example, the audiogram might be noted with HA-R to indicate the condition of only the hearing aid on the ear in question.
Figure 9.22  An example of an “aided audiogram.” The symbol “AR” represents how the individual hears with a hearing aid on the right ear only. The symbol “AL” represents how the individual hears with a hearing aid in the left ear only. The symbol “AU” represents how the individual is hearing with both ears simultaneously aided.

Figure 9.23  An aided audiogram with the symbol “CI” being used to illustrate how a person responds while using a cochlear implant.
right ear, CI-L to indicate the cochlear implant on the left ear, and perhaps AU to indicate the simultaneous use of the HA on the right ear and the CI on the left ear. See Figure 9.24 for an example of an aided audiogram of this type. Again, symbols may vary, but the symbols key will be indicated on the specific audiogram.

Regardless of the specific fitting strategy used for your patient, the audiogram and/or audiologic evaluation report should include information regarding device settings and details (for example, optimal volume setting or schedule of how and when the devices are to be worn) of which you should be aware. Remember, as the SLP providing services for this individual, you must familiarize yourself with this information in order to be as effective as possible with your therapeutic interventions.

Some of the types of information you might find on an aided audiogram include the person's responses to sound at different frequencies (either warbled pure tones or narrow bands of noise). You may also see SRT and WDT in quiet and in noise, and with or without visual (speech reading) cues. Sometimes results are obtained and reported for a variety of conditions, such as right ear aided only, left ear aided only, cochlear implant right, cochlear implant right with hearing aid left, and so on. Quite simply, the aided responses to specific frequencies can show the audiometric benefit when the devices are worn. Aided speech audiometry gives a guideline as to how well a person can understand speech when it has been made audible to them through the hearing aids or cochlear implants. Remember, however, that these are merely approximations; actual performance in real-life situations may (and should be expected to) vary.

Clearly, just knowing the patient's type and degree of hearing loss with SRT and WDT ability is not enough. Again, it is incumbent upon the SLP to seek out and incorporate the aided data in order to gain a better understanding of the patient's performance with amplification. This information is

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**Figure 9.24** An aided audiogram comparing performance of a hearing aid on the right ear (HA-R); cochlear implant on the left (CI-L); or simultaneously using a hearing aid on the right ear and the cochlear implant on the left. This simultaneous condition is referred to as a bimodal listening condition (BI).
vitaly important in the evaluation and treatment planning process for all hard-of-hearing patients. An individual with hearing loss can only function as well as his or her devices. It is critical to success that the hearing aids are routinely utilized (as recommended) and that they remain in good working condition.

**Tympanogram Interpretation**

Tympanometry is not a hearing test, and so cannot tell us whether a person has normal or impaired hearing; rather, this test gives us an objective indication of how the conductive mechanism is physically functioning. The results of tympanometry should be used in conjunction with the hearing test results because they can provide evidence to help distinguish between sensorineural and conductive causes. Also, tympanometry can provide data supporting the existence of fluid in the middle ear, a common childhood disease that requires immediate medical referral. The Liden-Jerger system is commonly used for the classification of a *tympanogram* (Jerger 1970; Liden, 1969); it breaks the results into the following categories: type A, type As, type Ad, type B, and type C. We will address each of these tympanometric types. Refer to **Figure 9.25A–E** for an example of each tympanogram type.

Tympanometric results reflect measurements of middle ear compliance and pressure along with the volume of the external auditory ear canal. It is worth pointing out that the precise separation between normal and abnormal pressure and compliance values differs very slightly from researcher to researcher. Regardless, the Liden-Jerger classification remains the benchmark for reporting data. Although tympanometry screening is part of the SLP’s scope of practice, most of today’s tympanometry screening equipment not only runs automatically, but also displays the results against a shaded background that visually defines the normal range, thus making interpretation that much easier.

**Figure 9.25A** A normal type A tympanogram, which is consistent with normal middle ear function.

**Figure 9.25B** A shallow type As tympanogram, which is consistent with a stiff middle ear system.
Ear Canal Volume (ECV)

The ear canal volume (ECV) measure is also known as equivalent ear canal volume (EECV) or physical volume test (PVT). A normal healthy ear canal ranges in size from 0.3 mL to 1.0 mL in children and from 0.65 mL to 1.75 mL in adults (Alencar, Iorio, & Morales, 2005). This value can simply be read off the tympanogram printout; no calculation is needed. Refer to Figure 9.25A–E; the ECV can be seen on each of the tympanograms in these figures. The ECV, although providing valuable information, should be interpreted along with the tympanogram and not in isolation.

The significance of seeing a reduced ECV is that there is a likelihood of excessive wax being in the ear canal. A second scenario related to an exceptionally small ECV is that of a young child with craniofacial abnormalities. This may be a result of an underlying genetic syndrome (for example in the case of Down syndrome) or other contributing condition such as hydrocephaly.

![Figure 9.25C](image1) A very deep type Ad tympanogram, which is consistent with a hypermobile middle ear system.

![Figure 9.25D](image2) A flat type B tympanogram, which is consistent with abnormal middle ear function.

![Figure 9.25E](image3) A type C tympanogram, which shows significant negative middle ear pressure.

**Figure 9.25C** A very deep type Ad tympanogram, which is consistent with a hypermobile middle ear system.

**Figure 9.25E** A type C tympanogram, which shows significant negative middle ear pressure.

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If results reflect an excessively large ECV, the measurement may not only reflect the volume of the external ear canal, but the middle ear cavity as well. Scenarios that may be responsible for such a finding may be either a perforation (hole) in the eardrum or a properly functioning pressure equalization (PE) tube in the eardrum. (To know the difference, one should either reference the case history narrative for the presence/absence of PE tubes or the Otoscopy section of the test results narrative where the visualization of a PE tube should be noted if seen by the evaluating audiologist.) The significance of the ECV in relation to tympanogram type will be noted in each of the following sections.

**Type A Tympanogram**

The type A tympanogram is displayed in Figure 9.25 A and is a pattern suggesting normal conductive system (outer and middle ear) functioning. The type A tympanogram is characterized by a peak pressure (as noted by the horizontal axis) between +50 daPa/mmH₂O and –100 daPa/mmH₂O to be considered within the normal pressure range, and between –100 daPa/mmH₂O and –200 daPa/mmH₂O to be considered borderline range; normal peak compliance (as noted by the vertical axis) reaches a height between 0.25 mmho/cc/mL and 1.05 mmho/cc/mL for children and between 0.3 mmho/cc/mL and 1.7 mmho/cc/mL for adults [Margolis & Hunter, 2000]. The value of the ECV in a type A tympanogram is typically normal (from 0.3 mL to 1.0 mL in children and from 0.65 to 1.75 mL in adults [Alencar et al., 2005]). Although the numerical data are important to establish the “normal range,” most devices include some type of reference, typically a box on the equipment read-out, denoting these normal parameters. The SLP needs only to judge if the results fall within this predetermined range on the digital readout. The significance of this pattern is that there is no evidence of pathology in the outer or middle ear; this is not to say that there is no hearing loss. Rather, it is saying that if the audiogram shows a hearing loss (in all likelihood, possibly as much as 99% of the time), it is not conductive in nature. A sensorineural loss can have a normal type A tympanogram because this type of loss arises from a problem in either the inner ear or the auditory nerve, not the outer or middle ear (the conductive system).

**Type As Tympanogram**

The subscript s in the classification of a tympanogram as As is a reference to the fact that the compliance of the pattern is “shallow.” A pattern of this type is characterized with a pressure value within normal limits (between +50 daPa/mmH₂O and –100 daPa/mmH₂O to be considered within the normal pressure range [Margolis & Hunter, 2000]), but the compliance value is very low or shallow. The compliance value for a type As tympanogram is less than 0.25 mmho/cc/mL for children and 0.3 mmho/cc/mL for adults. The value of the ECV in a type As tympanogram is also typically normal (from 0.3 mL to 1.0 mL in children and from 0.65 mL to 1.75 mL in adults [Alencar et al., 2005]). If you look at the pattern shown in Figure 9.25B, you will see that the peak value of pressure is again within the normal limits defined as well as the ECV, but the height of that peak is significantly reduced.

The significance of this finding is that there is a stiff middle ear system, with reduced or restricted mobility of the eardrum (as illustrated by the shallow peak). Some of the conditions that can cause a tympanogram to be shallow include **otosclerosis** (abnormal bone growth around the ossicles, typically the stapes), middle ear effusion, severely scarred or thickened eardrum, or plaque on the eardrum (the latter two sometimes are caused by a history of excessive ear infections). A type As tympanogram is often accompanied by a hearing loss. Regardless of whether your patient has passed a pure tone screening, if you perform a tympanometry screening and get this result, a referral needs to be made to an audiologist and/or otologist.
Type Ad Tympanogram

The subscript $d$ in the classification of a type Ad tympanogram refers to the fact that the compliance represented in this pattern is very “deep.” The pressure peak continues to occur in the normal range (between $+50$ daPa/mm H$_2$O and $-100$ daPa/mmH$_2$O [Margolis & Hunter, 2000]), but the peak compliance is excessive. The value of the ECV in a type Ad tympanogram is typically normal (from 0.3 mL to 1.0 mL in children and from 0.65 mL to 1.75 mL in adults [Alencar et al., 2005]) as is the ECV. Refer to Figure 9.25C and you will notice that the height of the peak is much higher and exceeds the normal value.

The significance of the type Ad tympanogram is that there is a hypermobile (excessively flaccid) middle ear system. Some of the conditions that can cause a type Ad tympanogram include a disarticulation of the middle ear ossicles (disconnected), minor scar tissue, and a very thin or monomeric (single layer) eardrum. As with any abnormal tympanogram, regardless of whether the pure tone screening has been passed, this requires a referral to an audiologist and/or an otologist.

Type B Tympanogram

The type B tympanogram is a flat pattern; that is, there is no peak at all, only a flat line. The ECV is a key finding with the type B tympanogram, and can be either normal (from 0.3 mL to 1.0 mL in children and from 0.65 mL to 1.75 mL in adults [Alencar et al., 2005]), exceedingly small, or excessively large. Refer to Figure 9.25D and you will notice that there is no clearly defined pressure peak to this pattern, and there is essentially no compliance either; it is basically a completely flat or near-flat line.

Regardless of the ear canal size (the ECV measure), a flat type B tympanogram generally suggests that no eardrum movement can be detected (as illustrated by the flat line). This can occur for a variety of reasons. In order to properly interpret a type B tympanogram, one must look to the ECV measure along with a visual inspection of the ear canal. Visual inspection (otoscopy) often helps us decipher the meaning of the tympanometric findings. In cases of a low ECV and a flat type B tympanogram, one must consider an occlusion in the ear canal by wax, foreign object, and the like. The ECV reading is being taken not to the point of the eardrum but to the point of the foreign object or wax in the canal. An eardrum that is bulging from the pressure of fluid in the middle ear cavity will yield results characterized by lower ECV as well. In cases of a high ECV and a flat type B tympanogram, one must consider that the reading obtained reflects a hole or perforation in the ear drum itself, whether by the placement of a pressure equalization tube or pathology, the reading incorporates the volume of the ear canal as well as the volume of the middle ear cavity in these cases. Combining these pieces of information can not only assist us in establishing the significance of the type B pattern, but also enable us to make the appropriate recommendations. Since these conditions can often be visualized by the naked eye, otoscopy becomes an important diagnostic tool in these cases.

A type B tympanogram is often associated with a conductive and sometimes mixed hearing loss. As with the previously discussed abnormal tympanogram findings, regardless of whether the pure tone screening has been passed, a referral to an audiologist and/or an otologist is required.

Type C Tympanogram

As you will notice, the pattern of the type C tympanogram is one in which the pressure peak is in the abnormally negative range. Peak pressure values that fall beyond $-200$ daPa/mmH$_2$O are considered outside the normal range (Margolis & Hunter, 2000). The compliance of a type C tympanogram typically falls within normal limits (between 0.25 mmho/cc/mL and 1.05 mmho/cc/mL for children and between 0.3 mL and 1.7 mL for adults), although slightly reduced compliance with the Type C is not terribly uncommon. The value of the ECV in a type C tympanogram is typically normal (from 0.3 mL to 1.0 mL in children and from 0.65 mL to
1.75 mL in adults [Alencar et al., 2005]). A type C tympanogram is illustrated in Figure 9.25E.

A type C tympanogram reflects a retraction of the eardrum and a system of negative pressure in the middle ear space. This condition can be caused by a partially blocked Eustachian tube, and is often seen with allergies or the developing or resolving of an ear infection. These individuals need to be monitored, and referral to an audiologist and/or otologist is recommended.

**Acoustic Reflex Testing**

As mentioned previously, the reporting of results of acoustic reflexes as part of the middle ear test battery has fallen from diagnostic favor over recent years. However, there still lies clinical use of the data in some cases. The SLP may see within the audiological report of findings a mention of their presence or absence, especially in cases of pseudohypacusis. Again, results should corroborate pure tone findings as a reliability check. Again, further interpretation of acoustic reflex findings to identify retrocochlear pathology concerns has fallen from the audiologist’s repertoire of test result interpretation.

**Otoacoustic Emission (OAE) Interpretation**

In addition to its utility in estimating the presence or absence of auditory dysfunctions, there are many other clinical applications for otoacoustic emissions (OAEs). However, much of this information is beyond the intended scope of this text. We are, therefore, limiting our discussion to what is most appropriate and necessary for you within your scope of practice as an SLP.

To reiterate, OAE testing is not actually a hearing test; rather, it assesses the functional health of the structures in the cochlea. When the cochlea is functioning properly, the OAE response is observed. In the majority of the population, this presence of a normal OAE response also means that the person has normal or near-normal hearing. However, because a person can have a normally functioning cochlea and then have a physical anomaly further along the auditory pathway that may produce a hearing loss, OAE results, viewed alone, should never be the determining factor in the diagnosis of hearing loss. Auditory neuropathy syndrome disorder (ANSD) is an example of such retrocochlear pathology.

With that caveat in mind, the OAE is an immensely useful tool; it allows us to glean the presence of normal hearing and alerts us to potential impairments. The first thing we can establish based on the presence of an OAE response is that there is no conductive pathology, regardless of whether it is the transient-evoked otoacoustic emission (TEOAE) or the distortion product otoacoustic emission (DPOAE) that has been tested. This means that the conductive mechanism (outer ear and middle ear) is free and clear of blockage and dysfunction. The reason we know this is quite simple—a pathology or blockage would physically prevent the forward and reverse transmission of sound on which the test is based.

Now, let us consider the additional significance of a response from each of the two separate types of OAE: the TEOAE and the DPOAE. The presence of a TEOAE response means that the outer hair cells in the sensory organ of the cochlea are working; in most cases, this means normal/near-normal hearing sensitivity as well, or at least not poorer than approximately 30 dB HL (the mild range of hearing loss; Hoth, Polzer, Neumann, & Plinkert, 2007). The significance of the DPOAE response is also that of a functioning cochlea, specifically the outer hair cells; however, in the case of the distortion product, the response can be seen with hearing levels up to approximately 40 dB HL to 50 dB HL (in the mild to moderate range; Schmuziger, Patscheke, & Probst, 2006). Therefore, the DPOAE response generally suggests hearing levels no poorer than the mild to moderate range, with no evidence of conductive (outer/middle ear) pathology. Figure 9.26 illustrates a normal DPOAE result.
Finally, there are common findings of both types of emissions that must be remembered. Specifically, conditions beyond the level of the cochlea can leave the OAE response intact, such as in the case of a child with ANSD. This can give a family a false sense of security about their child or loved one's hearing status. This is one reason why newborn hearing screening programs utilize a combination of both OAE and the auditory brainstem response (ABR). When reviewing the history and test results, if your patient passed the OAE screening, yet concerns remain, a referral to an audiologist for a complete diagnostic workup is essential.

**Auditory Brainstem Response (ABR)**

The ABR has multiple clinical applications, most of which fall outside the scope of this text. For our purposes we will again be limiting our discussion to what is most appropriate and necessary for you within your scope of practice as an SLP. It bears repeating that the ABR response is not a direct measure of hearing sensitivity; rather, it is a measure of the functional integrity of the auditory nerve up to and including the brainstem. Based on the information the test yields, we can glean estimates of hearing sensitivity that can later be confirmed with additional test procedures.

The types of ABR response modes we see employed when the test is performed to estimate audiometric function are either the screening “pass”- or “refer”-type responses, or diagnostic decibel threshold search results. When the results of an ABR screening indicate the individual has passed the test, it is assumed that the screened ear is functioning normally and that further testing is not warranted. When a refer response is obtained, further diagnostic assessment is necessary and referral to an audiologist for a complete evaluation is recommended. When the refer result is obtained, no conclusions should be drawn beyond the need for referral; there can be many reasons for someone not passing the ABR screening, ranging from the existence of a hearing loss to simple testing inaccuracies. Figure 9.27 illustrates normal ABR threshold search results.

When a diagnostic ABR has been done for the purpose of a threshold search, the results may be reported in a decibel reference known as dB n HL, with \( n \) signifying above normal hearing level. A response in dB n HL is within approximately 10 dB to 20 dB of the person’s behavioral response to sound (dB HL). Therefore, if results show, for example, an ABR response is at 65 dB n HL, we can assume that the behavioral hearing threshold will be at perhaps 45 dB HL to 55 dB HL, which is at the level of a moderate hearing loss (refer to the earlier section on moderate hearing loss).

**Questions to Guide Your Interpretation**

You should now have enough information to understand the meaning of the results in front of you. By asking yourself a few simple questions, you should
Can You Identify Behavioral Versus Nonbehavioral Results?

At first glance, the obvious implication of this question is: Can you distinguish between those tests that require a behavioral response and those that do not? The tests that require a behavioral response include, for example, pure tones and speech audiometry; the nonbehavioral tests include tympanometry and electroacoustic and electrophysiologic procedures. The implication that may be less obvious is: Do the specific procedures employed make sense based on the patient’s chronological age?

Let us consider the situation in which a child has been referred to you for a speech-language evaluation; in preparation you are reviewing the audiologic report. You notice that the procedures completed include tympanometry, acoustic reflex testing, and OAE. Now you take note of the date of birth and calculate that the patient is 9 years of age. The knowledge of the child’s age and that the tests employed are all nonbehavioral objective types of procedures should immediately raise the question of whether pure tone testing was attempted, what this child’s developmental age might be, and so on. The mere knowledge of the difference between what is behavioral and what is not can quickly guide you and assist in establishing your differential diagnosis.

Is There a Hearing Loss?

Whether there is the presence or absence of hearing loss, of any degree or type, must be ascertained. Speech-language services should not commence until you know the answer to this question and the questions that follow, should a hearing loss exist. If there is no hearing loss, yet there is still concern about speech-language development, a referral for a complete audiologic evaluation should be made because there are many etiologies for progressive and late-onset hearing loss. Do not let the fact that a child may have passed a newborn infant hearing screening create a false sense of security regarding hearing status.

What Are the Type, Degree, and Configuration of the Hearing Loss?

Assuming you have established that your patient has a hearing impairment, what is the nature of the hearing loss? Is it conductive, sensorineural, or mixed? What is the degree? Is it in one ear or both? Is the configuration of the hearing loss consistent with a known pathology or genetic predisposition? Remember, especially in the case of children, a slight or mild degree of hearing loss does not equate
with a slight or mild communication impairment. Refer back to the appropriate sections to review information about each of these categories and characteristics.

What Are the Speech Audiometry Findings?

You have determined the nature and the severity of the hearing loss for this patient. Look now at the results of speech audiometry, and consider the following questions:

• What is the SRT? Is it in agreement with the PTA?
• If an SRT could not be obtained and an SDT was obtained instead, why?
• What is the WDT score in each ear, and at what dB presentation level was the test performed?
• Does the presentation level of WDT and the score obtained make sense based on the pure tone findings?
• Look at the WDT score one ear at a time and together. Knowing that these scores represent the best possible speech discrimination skills, what does it say about this patient’s potential communication ability?
• Was the WDT test done with the addition of background noise? If so, what are the findings (i.e., will this patient have additional difficulties in noisy settings)? If so, what additional accommodations might need to be made?

What Are the Diagnostic Findings for the Outer Ear?

The initial consideration might involve the results of visual inspection of the pinna: Are there any malformations or abnormalities, such as atresia, microtia, ear tags, or keloids? What are the results of otoscopy? Is there any indication of excessive wax or other foreign body in the ear canals? Is there a PE tube visible in the ear canal or tympanic membrane? Has the tympanic membrane been visualized? Were any abnormalities noted in its appearance? If the diagnostic findings show evidence of the possibility of any outer ear pathology, has a medical/otologic referral been recommended?

What Are the Diagnostic Findings for the Middle Ear?

When considering diagnostically significant findings related to the middle ear, how do they relate to the results of the otoscopy? Is there any indication that there is perhaps occluding or partially occluding cerumen, a perforation of the eardrum, a meniscus (fluid line) visible on the eardrum, bulging and/or pus-filled outer/middle ear, or the like? These otoscopy findings will manifest themselves in the tympanometry results as well.

What do the results of tympanometry reveal? What type or configuration of tympanogram is reflected in the report? Is it a type A, As, Ad, B, or C? Do the tympanometry findings corroborate the presence of either a conductive or mixed hearing loss? Any abnormal tympanometric findings, individually or in combination with abnormal otoscopy results, can indicate the possibility of middle ear pathology and a recommendation for a medical/otologic examination should have been made in the report.

Do tympanometry results match the audiogram? Normal (type A tympanograms) tympanometric findings are associated with normal hearing and sensorineural hearing loss, whereas abnormal tympanometric results are associated with conductive and mixed types of hearing loss.

Are There Other Nonbehavioral Diagnostic Findings, and If So, Do They Match the Audiogram?

Are there other audiometric findings, such as OAEs, acoustic reflexes, or ABR? Each of these procedures may potentially add significant diagnostic information. Carefully review the audiogram, the evaluation
What Is the Reported Reliability?

Each time the patient is tested, the audiologist should make a statement regarding the reliability of behavioral results. This information is very important and may provide valuable insight into the patient on its own. When reliability is judged to be very good, this tells us that the examiner trusts the information obtained. Conversely, if reliability is poor, one must then look further. For example, if a patient is a young child or a child with multiple disabilities, has further testing been recommended (e.g., additional test sessions, sedated diagnostic ABR study, and the like)? If a patient is an adult with poor reliability, one must also investigate why this is possibly the case. Such reasons might include pseudohypacusis (see the following section), multiple impairments, developmental delays, and so on.

Pseudohypacusis

Pseudohypacusis is one of many terms used to refer to a false or exaggerated hearing loss—that is, hearing loss that is not organic in nature. The numerous terms used that can be found in the literature may reflect the many reasons why a person might present with a hearing loss, either wittingly or not, when a loss does not exist. Some of the other terms found include nonorganic hearing loss, psychogenic hearing loss, malingering, and functional hearing loss. Regardless of the reasons why this type of hearing loss might exist—a topic that is interesting but beyond the scope of this chapter—it is critical that the audiologist and SLP be alert to the signs that a true organic hearing loss might not exist, or at least not to the degree shown. There are many indicators of pseudohypacusis; we will discuss some of them in this section.

An alert clinician will be able to glean much diagnostically useful information before the actual testing procedures begin. Some mannerisms frequently observed in such cases are exaggerated difficulty hearing during the case history interview, such as leaning one’s ear in toward the audiologist speaking, squinting of the eyes, or frequently asking “huh” or “what.” Alternatively, the patient may not appear to experience difficulty communicating during the interview process, but may present with a significant handicapping hearing loss during behavioral testing. Either way, there is an unexplained discrepancy. Another red flag is whether the individual is anxious to have insurance or disability paperwork completed by the examiner.

Results of behavioral audiometry can also provide strong indications of pseudohypacusis. For example, if the pure tone responses are inexplicably poorer than the results of speech audiometry (SRT and/or WDT scores), pseudohypacusis should be strongly suspected (refer to Figure 9.28). Similarly, if a person claims not to be able to respond to pure tones until a very intense 100 dB HL, but then is able to repeat back words (for WDT) with excellent accuracy when the words are presented at the much lower average conversational level of 50 dB HL, a case of pseudohypacusis must be suspected. Another indication that this type of condition may be present is when a person shows normal hearing in one ear and a total loss of hearing in the other ear before the masking process has been performed (Figure 9.29). This would not be possible, because cross-hearing/cross-over would occur. In a real case of normal hearing in one ear with a profound hearing loss in the other ear, hearing test results before masking (refer back to Figure 9.12) would show a shadow curve. Additionally, these individuals will also frequently show very poor test–retest reliability; that is, the results obtained from one session may be significantly different from those obtained even 1 hour later.

Other indications of pseudohypacusis include differences between the behavioral and nonbehavioral test results. For example, if a patient is volitionally showing a severe to profound hearing loss in both ears when tested using pure tones, and then
Figure 9.28 An audiogram illustrating an example of pseudohypacusis. Notice the inconsistency between the pure tone averages and the results of SRT and WRT testing.

Figure 9.29 An audiogram illustrating another example of pseudohypacusis. Notice the lack of a shadow curve before masking has been performed.
the OAEs are all completely within normal limits and the ABR is also normal, pseudohypacusis must immediately be suspected.

A number of tests can be done proving the presence of pseudohypacusis. Frequently, when a false or exaggerated hearing loss is suspected, a clinician will turn to the nonbehavioral measures such as acoustic reflexes, OAE and ABR; however, there are several behavioral test techniques specifically designed for this purpose, relegated to the practice of audiology, that can provide the information necessary to establish that the hearing loss has a nonorganic cause. Whenever there is the suspicion of pseudohypacusis, or the results do not appear to make sense for whatever reason, a referral is essential.

Counseling with Your Audiogram

A comprehensive presentation of the role of the communication disorders specialist in counseling is far beyond the scope of this chapter; some of the components of the counseling process include psychosocial support, individual and family counseling, and assertiveness training in addition to the need for informational counseling and guidance. We strongly encourage all SLPs and audiologists to further explore this area on their own. Nevertheless, this is a very appropriate time to point out that the audiogram itself may be very instrumental in the informational portion of the counseling process. The following sections present two tools that the SLP may find useful when working with patients, their families, and loved ones.

Speech Banana Audiogram

One of the methods used to convey the significance and impact of a person’s hearing loss is to use the speech banana audiogram (see Figure 9.30), which is a typical audiogram with a shaded banana-shaped area on it that is positioned in such a way as to represent the approximate frequency and intensity of most common speech sounds. Some professionals find it useful to superimpose a patient’s hearing test results onto this type of audiogram to visually

Figure 9.30 The speech banana audiogram, charting the typical frequency and intensity locations of the phonemes of speech.
explain the impact the hearing loss will have on his or her ability to hear normal conversational speech. When the Xs and Os of the audiogram fall well above the banana-shaped area, the person should be hearing speech sounds comfortably. However, if the Xs and Os fall below, this suggests that the sounds of average-level conversational speech are inaudible to him or her.

**Familiar Sounds Audiogram**

Like the speech banana audiogram, the familiar sounds audiogram (see Figure 9.31) is another tool that may be used to help explain to patients and their families what kind of impact the hearing loss may have on their ability to function and respond to sounds that are routinely encountered in everyday life. Although the placement of the objects on the familiar sounds audiogram is approximate, the form is a very useful tool, particularly when dealing with a patient who has been newly diagnosed with hearing impairment. It may be desirable to use a form that contains both familiar sounds and the speech banana. An example of this type of audiogram is shown in Figure 9.32.

![Figure 9.31](image-url) An example of a familiar sounds audiogram, displaying the approximate frequency and intensity of several everyday sounds.
Summary

In this chapter we have described the results of the evaluation process: typical results and their interpretation. It bears repeating that the most comprehensive picture of an individual’s functional ability can be obtained only by reviewing the results in their entirety. The SLP must have a firm understanding of how to go about the process of interpreting the information to best understand the implications and appropriately utilize the information in the implementation of intervention strategies.

It is important to reiterate that the goal of this particular chapter is to help the SLP gain a secure and comfortable understanding of the test.

Figure 9.32  An audiogram with both familiar sounds and the speech banana superimposed on it.
results and their implications. If the test results do not make sense to you, find an audiologist with whom you can network. If your interpretation of the results has left you with more questions than answers, do not proceed with inaccurate information or results that you either do not understand or with which you do not feel confident. Inaccurate results and/or misdiagnoses happen; although we hope they are infrequent, they do occur.

**Discussion Questions**

1. A child is referred to you by his kindergarten teacher. She indicates that an audiological evaluation was recently completed (within 1 month), revealing a mild sensorineural hearing loss. Describe some behaviors that the teacher should expect from such a student. What are some questions you would ask the parents of this child?

2. What are the reliability measures between pure tone audiometry and speech audiometry that you should always double check?

3. If a child has a moderate conductive hearing loss based on pure tone and speech audiometry, what findings would you expect to see for tympanometry? For otoacoustic emissions?

4. Why would the familiar sounds audiogram and the speech banana be useful counseling tools for the speech-language pathologist?

5. You have received an audiological report and audiogram from an unknown clinical facility. Your personal clinical judgment tells you that two of the test results just do not corroborate each other. Hypothetically, choose those two measures. What about them does not make sense? What is your next step?

**References**


CHAPTER 10

AUDILOGICAL DIAGNOSES, ETIOLOGIES, AND TREATMENT CONSIDERATIONS

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KEY TERMS

- Acoustic neuroma
- Anotia
- Atresia
- Autoimmune inner ear disease
- Autosomal dominant
- Autosomal recessive
- Bilaterally
- Cerumen
- Cholesteatoma
- Collapsed canals
- Congenital
- Diplacusis
- Effusion
- Eustachian tube dysfunction
- Hyperacusis
- Impacted cerumen
- Loudness recruitment
- Malignant (necrotizing) otitis externa
- Mastoiditis
- Mastoidectomy
- Meniere’s disease
- Meningitis
- Microtia
- Noise-induced hearing loss (NIHL)
- Neurofibromatosis type 2
- Ossicular discontinuity
- Ossicular malformation
- Otalgia
- Otitis externa
- Otitis media
- Otosclerosis
- Otospongiosis
- Ototoxicity
- Perforated tympanic membrane
- Periauricularly
- Presbycusis
- Site of lesion
- Silent ear infection
- Suppurative
- Swimmer’s ear
- Tinnitus
- Unilaterally
- X-linked

OBJECTIVES

- Name the type of hearing loss and the anatomical location of the auditory system with which it is associated.
- Identify and describe some of the common etiologies that produce conductive hearing loss.
- Identify and describe some of the common etiologies that produce sensorineural hearing loss.
- Identify and describe some of the common etiologies that produce mixed hearing loss.
- Discuss some of the medical and audiological characteristics of different etiologies of hearing loss.
- Identify and describe some of the non-site-specific etiologies of hearing loss.
Introduction
In as much as we have covered how hearing is evaluated, how to read an audiogram, and how to interpret the results, the next step is to connect those results with a diagnosis. There is a distinct difference between identifying the presence of hearing loss and identifying the reason that hearing loss exists. In some cases, it is due to a medical diagnosis that has been determined by a physician; in other cases there is an etiology of the hearing loss that is not necessarily connected with a treatable medical condition. While the content of this chapter is intended to provide the speech-language pathologist (SLP) with an overview of the most common diagnoses and etiologies, it is by no means exhaustive.

Diagnoses and Etiologies of the Outer Ear
There are several common physical abnormalities of the outer ear that can cause hearing loss. Anatomically, as you will recall, the pinna and external auditory meatus (ear canal) collect and channel sounds from our environment to the tympanic membrane. Therefore, any abnormality in this area would result in a conductive hearing loss.

Conductive Hearing Loss
As described previously, a conductive hearing loss is the result of any type of damage occurring within the conductive mechanism. Audiometrically, this manifests as air conduction (AC) thresholds being outside of the normal range and bone conduction (BC) thresholds being within normal limits (see Figure 10.1); hence, the presence of air–bone gaps. Functionally, this type of hearing loss often results in a loss of sensitivity, but not a loss in the clarity of speech as long as it is sufficiently loud for the person to hear the words.

Visual Inspection and Otoscopy
In many cases, a disorder of the outer ear will be visually evident. A superficial otoscopic inspection becomes a valuable procedure in identifying the etiology of an outer ear disorder. Whether it is inflammation, drainage, malformation, blockage, or foreign body, all are easily identified visually. Refer to Figure 10.2A and Figure 10.2B.

Figure 10.1 An audiogram illustrating a bilateral conductive hearing loss.
Tympanometric findings

Tympanometric findings may or may not be abnormal in a disorder of the outer ear. In a case of a malformation or foreign body, a telltale finding revealed through tympanometry would be a significantly lower ear canal volume than average for the person’s age, while compliance may either be within a normal range (type A, pictured in Figure 10.3A) or slightly reduced (Type As, pictured in Figure 10.3B). In the case of a complete blockage, one would discover both a low ear canal volume and no tympanic membrane compliance (Type B, pictured in Figure 10.3C) because the reading for compliance would be taken from the blockage itself and not the tympanic membrane. Lastly, in the case of significant negative middle ear pressure, one would see a type C tympanometric pattern, pictured in Figure 10.3D.

What follows is a brief description of the more common pathologies of the outer ear, as well as some general information regarding medical and/or audiologic treatment options. The interested readers are encouraged to explore the references at the end of this chapter for more information on the disorders presented.

Microtia and Atresia

Microtia is a congenital deformity of the ear, and it may include a wide array of abnormal appearances of the pinna and additional structural anomalies such as a misshapen, extremely narrow or nonexistent external auditory ear canal, abnormalities of the tympanic membrane, numerous structural

Figure 10.2A Drainage from the external ear canal.

Figure 10.2B Bug in the ear.
Figure 10.3A  The diagram above shows a normal type A tympanogram, which is consistent with normal middle ear function.

Figure 10.3B  A shallow type As tympanogram, which is consistent with a stiff middle ear system.

Figure 10.3C  A flat type B tympanogram, which is consistent with abnormal middle ear function.

Figure 10.3D  A type C tympanogram, which shows significant negative middle ear pressure.
deformities of, or missing, middle ear ossicles, or any combination of the above. It is for this reason that while the term “microtia” specifically refers to anomalies of the auricle (pinna), more than 90% of patients with microtia experience conductive hearing loss on the affected side (Cox, Camci, Vora, & Luguetti, 2014) as a result. Most cases of microtia occur unilaterally (one side only), affecting the right ear more commonly than the left, and males more so than females (Cox et al., 2014; Lugueti, Heike, Hing, Cunningham, & Cox, 2012; Patil et al., 2012).

The severity range is from very mild to a complete absence of the pinna (anotia) and may be accompanied by an absence of an opening to the external ear canal (atresia). A common grading classification of microtia (see Patil et al., 2012) includes anotia and three grades. Grade I is characterized by a smaller-than-normal pinna with many normal features preserved, and can occur with or without atresia (closing off) of the external ear canal. Grade II has an earlobe and some other recognizable features, but the helix and other landmarks are not fully developed. Grade III is perhaps the more commonly recognizable form of microtia, with a tissue mass that does not resemble a pinna; the ear canal is usually missing (atresia). Finally, there is the condition known as anotia, which is the most severe form of the disease and is characterized by a complete absence of the pinna and ear canal (atresia).

Given the wide variability in the expression and severity of this condition, there are many different treatment recommendations that may or may not be appropriate. However, regardless of the expression of the condition, the lack or absence of a pinna and lack of or absence of an external ear canal will result in a hearing loss that is most commonly conductive in nature. While treatment may include medical/surgical options, an extensive examination and work-up by an interdisciplinary team is necessary in order to arrive at the most appropriate treatment plan for the patient. This may include the pediatrician/primary care physician, otologist, audiologist, SLP, and others as needed.

**Collapse of the External Auditory Meatus (Collapsed Canals)**

The pinna and the outer portion of the external ear canal normally have soft skin overlaying stiffer cartilage. For some people—often the elderly, those with craniofacial abnormalities, or the very young child—the tissues and cartilage of the ear canal are or have become very soft. While this does not ordinarily cause concern for hearing loss, it can confound test results or cause temporary hearing loss if the individual is wearing apparel, headphones, or even eyeglasses that cause the ear canal to close in on itself. During the audiological testing procedure, this condition becomes problematic when supraaural earphones are used. What may occur for those with “very soft” tissue/cartilage is that the pressure from the earphone may cause the canal to collapse and prevent the test sounds from entering the ear.

When collapsed canals are suspected, one solution would be for the professional to use insert earphones for pure tone air conduction testing, instead of supraaural earphones. This will ensure that the ear canal remains open and the test sounds are being appropriately delivered down the ear canal to the eardrum and further. If you are a speech-language pathologist performing a screening prior to evaluation and/or therapy and your portable air conduction audiometer does not have insert earphones as an option, make note of your suspicions and be sure to refer for a complete audiologic evaluation. Again, the condition may also occur if the individual is wearing something that creates pressure periauricularly, that is around the pinna and ear canal itself, causing the ear canal to collapse. When providing therapy for an individual with such a condition, requesting that they remove anything that may cause collapse prior to the beginning of a therapy session would be prudent.
Impacted Cerumen (Ear Wax)

Cerumen, also known as ear wax, is a substance that is produced by the body for the purpose of keeping our ear canals lubricated, clean, and protected from dust, bacteria, and other microorganisms that can enter and potentially irritate and infect the skin of our ear canals. It is a normal bodily function to produce ear wax, and for most people the movement of the jaw from speaking and chewing will move the wax to the outside of the ear canal where it will naturally flake off (self-clean).

There are many reasons why this natural process may not occur; for example, some people may produce excessive amounts of wax, use hearing aids or other devices that “plug up” the ear canal, or try to clean their ears using cotton swabs and, while removing some of it, succeed in pushing a portion of the wax further into the ear canal. Any of these scenarios is likely to result in the condition known as impacted cerumen, which in turn can cause a conductive hearing loss.

It is strongly recommended that the patient consult with his or her physician if impacted cerumen is suspected. It is first and foremost advised that cotton swabs (and other similar items) never be used to clean your ears. The only ear cleaning recommended is a soft cloth on the outside of the ear. When cerumen does become impacted, for whatever reason, there are a number of possible solutions but should always be managed by a healthcare provider. While there are many over-the-counter products intended to soften ear wax, a physician or other healthcare professional will be able to inspect the ear with an otoscope to ensure that there are no additional problems or concerns. The wax may then be removed by the professional or other appropriate recommendations will be made.

Foreign Bodies

“Never stick anything smaller than your elbow in your ear” is a phrase repeated by many a grandmother throughout time. However, as many times as granny may echo this warning, there are those who fail to heed the advice. Particularly in younger children, the curiosity of their physical being and the desire to determine the size of their ear canal has lead to many objects being inserted into the external ear canal: plastic building blocks, beads, small round objects, and doll shoes are just a few in a seemingly exhaustive list of objects small enough to fit into a child’s ear canal. However, children are not the only culprits. Adults trying to relieve an itching feeling, for example, may have the tip of a pencil eraser break off in their ear, or the end of a cotton swab. Older adults with impaired cognitive function may likewise place objects in their ears seemingly without cause or reason. Because the ear canal is a warm, dark environment, insects have also been known to enter the ear canal during one’s sleep.

Symptoms of the presence of a foreign body in one’s ear are similar to that of impacted cerumen. Severe ear pain (otalgia) may occur, along with a feeling of fullness, because typically the object has become stuck in the canal. Complete blockage of the external ear canal by a foreign body will cause a conductive hearing loss.

The extraction of a foreign body from one’s ear canal should only be accomplished by a physician. Any attempt to remove the object by an individual other than a trained medical professional can cause further damage to the ear by forcing the object further down the ear canal and potentially through the tympanic membrane. Because the pain that could be caused by the extraction of the object may be unpleasant to some, especially young children, sedation may be recommended for the extraction procedure.

Otitis Externa

Otitis externa, sometimes referred to as swimmer’s ear, is the general term used to describe an inflammation of the skin of the external ear canal. There are many potential causes of otitis externa, ranging in severity from common fungal and bacterial infections in young children, those participating in athletics, and the like to the rarely occurring
malignant (necrotizing) otitis externa that may occur in the elderly diabetic or immunocompromised patient (Bhat et al., 2015). Some common characteristics of this disease include tenderness of the tragus, otalgia, irritation and itching, aural fullness, and discharge from the ear canal (Hui, 2013). In instances where it is severe enough to cause swelling of the ear canal, a temporary conductive hearing loss may occur as well.

Treatment for otitis externa will vary depending on the etiology. The common fungal and bacterial causes may simply require temporarily refraining from swimming/bathing and/or antibiotics and topical solutions prescribed by a physician. Treatment for the more severe malignant form is more involved and may include medicines and surgery; additionally, because patients with this form of the disease often have a compromised immune system, there would appear to be a greater risk of recurrence of the condition.

Diagnoses and Etiologies of the Middle Ear
Moving from pathologies of the outer ear that result in hearing loss, there are likewise numerous pathologies of the middle ear that will impede the conduction of sound as well. Anatomically, pathologies of the middle ear will also cause conductive hearing loss, like those resulting from outer ear pathologies (refer to Figure 10.1). Structurally, the tympanic membrane is the point at which the middle ear begins: the boundary where acoustic energy is converted to mechanical energy and channeled through the ossicular chain (malleus, incus, and stapes) to the oval window of the cochlea.

Perforated Tympanic Membrane
A perforated tympanic membrane, also referred to as a ruptured tympanic membrane or ruptured eardrum, is a tear in the thin membrane that separates the outer ear canal from the middle ear cavity. Etiologically, tympanic membrane perforations are due either to inflammation or trauma. While anyone of any age may experience a perforation, acute otitis media with subsequent drum perforation and ear discharge predominantly affects children younger than 5 years (Morris, 2005). Many of the perforations due to otitis media heal spontaneously, unless there is a coexisting Eustachian tube dysfunction that is the main reason for the permanent perforation (Santhi and Rajan, 2012). Another possible cause of a perforation is by inserting an object, such as a cotton swab or a hair pin, into the ear canal so deeply so, that it punctures the tympanic membrane. Children may also accidentally puncture their eardrums using toys, sticks, or other objects. Symptoms of a ruptured tympanic membrane may include severe acute pain, prolonged pain/discomfort, drainage, tinnitus (ringing or buzzing in the ear), and hearing loss that may range from minimal to moderate in degree.

In discussing treatment options, remember that a perforated eardrum can be caused by or lead to serious medical conditions and, therefore, regardless of its etiology, the identification or suspicion of a ruptured eardrum requires an immediate referral to a medical professional. There are several medical (e.g., topical or systemic antibiotics) and surgical (e.g., myringoplasty, tympanoplasty) treatment options for this condition. Only a medical professional should diagnose and treat tympanic membrane perforation. Audiological testing should be done throughout, both preceding and following medical intervention.

Otitis Media
Perhaps the most common referral made to an audiologist is the manifestation of hearing loss secondary to otitis media. However, it is imperative to note that otitis media is a medical diagnosis and therefore cannot be determined by anyone other than appropriately credentialed medical personnel (physicians, nurse practitioners, and the like). Otitis media can be defined as an inflammation or infection of the middle ear. It can occur in one or both
ears simultaneously, and, if bilateral, can be in varying stages of the infection cycle in each individual ear. While it is extremely common in children, ear infections do occur in adults as well. Statistics vary from source to source, but it has been reported that at least 80% of children will experience one or more bouts of otitis media before they reach 3 years of age (Liberman, Liberman, & Maison, 2015), and 90% of children can be expected to have at least one episode of otitis media with effusion before school age (Harmes et al., 2013).

The etiology of otitis media has been associated with the presence of a pathogen, Eustachian tube dysfunction, allergies, colds, upper respiratory tract infections, and environmental factors (e.g., bottle feeding, supine feeding, attending daycare, living in a home in which someone smokes, socio-economic status [Rovers, de Kok, & Schilder, 2006]). It may be subcategorized according to duration (e.g., acute, recurring, or chronic) and presence of fluid and/or infection (e.g., with or without effusion [fluid], or suppurative [containing discharge or pus]). Common characteristics of otitis media may include any of the following: crying, sleeplessness, pain, aural fullness, irritability, pulling or tugging at the ears, drainage from the ears, headache, neck pain, inconsistent response to sound, and (conductive) hearing loss. There is however, a confounding element of otitis media as well, called silent ear infection. For reasons unknown, some children are completely asymptomatic, and so the presence of the pathology can go undiagnosed because the parent or caretaker does not see any of the above symptoms that would warrant a visit to the pediatrician.

The degree of conductive hearing loss associated with otitis media can vary from minimal to moderately severe. However, it should be noted that the severity of the ear infection does not always correspond to the severity of the hearing loss. The effect an ear infection has on an individual’s hearing sensitivity varies from person to person. It is critically important to understand that presence of otitis media can lead to additional medical diseases, such as cholesteatoma, mastoiditis (infection/ inflammation of the mastoid bone), meningitis (inflammation of the meninges caused by the spread of infection), and other less common complications, but no less severe.

Treatment for otitis media will depend on the individual’s specific diagnosis. Routine medical/otologic and audiologic referrals, examinations, and management are imperative. From a treatment perspective, medications (e.g., antibiotics) and/or surgeries (e.g., myringotomy, myringotomy with pressure equalization [PE] tube insertion) are often successful. It is not uncommon, however, to encounter a situation where a patient’s episode of otitis media is not successfully eradicated. The importance of ongoing medical/otologic management cannot be overstated. Additionally, from a functional perspective, not only is there a degree of hearing loss that most likely will be associated with otitis media, but there may be associated developmental, academic, or workplace difficulties that should also be addressed. In such cases, collaboration is key; physicians, audiologists, speech-language pathologists, classroom teachers, and others should be involved in the intervention process in order to appropriately and effectively meet the individual’s ongoing needs. You must also remember that the hearing loss caused by otitis media will fluctuate as the individual responds to medical treatment; therefore, management and planning must be closely monitored for appropriateness of the recommendations made. What will accommodate an individual one day may not be an appropriate accommodation another as the pathology resolves.

There is a plethora of information regarding interventions for otitis media; there are numerous current research articles, book chapters, and entire textbooks devoted to the topic of otitis media and its impact medically, developmentally, academically, and so forth. All interested readers are strongly encouraged to explore the vast wealth of knowledge available in the literature for additional information and guidance in this area. Again, while the practicing audiologist sees many a patient with symptoms that are associated with otitis media and is within
his/her scope of practice to diagnose a conductive hearing loss that may be consistent with middle ear pathology, the specific diagnosis of otitis media can only be made by a medical professional.

**Eustachian Tube Dysfunction**

As part of the middle ear system, the role of the Eustachian tube is to provide a means by which the pressure inside of the middle ear cavity is equalized to that of atmospheric pressure. Anatomically, the Eustachian tube courses from the inferior section of the anterior wall of the middle ear to the back of the nasal pharynx. A small sphincter muscle on the end of the tube allows for opening and closing as needed for pressure equalization. Because a large majority of upper respiratory infections begin in the nasal pharynx, a swelling of the membrane results. This edema prevents the proper function of the sphincter muscle. When pressure cannot be properly equalized between the middle ear cavity and the nasal pharynx, this condition is referred to as **Eustachian tube dysfunction**.

Symptoms of Eustachian tube dysfunction can include chronic discomfort with a feeling of fullness in the ear, snapping and/or clicking noise, otalgia, hearing loss, vertigo, recurrent otitis media, and even cholesteatoma (Dalchow et al., 2016). Audiometrically, this condition can manifest itself in a low-frequency, reverse curve conductive hearing loss, typically of minimal to mild degree. The most prevalent finding of Eustachian tube dysfunction is a Type C tympanogram, like that seen in Figure 10.3D. Because the pressure in the middle ear cavity cannot be equalized with that of normal atmospheric pressure, the peak of the tympanogram will be shifted outside of the range of normal, typically into the negative pressure range. While a less-common finding, a pressure reading outside the range of normal but to the extreme positive range is also possible.

Treatment of Eustachian tube dysfunction will vary. Most often there is no treatment prescribed by a physician other than close monitoring. The reason for such monitoring is that Eustachian tube dysfunction can be a precursor finding for otitis media. If the nasal pharynx is swollen due to an upper respiratory infection, that bacteria or virus can also move up the Eustachian tube into the middle ear cavity. It incubates in what is now the warm, sealed environment of the middle ear cavity and breeds as an ear infection. Eustachian tube dysfunction can also be the indicative finding that an acute otitis is resolving. Once the body responds to antibiotic therapy or other treatment, the fluid that houses the infection becomes sterile again and is slowly reabsorbed into the body. Once the middle ear cavity is clear and the edema of the nasal pharynx begins to resolve, the Eustachian tube once again begins to function as intended. As with otitis media, Eustachian tube dysfunction is a medical diagnosis and the presence of this condition can only be diagnosed by an individual with medical credentials.

**Cholesteatoma**

A cholesteatoma is an abnormal growth of skin that forms behind the eardrum in the middle ear space; less commonly it may occur in the external auditory canal and in nearby skull bones. It is a cyst-type structure that is composed of skin, cellular debris, and tissue that can increase in size as time passes. Cholesteatomas can be **congenital** or acquired; the more-common acquired form is often the result of an ear infection, is considered a severe middle ear pathology, and can affect both children and adults (Shishegar & Ashraf, 2015). Some possible symptoms include pain, drainage with a foul odor, fullness or pressure in the ear, and dizziness. If the cholesteatoma houses infection and spreads, there can be erosion of the bones of the middle ear and surrounding structures, including the inner ear and brain. As a result, when left untreated there is a risk of meningitis, brain abscess, and even death (Mustafa, Kuci, & Behramaj, 2014).

Audiometrically, the resulting hearing loss in individuals with a cholesteatoma will vary greatly. Because this growth is often the result of chronic otitis media, a conductive hearing loss of mild to moderately severe degree can result. However, if
erosion of anatomical structures has occurred and/or surgical intervention has been extensive, these individuals may have a sensorineural component of the hearing loss as well. As you will recall, a mixed hearing loss occurs when both air conduction and bone conduction thresholds are outside of the range of normal, but air–bone gaps are evident. This mixed type of hearing loss is illustrated in Figure 10.4.

Treatment for cholesteatoma may include a variety of medical and surgical interventions. Patients may be medically treated with the use of antibiotics and eardrops with the goal of controlling the infection. Surgical procedures are also often necessary and will depend on the particular medical situation. For example, infection spreading to the mastoid bone may require a mastoidectomy, which is a procedure that removes diseased portions of the mastoid bone. Alternately, if there has been erosion of the bones of the middle ear, reconstruction of those affected structures may be necessary. Unfortunately, treatments have varying degrees of success, and the primary focus must always be on the eradication of the disease condition; consideration of hearing status is important, but secondary to the person’s physical health.

Following successful medical/surgical management of a patient’s cholesteatoma, improvement in hearing sensitivity is typically also realized. However, on average, some degree of conductive hearing loss remains (Lin, 2009). If a sensorineural component of the hearing loss was present prior to surgical intervention, threshold recovery is less likely. Lastly, as with otitis media, collaborative intervention decisions involving all other professionals (physicians, audiologists, speech-language pathologists, classroom teachers, etc.) may be necessary in order to appropriately and effectively meet the patient’s needs. The diagnosis of cholesteatoma itself is, as with other conditions of the outer and middle ear, is made by an appropriately credentialed medical professional, not an audiologist or SLP.

Otosclerosis

Otosclerosis (or otospongiosis) (refer to Figure 10.5) is an inherited disease that is characterized by abnormal growth of bone, potentially affecting the middle and inner ears. The onset of otosclerosis is marked by spongy bone growth in the labyrinth of the inner ear that usually targets the stapedial footplate (Garstecki & Erler, 2002). This
condition is more common in females; the onset is at approximately 20 years of age and the condition progresses over time. Those with otosclerosis may also suffer symptoms of tinnitus and occasionally dizziness.

Audiometrically, the earliest symptoms of otosclerosis include a mild conductive hearing loss that becomes progressively worse. As the condition progresses, a characteristic decrease in bone conduction hearing at 2000 Hz (known as a “Carhart Notch”) manifests itself in many patients. In more severe cases, as the growth extends to the labyrinth of the inner ear, a sensorineural component will also exist, causing a mixed hearing loss.

Diagnosis and treatment for otosclerosis, like most conditions described previously in this section, requires a referral to a medical professional. Initial medical treatment may involve sodium fluoride (Garstecki & Erler, 2002); in later stages surgical procedures (e.g., stapedectomy) may be recommended.

Ossicular Disruption (Ossicular Discontinuity/Ossicular Malformation)

Anatomically, the ossicular chain—the malleus, incus, and stapes—are connected together and attach to the tympanic membrane and the oval window of the cochlea. A traumatic event can cause a disconnection of the bones from each other or the other structures of the auditory system. This is known as ossicular discontinuity. The bones of the ossicular chain may be congenitally malformed (ossicular malformation) with or without other prominent cranial-facial abnormalities, or the absence of the ossicular chain can occur. Typically, there will be no classic physical symptoms (e.g., otalgia, tinnitus) beyond those caused by a traumatic event or accident itself.

Audiometrically, a maximum conductive hearing loss of moderate to moderately severe degree will most definitely occur, as the structures responsible for channeling the sound through the middle ear cavity are affected.

Treatment for ossicular discontinuity includes surgical reattachment of the ossicular chain or, in its absence or malformation, use of a prosthesis (refer to Figure 10.6). Post-surgical intervention, hearing loss may recover to varying degree. In some cases, minimal/mild conductive hearing loss will still exist. As such, treatment should be done...
collaboratively to ensure proper accommodations (educationally for children and vocationally for the adult population) for these individuals. While audiometric results will reveal a conductive hearing loss in these cases, the diagnosis of ossicular discontinuity, ossicular malformation, or the absence of the ossicular chain is confirmed medically through a variety of imagining procedures.

Diagnoses and Etiologies of the Inner Ear

The anatomical structures that make up the inner ear include the vestibule, semicircular canals, and the cochlea. For the purposes of this chapter, we will focus on diagnoses and etiologies that have resulting hearing loss. While disorders focusing solely on the semicircular canals also exist, they are manifested in disorders of balance; as such, they are beyond the scope of this chapter and will not be addressed in this section.

Sensorineural Hearing Loss

Hearing loss that is the result of an etiology within the inner ear structures is referred to a sensorineural hearing loss. As discussed elsewhere, a sensorineural hearing loss can vary greatly in its degree and configuration; however, in all sensorineural hearing losses, bone conduction and air conduction thresholds match in severity. Figure 10.7 illustrates a high-frequency sensorineural hearing loss.

Noise-Induced Hearing Loss

Noise-induced hearing loss (NIHL) occurs as the result of overexposure to loud sound of any type—at work, leisure, or during other activity in any setting. This excessive exposure to loud sounds causes damage to the delicate structures of the cochlea and result in hearing loss. NIHL is a complex interaction of the amount of sound (in decibels), the character of the noise (continuous versus intermittent), the amount of time spent in the “noisy” setting, and genetic risk factors (Sliwinska-Kowalska & Davis, 2011; Zhang et al., 2015). It does not matter if you happen to enjoy the “noise” you are exposed to (for example, your favorite music) or not; when sound becomes sufficiently loud for a sufficient time frame, hearing loss may occur. It should be noted, however, that if the cause is an extremely loud burst, such as an explosion or a gunshot, a perforation

![Figure 10.7](image_url) An audiogram illustrating a high-frequency sensorineural hearing loss bilaterally.
of the eardrum may occur as well (see “Perforated Tympanic Membrane”). Physical symptoms of NIHL include tinnitus (ringing, buzzing, or roaring sound in the ears) and hyperacusis. Hyperacusis may be defined as an increased sensitivity to sound that may even cause pain and discomfort.

Audiometrically, the type of hearing loss caused by noise is sensorineural in nature. It will result in a loss of high-frequency hearing sensitivity, typically in the form of a notch at 4000 Hz first and then will gradually increase in severity and affect other frequencies of hearing; sounds will become muffled and speech may sound distorted. Because NIHL is progressive, individuals may not typically seek out assistance until others in their immediate circle of family and friends identify difficulty in social communication. Hearing loss can be bilateral, in cases of industrial and recreational noise exposure, or unilateral in the case of firearm use or trauma. The presence of hyperacusis in some may likely result in the individual having difficulties with the use of hearing aids.

Once the NIHL develops, there is currently no known treatment to reverse it; however, NIHL is a preventable condition. It has been suggested, and it is also the expressed opinion of these authors as well, that the best treatment for NIHL, by far, is prevention. Other treatment interventions include education and training, audiological assessment, hearing aid fittings, aural rehabilitation, and hearing protection and conservation.

## Ototoxicity

**Ototoxicity** refers to the deleterious effects that certain drugs or substances (e.g., aminoglycoside antibiotics) have on the organs of hearing and balance in the ear. Note that there are perhaps hundreds of known drugs and chemical agents that have a toxic effect on the structures of the ear; the resulting symptoms, and whether those symptoms are temporary or permanent, depend on the offending agent. Aminoglycosides, such as streptomycin and gentamycin, and chemotherapeutic agents are known to cause permanent damage, while the effects of salicylate pain relievers (e.g., aspirin) are typically temporary. Additionally, exposure to sub-damaging levels of aminoglycosides aggravates noise-induced damage, causing synergistic effects (Li & Steyger, 2009). Common characteristics of ototoxicity relating to hearing include sensorineural hearing loss, dizziness and disequilibrium (disturbances in balance), and tinnitus. However, the list of other physical manifestations of such drugs is exhaustive.

Audiometrically, an ototoxic hearing loss will manifest itself in a sensorineural hearing loss that begins in the higher frequencies and then progress into the mid and low frequencies. Because the medication causing the hearing loss is systemic, these losses are typically bilateral and symmetrical. Audiological monitoring is common practice while such medications are administered. However, following completion of the medical regime, audiological monitoring is also imperative as the hearing loss will continue to progress as the drugs titrate from the body. In some cases, there have been reports of some hearing loss recovery after ototoxic agents have stopped.

Intervention or prevention of ototoxicity is not clear-cut, at least in part because some of the most toxic drugs are administered for life-saving purposes (e.g., cancer chemotherapy drugs). It is recommended that during a course of treatment that frequent hearing tests should be conducted for monitoring purposes. Interventions vary as patient outcomes vary. However, an individual’s vitality must always supersede the consideration of intensive intervention.

## Trauma

Trauma as referred to here is any event that causes a disturbance or damage to the skull or brain structures. There are numerous possible etiologies, which include skull fracture (longitudinal temporal bone line fracture and the like), traumatic brain injury (as a result of a severe blow, explosive blast, sports injury, etc.), cerebrovascular event (CVA/stroke), and others. The precise symptoms will depend
on the particular event that occurred. Some common symptoms of mild injury may include headache, dizziness, nausea, and tinnitus, while a more serious event may include all of the above as well as balance disturbances, abnormal vision, loss or impairment of vision and/or consciousness, aphasia, and possible hearing loss. The characteristics of the accompanying hearing loss, when present, will vary depending on the exact accident or injury involved. Hearing loss is typically sensorineural, and can be either unilateral or bilateral depending on the nature of the injury.

Treatment will include a variety of injury-specific medical and health-related evaluations and interventions. Audiologic assessment and intervention is important for all such patients, in order to ensure that the presence of the comorbid hearing loss does not interfere with the overall treatment plan of the patient across medical and allied health disciplines.

**Meniere’s Disease**

Meniere’s disease (MD) can be described as a chronic and progressive inner ear condition characterized by a buildup of fluid (endolymph) in the labyrinth; this in turn interferes with the normal functioning of the organ of hearing (auditory system) and balance (vestibular system) in the inner ear. The vestibular symptoms include nausea, vomiting, and feelings of imbalance or instability, and these may last for some time. MD can occur either unilaterally (one ear only) or bilaterally (both ears).

Audiometrically, individuals with MD may or may not have accompanying sensorineural hearing loss. If hearing loss is present, it can be fluctuating and progressive and may be accompanied by tinnitus, intolerance to noise, and diplacusis (the phenomenon of perceiving one tone as two separate tones; Belinchon, Perez-Garrigues, & Tenias, 2012). As MD can occur either unilaterally or bilaterally, the accompanying hearing loss can either be unilateral or bilateral as well.

Meniere’s disease is typically diagnosed by an otolaryngologist. As yet there is no known cure; however, that are several treatment recommendations. Some of the options include medications for relief of dizziness, dietary changes (reduction of salt, caffeine, and alcohol), surgery, and other alternative options (e.g., cognitive therapy and alternative medicine). The stage and severity of the disease and symptoms guide intervention. Because the hearing loss associated with MD is known to be fluctuating and progressive, interventions will vary from patient to patient depending on symptomatology.

**Presbycusis**

The term presbycusis refers to the decline in hearing that is associated with the aging process—that is, without other traumatic or pathological conditions. While it is generally assumed that the onset of age-related hearing loss occurs after age 50 or so, evidence of the systematic decline in hearing occurring as early as the second, third, and fourth decade has been documented (Arvin, Prepageran, & Raman, 2013).

Audiometrically, a hearing loss from presbycusis will manifest itself in the form of a high-frequency sensorineural hearing loss, a loss of clarity of speech (discrimination ability), tinnitus, and loudness recruitment (abnormal growth of loudness). Presbycusis hearing losses are often bilateral and symmetrical in nature, but there can be variability in some cases. This loss will progress into the mid and lower frequencies and increase in severity over time as the aging process continues.

As any individual client with presbycusis may experience a variety of other challenges in addition to the physical hearing loss, treatment planning will ideally be comprehensive and multidisciplinary because the hearing loss itself is only a portion of the overall aging process.

Quality of life becomes an important part of the intervention process for individuals with presbycusis. While more-active seniors will seek out
remediation for hearing loss, the less-active elderly person may not find such intervention necessary.

**Autoimmune Inner Ear Disease**

Autoimmune inner ear disease (AIED) is a poorly understood form of sensorineural hearing loss. The cause and etiology of AIED, despite many years of interest and research, remain unclear. There are, however, many possible autoimmune system diseases that have been associated with AIED, including ankylosing spondylitis, systemic lupus erythematosus, Sjögren’s syndrome (dry eye syndrome), Cogan’s disease, ulcerative colitis, Wegener’s granulomatosis, rheumatoid arthritis, scleroderma, and psoriatic arthritis (McKean & Hussain, 2009; Srikumar, Deepak, Basu, & Kumar, 2004). There is no disease prevalence—male versus female, young versus old—stated in the current literature as the disease itself remains somewhat of a mystery to the medical community and there are many hundreds of reported autoantibodies. Viral infection, trauma, and vascular damage may be triggers for AIED (McKean & Hussain, 2009). Frequently, a patient with AIED will report a sudden onset of hearing loss or a rapidly progressing loss.

Audiometrically, AIED can manifest itself in bilateral, asymmetric, progressive hearing loss, sometimes with vestibular (balance-related) symptoms (Goodall & Siddiq, 2015). Other symptoms may include tinnitus and aural fullness. As with the disease itself, the severity of the hearing loss can vary significantly from patient to patient.

Treatment and interventions include pharmacological management (steroidal therapy), which has shown to provide improvement in hearing in approximately 60% of AIED cases (McKean & Hussain 2009). Research continues to focus on identifying the cause as well as other treatments. Intervention for AIED are varied as the resulting hearing loss varies. In the case of fluctuation in hearing, interventions should be monitored and modified as the hearing loss changes.

**Diagnoses and Etiologies of the Eighth Cranial Nerve**

A sensorineural hearing loss can also be associated with damage to the eighth cranial nerve, which transmits sound from the cochlea to the brainstem and ultimately to the auditory reception area of the brain. While such conditions are rare, they warrant mentioning as we cover the pathway of sound from our environment to our cerebral cortex for processing.

**Acoustic Neurona**

An acoustic neuroma (AN), also known as a vestibular schwannoma, is an uncommon and noncancerous tumor that grows on the auditory nerve (cranial nerve VIII), often extending into the cerebellopontine angle (CPA). It is a slowly progressing pathology, with up to 57% of cases showing no further tumor growth (McDonald, 2011) after diagnosis. McDonald (2011) reported that the “sporadic type” of AN occurs in 95% of cases, is unilateral, and affects males and females equally. The remainder of cases are associated with vestibular schwannomas are the result of neurofibromatosis type 2 (NF2; a hereditary condition most commonly associated with the growth of noncancerous tumors of the nervous system) and are bilateral. Symptoms of AN may include dizziness and tinnitus. As the tumor grows there may be progressive hearing loss and facial weakness/numbness or paralysis.

Audiometrically, the common pattern of hearing loss associated with an AN is unilateral sensorineural that may start out as mild and become progressively worse as the tumor increases in size. In cases such as NF2, where the tumors are bilateral, the resulting hearing loss will be bilateral as well.

There are three treatment options for acoustic neuroma; they include “watchful waiting, microsurgery and stereotactic radiosurgery” (McDonald,
2011; Patel, Rohit, van Loveren, Downes, & Agazzi, 2014). Outcomes vary depending on the disease course and the treatment employed; hence, ongoing medical management is necessary. Audiologically, hearing preservation is poor following surgery for most patients (Iwai et al., 2016)

**Diagnoses and Etiologies: Site of Lesion Nonspecified**

In many cases, while a hearing loss exists, the exact site of damage is unknown or can vary. In the case of permanent sensorineural hearing loss, extensive testing may be recommended by the primary or specialty physician in attempt to pinpoint the cause of hearing loss, which may or may not be successful. In the case of external pathogens, sensorineural hearing loss may be one of many resulting permanent conditions from a disease, whether the cause is from sensory damage (the cochlea) or from damage to the nerve itself.

**Viral Causes of Hearing Loss**

Mumps, measles, rubella, cytomegalovirus (CMV), human immunodeficiency virus (HIV), herpes simplex virus (HSV), TORCH syndrome (infection of a developing fetus or newborn by [T]oxoplasmosis, [O]ther Agents, [R]ubella (also known as German measles), [C]ytomegalovirus, and [H]erpes simplex, and lymphocytic choriomeningitis virus (LCMV) are among the known viral causes of sensorineural hearing loss. While the prevalence of many of these viruses has waned in the United States and other countries through pediatric vaccinations, they have not been completely eradicated. Prevalence varies with the disease itself as well as the symptoms.

Audiometrically, each of these viruses can cause significant hearing loss. While the site of lesion (the exact anatomic location where the damage occurs) may be either the cochlea or the auditory nerve, a sensorineural hearing loss may result, in many cases profound in degree. However, degree and configuration can and will vary from patient to patient and also with the type of viral infection present.

Treatment and intervention will also be dependent on the viral infection itself. In many cases, pharmacological management that is recommended as medical management can itself have ototoxic effects on the patient. Audiological monitoring and early identification of the presence of hearing loss will drive interventions, especially in infants and children affected by these viruses.

**Genetically Linked Hearing loss**

Hearing loss can be passed from generation to generation, which makes an individual predisposed to a specific degree, type, or configuration of auditory impairment. There are three main ways that a hearing loss can be passed from parent to child: autosomal dominant (when a hearing loss is directly passed from parent to child), autosomal recessive (when there are genetically linked members of a family with hearing loss but both parents have unaffected hearing), and x-linked (when the mother has the recessive trait but only passes the hearing loss to male offspring).

Audiometrically, these hearing losses may closely resemble the loss that runs in the family. For example, parents with profound hearing loss may have a child with profound hearing loss as well. A grandparent with a cookie bite hearing loss, concentrated in the mid-frequencies, might have a grandson with a similar loss. Conditions like otosclerosis also run in families, as does hearing loss that is progressive in nature. Herein lies the importance of taking a comprehensive case history when discussing the origin of a patient’s hearing difficulties.

Treatment and interventions will certainly vary for these individuals. Frequently, physicians will recommend an extensive medical work-up, which may include consultation with a geneticist or genetic counselor. Interventions will also vary based on the nature and degree of the loss as well as the perception of handicap a family may have relative
to the loss itself. If a whole family, for example, is Deaf (capital D emphasized), the identification of deafness in a child may not require the same interventions as a deaf child born to typically hearing parents.

**Syndromes with Associated Hearing Loss**

The list of syndromes with associated hearing loss as well as other medical features is, in itself, the topic of complete textbooks. To review specific syndromes associated with a specific degree and configuration of hearing loss is outside the purpose of this chapter. The reader is encouraged to research the individual syndrome, its background, and symptomatology to determine the prevalence of hearing loss. Again, there are full textbooks dedicated to this topic as well as online resources available to the SLP for this purpose.

**Auditory Neuropathy Spectrum Disorder (ANSD)**

Auditory neuropathy spectrum disorder is the term used to describe the condition in which an individual has present otoacoustic emissions (OAEs) and/or a cochlear microphonic but an absent or abnormal auditory brainstem response (ABR) (Norrix & Velenosky, 2014). ANSD is perhaps the more recent of auditory diagnoses one may encounter in her or his practice as an SLP. There is a plethora of information surrounding ANSD. The reader is encouraged to seek out current information as research unfolds as to the causes, treatment, and therapeutic intervention strategies develop surrounding ANSD.

**SUMMARY**

As a practicing speech-language pathologist, you will eventually be faced with the question, “Where did this hearing loss come from?” Whether that question is from an inquiring patient or a parent of a child, it is necessary to have the appropriate materials at hand to work through this question in an educated and professional manner. The causes of hearing loss, whether conductive or sensorineural, are extensive, but in many cases can be diagnosed. It is with knowledge in hand that appropriate treatment and interventions can be fashioned.

**DISCUSSION QUESTIONS**

1. Name one cause of hearing loss for each anatomical location: outer, middle, and inner ear.
2. What is the relationship between Eustachian tube dysfunction and otitis media?
3. Describe three ways a noise-induced hearing loss can be prevented.
4. Research one genetic syndrome that causes hearing loss. Discuss its medical manifestations, degree, type, and configuration of the most commonly associated hearing loss.
References


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# Chapter 11

## Audiologic Screening

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### Objectives

- Describe the equipment needed to perform an audiological screening battery.  
- Compare screening procedures and their use with the appropriate ages and functional ability levels of the client.  
- Explain the necessary procedures to obtain reliable behavioral screening measures.  
- Demonstrate those procedures used for non behavioral screening measures.  
- Determine the appropriate follow-up necessary when a screening results yield a “fail.”

### Key Terms

<table>
<thead>
<tr>
<th>Attenuator</th>
<th>Ear tags</th>
<th>Listening check</th>
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<tbody>
<tr>
<td>Auditory disorder</td>
<td>Electroacoustic calibration</td>
<td>Modified play technique</td>
</tr>
<tr>
<td>Auditory impairment</td>
<td>False-negative response</td>
<td>Otoacoustic emission screening</td>
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<td>Biological calibration</td>
<td>False-positive response</td>
<td>Output switch</td>
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<td>Conditioned play audiometry</td>
<td>Frequency</td>
<td>Portable audiometer</td>
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<td>Diagnostic audiometry</td>
<td>Hearing handicap</td>
<td>Screening procedures</td>
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<td>Disability</td>
<td>Hearing screening</td>
<td>Sensitivity</td>
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<tr>
<td>Earphones</td>
<td>Hertz (Hz)</td>
<td>Specificity</td>
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<tr>
<td>Ear pits</td>
<td>Interrupter switch</td>
<td>Transducer</td>
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Chapter opener image: © Filip Fuxa/Shutterstock
Introduction

A client is sitting in front of you while you are preparing to perform your speech-language evaluation. Whether this client is a child who has been referred to you due to delayed speech and language development, or an adult who has suffered a stroke or other traumatic brain injury (TBI), there is a concern about the individual’s level of functioning. The client and his or her family and loved ones are looking for answers and guidance. Decisions regarding your client’s communication ability and appropriate intervention plans depend on a thorough and accurate diagnosis. Therefore, it is critically important for the speech-language pathologist (SLP) to consider hearing loss as a primary or comorbidly occurring condition.

While it is not within the American Speech-Language-Hearing Association’s (ASHA, 2016) scope of practice for the speech-language pathologist to conduct tests of auditory system function in a diagnostic mode, it is expected, based on the scope of practice, that SLPs will be able to competently and accurately perform some of these procedures in the screening mode. The results of such a screening will enable the SLP to establish whether there is any suspicion of hearing difficulty necessitating a referral for complete diagnostic audiologic testing, thus eliminating, or at least minimizing, the chance that hearing loss is playing a role in the suspected speech and language disorder for which your client (client’s family) has come to you.

The information contained within this chapter will help guide the reader through the entire screening process, including general screening information, prescreening decisions, different screening test options, individual test preparations, procedures, instructions, administration, results, and follow-up recommendations. Finally, a section is included that addresses screening for hearing handicap. While these types of tools are not truly a “hearing screening” measure, the information obtained may be particularly useful when used as a supplement to other screening results obtained.

Definitions

A hearing screening can be defined as a means to separate apparently healthy individuals from those for whom there is a greater probability of having a disease or condition, and then to refer the latter for appropriate diagnostic testing (ASHA, 1994).

Diagnostic Audiometry versus Hearing Screening Procedures

The difference between diagnostic audiometry and hearing screening procedures can sometimes be confusing. Simply put, a diagnosis of hearing status cannot be made based on a screening procedure; it can be made only as a result of a complete evaluation. A screening is generally a less time-intensive procedure, sometimes taking only 1 minute, whereas a diagnostic assessment is a comprehensive and time-consuming process that starts with a thorough case history and incorporates multiple behavioral, physiologic, and/or electrophysiologic measures. The hearing screening can identify only those individuals who appear likely to have a hearing loss, whereas the diagnostic assessment can confirm and delineate the type and severity of auditory disorder, as well as provide possible recommendations for remediation.

Disorder, Impairment, Disability, and Handicap

When working with clients, it is important to be clear on the information we need to obtain and how we intend to use that information. As an SLP is preparing to perform a speech-language assessment on a client, a hearing screening is performed first, which will result in either hearing loss being ruled out as a potential contributing factor or a referral for diagnostic audiometry will be made. An alternate scenario might be a client whose auditory and speech-language diagnoses have already been established; the goal for this client may be screening for potential impact of hearing loss on the client’s activities, and/or a needs assessment might be in order for the purposes of intervention planning.
In the first scenario, the screening of interest relates to screening for disorder and/or impairment, while the second scenario relates to screening for disability and/or handicap. It is important, therefore, that we first clarify these terms with specific reference to the auditory system.

Disorder
An auditory disorder refers to an abnormality of the anatomical structure(s) of the auditory system, with or without a concomitant impairment. Examples of auditory disorders can include occluding earwax in the ear canal and/or otitis media (common ear infection). Both the presence of excessive cerumen (earwax) and/or an ear infection are considered medical conditions resulting in a physical abnormality of the auditory system. The presence of the disorder can be directly related to the presence of decreased auditory sensitivity and can be conveyed thusly in a written report of audiological findings.

Prevalence of Disorder While the exact statistics for the prevalence and incidence of hearing loss vary slightly, depending on the source and exact population studied, the available data are uniformly alarming. What follows are a few highlights worthy of consideration:

- According to the National Institute on Health and Other Communication Disorders (NIDCD, 2015), 2 to 3 out of every 1000 children in the United States are born with a detectable level of hearing loss in one or both ears, and 5 out of 6 children experience ear infection (otitis media) by the time they are 3 years old.
- According to the American Academy of Audiology (AAA, 2011), hearing loss is the most common developmental disorder identifiable at birth, and its prevalence increases throughout school age due to the additions of late-onset, late-identified, and acquired hearing loss.
- The Hearing Health Foundation (HHF, 2015) reports that from 2000 to 2015, the number of Americans with hearing loss doubled. Hearing loss is now the second most prevalent health issue globally, the number of people with hearing loss being higher than those living with Parkinson’s, epilepsy, Alzheimer disease, and diabetes combined.

Impairment
An auditory impairment refers to the loss of function of the auditory system. This impairment (also referred to as hearing loss) may occur as a temporary, fluctuating, or permanent condition. Common categories of hearing impairment include conductive, sensorineural, and mixed. This auditory impairment—the hearing loss—is further categorized by specific parameters of minimal, mild, moderate, moderately severe, and profound. However, this only refers the presence/degree of a hearing loss, but should not be automatically related to an individual’s ability to function with the impairment.

Disability
Consistent with policy documents of ASHA (2004), a disability is any restriction or lack (resulting from an [auditory] impairment) of ability to perform an activity in the manner or within the range considered normal for a human being—that is, disability relates to performance of the individual. For example, an auditory impairment (hearing loss) may result in the individual not being able to understand speech in a background of noise, causing this person to experience difficulty carrying on a conversation in environments that are very noisy. Another individual with a similar auditory impairment may not find this scenario of background noise problematic; again, disability is specific to how the hearing loss manifests itself in the individual’s ability to function in daily life with the disorder and/or impairment.

It is necessary to point out that the concept of disability means various things in various communities. For example, a traditional (medical) model of deafness interprets “Deaf” as disabled; however,
this model of d/Deafness ignores the belief widely held among signing Deaf communities that their existential situation is primarily that of a language minority, rather than as a disability group (Ladd, 2003, p. 15). Therefore, the watchwords here ought to be open-mindedness and cultural sensitivity.

**Handicap**

Hearing handicap refers to the difficulty an individual experiences as a result of an impairment and disability, and as a function of barriers (e.g., structural, communication architectural, attitudinal), lack of accommodations, and/or lack of appropriate auxiliary aids and services (ASHA, 2004). Clearly, an extensive range of factors combines to define and describe hearing handicap.

As an example, a place of worship may provide assistive listening technology for its parishioners to participate in the service. Those with hearing devices that easily couple to such a system can easily become active participants, while others without such technology may still hear some of the service, but miss what is beyond their hearing aid to amplify. While both individuals may have the same disorder, impairment, and disability, one may be handicapped by this social situation while the other is not.

**The Clinician’s Role and Responsibility in the Screening Process**

SLPs receive specialized education and clinical training that uniquely qualify them to provide habilitative and rehabilitative services to individuals who display communication difficulties affecting listening, speaking, reading, writing, thinking, swallowing, etc. It is, therefore, incumbent upon the professional to ensure that, prior to completion of speech-language assessment and intervention planning, a screening for auditory impairment, disability, and/or handicap is completed. In this way, auditory pathology may be either ruled out or appropriate referrals for audiologic assessment and interventions can be made in a timely fashion (ASHA, 2008).

For more detailed information regarding the roles and responsibilities of speech-language pathologists in a variety of populations, the reader is directed to review the publications from ASHA (n.d., 2008, 2016) listed in the references.

**Principles of Screening**

**Purpose**

Unlike the intent of a complete audiological assessment, the purpose of a hearing screening is merely to identify those individuals who are in need of further testing. A diagnosis is not derived from a screening procedure, nor should the presence or absence of hearing loss be determined; it is simply a conduit through which an appropriate referral for a suspected condition is made.

Similarly, screening for a hearing handicap is not intended to provide an exhaustive description of the specific barriers and circumstances that require accommodation; rather, it is a quick and simple means of identifying individuals who may be experiencing social, emotional, and/or other circumstantial effects of hearing loss that require a more in-depth investigation.

**Availability of Assessment and Treatment**

In order to achieve the maximum benefit from any screening program, appropriate follow-up steps must be available and routinely in place. That is to say, when a patient is seen for a screening and a full assessment is deemed necessary, evaluation and treatment intervention services, and the professionals who provide them, need to be available for the screening program to be successful.

When seeking out diagnostic services as follow-up to a failed screening procedure, the SLP should search for professionals who specialize in a broad range of hearing impairments, disabilities, and handicaps across both the chronological and developmental lifespan.
**Test Performance**

**Sensitivity and Specificity**

As mentioned above, a screening can be defined as a means to separate apparently healthy individuals from those for whom there is a greater probability of having a disease or condition, and then to refer the latter for appropriate diagnostic testing (ASHA, 1994). All screening methods should be scrutinized using two criteria when determining the process of pass and fail—sensitivity and specificity. These terms relate to the screening test’s ability to accurately separate those who have a given disorder (in this case hearing loss) from those who do not. **Sensitivity** represents the percentage labeled positive on a test that truly have the target condition; **specificity** represents the percentage labeled negative who are truly free of the condition (ASHA, 1997). Table 11.1 provides an illustration of sensitivity and specificity possibilities.

In the case of air conduction hearing screenings, one critically important consideration is the intensity (or loudness) level used to do the screening. When the decibel level is set inappropriately low (too soft), a larger number of individuals will fail the screening. An individual who failed under this very strict condition, but really does not have a hearing loss, is considered to be a **false-positive response** to the screening measure (B in Table 11.1). This scenario actually might identify all individuals who really do have a hearing loss (high sensitivity); unfortunately, it also wrongly identifies many who really do not have a loss (low specificity).

If, on the other hand, the test intensity is set at a higher (too loud) decibel level, a larger number of individuals might pass under this inappropriately lenient condition. An individual who passes under this condition, but really does sustain hearing loss, is considered to have a **false-negative response** to the screening measure (C in Table 11.1). This scenario will correctly identify all of those cases that truly do not have a hearing loss (high specificity); however, the false-negative responses represent the individuals who truly do have a hearing loss and were—quite unfortunately—not identified (low sensitivity).

The percentages of individuals who fall into each category for a given hearing screening event will depend largely on the parameters set, but they may also depend on other logistical concerns such as cost in time and money (McPherson, Law, & Wong, 2010; Peterson & Bell, 2008). Ideally, a screening protocol will be established that achieves sensitivity (true-positive responses; A in Table 11.1) and specificity (true-negative responses; D in Table 11.1) that are as high as possible. We must recognize, however, that real-life circumstances and considerations preclude the statistical perfection that would result in having a protocol that correctly separates out, with 100% accuracy, those who have the disorder from those who do not. We believe it is a reasonable goal to institute a hearing screening protocol that will minimize the false-negatives as much as is possible and reasonable. Thus, no individual who actually sustains a hearing loss will miss out on the opportunity for follow-up and intervention. There will never be a “perfect” screening protocol whereby all individuals are identified appropriately by the very nature of the procedure being a “screening.”

**Behavioral versus Nonbehavioral Procedures**

The numerous procedures used in the audiologic screening, as well as the entire test battery, include both behavioral and nonbehavioral types. Very simply stated, a behavioral procedure requires the client to actively participate in the task; thus, these types of tests are considered subjective. An example of a behavioral task is when pure tone audiometry is performed and the client is required to raise his or her hand each time a tone is heard. A nonbehavioral procedure does not require the active participation

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**Table 11.1** Sensitivity and Specificity

<table>
<thead>
<tr>
<th>Test Positive</th>
<th>Disease Positive</th>
<th>Disease Negative</th>
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</thead>
<tbody>
<tr>
<td>Test Positive</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>Test Negative</td>
<td>C</td>
<td>D</td>
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</table>
of a client and, in fact, can be performed while the individual is asleep or sedated; thus, this type of task is referred to as objective. Examples of this type of procedure include tympanometry and otoacoustic emissions (OAE).

Both behavioral (subjective) and nonbehavioral (objective) test measures may be employed in various combinations for screening purposes. While the test battery approach, using a combination of objective and subjective techniques, yields the most comprehensive and useful information, the general principle of combining these types of measures can be easily applied to the screening activity most beneficial in the time allotted. The battery of procedures will also vary when used for the very young and those with special needs.

**Screening Program Considerations**

**Who Should Be Screened?**

A good rule of thumb to remember is that no diagnostic conclusion or treatment intervention decisions should be made or implemented without first considering hearing loss as a contributing factor. Every single client who is referred to you for any speech-language evaluation or therapeutic service is in need of an audiologic screening if a complete audiologic evaluation has not been conducted in preparation for your appointment. Should your client fail the hearing screening, an immediate referral to an audiologist or other appropriate professional should be made. Clients who are already on your caseload should be periodically screened as well. Who should be screened? In short, the answer is everyone, and not just upon initial evaluation by an SLP. Hearing losses can be transient, as with those that accompany otitis media, and hearing losses can be progressive in nature. Never assume that if an individual presents with results of an evaluation that those results reflect his or her current hearing status. If your client expresses concerns or is experiencing difficulty, these concerns should not be disregarded.

There are more extensive guidelines that can and should be reviewed and referenced, as they will further assist you in your practice. The websites of ASHA and AAA can be sources of a wealth of information on the topic. Additionally, all readers are strongly advised to research the recommendations, policies, and procedures of your individual state and local municipality, or individual healthcare facility, as they may be far more specific than the general guidelines offered by ASHA or AAA. Remember, your diligence in screening and following up with recommendations for audiologic evaluations and/or interventions will help to ensure the best possible outcomes for all clients.

**Permissions**

Part of the planning process of any hearing screening activity is consideration of the need to obtain permission. This is commonly the case where children are concerned, but there are also adult populations in certain settings where such consent will also be necessary. An additional consideration is determining who is responsible for obtaining and documenting that the required written consent has been obtained. The answers to these questions will vary from site to site, state to state, etc., and, as such, readers are again advised to take the time to seek out the appropriate guidelines and make informed decisions accordingly. First, determine if written permission is necessary, and second, confirm that it has been granted. If you cannot, it is best that you do not perform the screening. Rescheduling for a later date is a prudent action to take.

**Screening Test Environment**

The testing environment in which audiometric procedures are performed is critically important, regardless of whether the procedure is pure tone air conduction, otoacoustic emissions, or another similar procedure. The presence of background noise can interfere with the client's ability to hear and respond to sound and, therefore, must be kept to specified levels in order to ensure accuracy of the test results (see ANSI/ASA S3.1-1999 [R2008]).
When conducting any hearing procedure in an audiology sound booth (see Figure 11.1A and B), calibration ensures that background sound levels are sufficiently controlled and will not significantly impact the test results in a negative way. The SLP working in a speech and hearing center alongside their colleagues in audiology will typically be afforded this luxury. Unfortunately, not all assessments have the benefit of a sound-controlled environment, which is most often the case when an SLP (or audiologist) is required to do a hearing screening in a typical school setting. When in this situation (that is, when the environment has not been calibrated and certified as meeting ANSI [American National Standards Institute] specifications for background noise levels), the tester must make every effort to ensure that the test is being conducted in the quietest environment possible, using insert earphones or other noise-reducing earphones if available. When the background noise-controlled conditions cannot be met and no noise-reducing earphones are available, extreme caution must be used in the interpretation of any results.

When background noise levels are such that they interfere with the screening, potentially erroneous interpretations may occur. For example, a tester may conclude that because the person failed the hearing screening that a hearing loss must be present. Alternately, the tester may be tempted to draw the conclusion, based on the “high” levels of noise during the screening, that the failure of the screening was only due to the background noise, and that the client's hearing is “probably normal.” Both of these conclusions are likely to be incorrect and can result in missing the presence of a hearing loss based on a personal assumption.

Finally, while some “screening activities” may not be as critically dependent upon a quiet environment as others, the presence of background noise and other distractions may still be detrimental to the client’s ability to focus and may yield results that are not deemed valid or reliable. For example, other screening activities might include otoscopic inspection and self-assessments and hearing handicap scales.

**Universal Precaution**

Universal precautions are a set of procedures and practices designed to help protect healthcare
workers and patients alike from a wide range of pathogens. Instrumentation coming into physical contact with the patient must be cleaned and disinfected after each use. According to the Occupational Safety and Health Administration (OSHA) 29 CRF standard 1910.1030, all human blood and certain human body fluids are to be treated as if they are already known to be infectious for human immunodeficiency virus (HIV), hepatitis B virus (HBV), and other bloodborne pathogens. Therefore, in agreement with the recommendations of the Centers for Disease Control and Prevention (CDC), standard precautions should be taken as the foundation for preventing transmission of infectious agents during the care of all patients, regardless of their diagnosis or presumed infection status.

The recommendations of ASHA are in agreement with these statements; the 2004 guidelines for manual pure tone audiometry state that adherence to universal precautions and appropriate infection control procedures should be in place. The use of disposable acoustically transparent earphone covers or disposable insert earphone tips is recommended. Hand washing should be routine for the audiologist (or SLP) between patients (ASHA, 2005). In addition to these recommendations, it is also suggested that the policies and procedures of the individual facility sought out and followed. For specific information, recommendations, and guidelines, the readers are referred to Siegel, Rinehart, Jackson, Chiarello, and the Healthcare Infection Control Practices Advisor Committee (2007).

Information Gathering

In many cases, a hearing screening may be part of an overall health screening or done as a precursor to your own speech and language evaluation. Regardless of the situation, case history information should always be either present for review or gathered at the time of screening. How much time is allotted and how much information can be gathered will be dependent on the circumstance. Screening questionnaires can also be disseminated to those waiting for their appointment. Regardless of the means by which information is gathered, the following should be included in this questioning process:

- Results of newborn infant hearing screening
- Failure of prior screening results (exercise caution regarding the validity of previous test results; even if prior screening test was a “pass,” you cannot take that result at face value)
- Medical/otologic history
- Significant precipitating events
- How is the child doing in school?
  - 504
  - IEP
- Family history of hearing loss
- Injuries and surgeries
- Presence of any suspected hearing problem at home

Visual Inspection/Otoscopy

Visual inspection is a means of identifying the presence of obvious physical abnormalities that may exist of the pinna, temporal region of the head, and surrounding area. Otoscopy involves the use of the otoscope and allows for visualizing the inside of the external ear canal for presence of drainage, foreign bodies, excessive wax, and any other structural irregularities of the canal or the tympanic membrane (eardrum). This process may yield important information that can be used as a springboard to further the identification of auditory problems and/or may result in the discontinuation of screening and an immediate referral to medical personnel. If a screener is not trained or not comfortable with otoscopy, he or she can and should perform a general visual inspection of the outer portion of the ear and make notes of any obvious abnormalities or suspicious and concerning observations. Any abnormal or concerning visual observations may also result in discontinuation of the screening and an immediate referral to a physician.
Equipment

Visual inspection of the pinna and surrounding area needs only the observant eye. Otoscopy requires the use of an otoscope in order to further visualize the integrity of the external ear canal and tympanic membrane. Figures 11.2A and B show an otoscope with various different speculum sizes.

Familiarization with Equipment Components

The otoscope is used to perform the otoscopic inspection. This device consists of a handle and a head, which provides a magnifying lens and light source for visual inspection of the length of the ear canal and the tympanic membrane. The variety of different specula are designed to fit different ear canal sizes. As with most all audiological equipment, there are various manufacturers and models; for the otoscope shown in Figure 11.2A, there is a small button that needs to be pushed in order to turn on the light that illuminates the otoscope.

Test Environment

Visual inspection and otoscopy results are generally not negatively impacted by background noise. However, when we consider the fact that the visual/otoscopic inspection may be the first or prerequisite in the sequence of steps air conduction and OAE screenings, care must be taken in choosing where you will be setting up and beginning your screening activity. Sensitivity should also be exercised when determining a place that will provide relative privacy to the individual being screened.

With this in mind, the site should be chosen carefully—that is, away from sources of background noise. Examples of sources of background noise include stairways, open windows, open doors leading to populated areas, gyms, and rooms that house the heating and cooling vents and equipment. In a school setting, the nurse’s room, an unoccupied classroom, or unused office space away from noise and activity are sometimes viable options. For home-based therapy the goal is the same: Try to avoid noise sources such as the television or radio, siblings playing, traffic from a busy street, external noise sources near the home, etc.

Client Preparation and Instructions

Client preparation and instruction for visual inspection/otoscopy are straightforward. Because no behavioral response is required from the individual, there are no lengthy and wordy instructions to be understood. However, the client needs to keep fairly still, as excessive movement may prevent the tester from being able to effectively visualize the structures. A few concerns that are worthy of consideration follow below.
Excessive crying, resistance, and movement in general will interfere with the process of visual and otoscopic inspection just as much as background noise. Ideally, your client will remain as still as possible during this procedure.

For a client who is very young, tactiley defensive, and/or simply difficult to test regardless of age or reason, completing this part of the process during a sleep cycle may prove more successful. For the practicing SLP, this may not be possible. Should your best efforts at keeping your client calm be unsuccessful, refer the client to an audiologist and physician for an audiological evaluation and medical examination. The fact that you were unable to appropriately screen the client’s hearing as part of your speech and language evaluation should be clearly documented in your written report and an appropriate referral for a comprehensive hearing evaluation should be made in the “Recommendations” section of the report as well.

For the more amenable client, you can simply instruct the individual to be calm and not to move around. Remember that clients who are referred for speech-language evaluations typically have an obvious or suspected speech-language difficulty. Therefore, a young child—even if pleasant and cooperative—may do better without “wordy” explanations.

Test Sequence
- In an effort to minimize the time a client will wait for you to get organized, have all equipment and other supplies at hand (e.g., screening device that you are expecting to use, toys, forms, etc.).
- Seat the client comfortably in a chair or on a parent’s lap.
- Visually inspect the pinna, around the ear, and the temporal portion of the head. Look for overt indications of abnormality such as visible wax, external otitis, drainage, ear pits, ear tags, microtia, and the like. Also make note of any redness or sensitivity to touch, and refer accordingly.
- Prior to making physical contact with a client, it is important to adhere to your facility’s recommendations and guidelines for cleanliness and universal precaution both before and following testing.
- Select a speculum for your otoscope based on its aperture (size of the speculum opening) as it compares to the relative size of the patient’s ear. Note: You should choose the largest size speculum that will comfortably fit the client’s ear canal opening.
- The external ear canal is normally a curvy “S” shape; therefore, in order to obtain a clear view of the entire canal and tympanic membrane, you must first straighten the canal. In order to do this, you must gently pull upward and backward for adults, and downward and backward for children.

Visual and Otoscopic Observations and Recommendations
- Look at and around the external ear and temporal portion of the head. Make note of any abnormalities of the pinna shape, position, and other landmarks, including the ear canal opening. Are there any ear tags, preauricular pits, or other obvious or suspected abnormalities? Make note of any observations.
- If upon visual inspection there are any signs of infection, pus, draining ear, etc., your client should immediately be referred to a physician for medical assessment as well as an audiologist for full evaluation. Do not put anything in the client’s ear and do not proceed under these conditions.
- Using the otoscope, place the speculum into the external ear canal. Look for the landmarks of a normal tympanic membrane (see Figure 11.3).
• Make note of any physical abnormalities, such as perforations of the eardrum, drainage, redness, excessive wax, foreign objects, presence of pressure equalization (PE) tubes for the remediation of otitis media, or any other structural anomaly. This may be noted on the hearing screening; see an example of such a form in Appendix 11.A.
• The goal is not to arrive at any diagnosis of medical pathology, but merely to look and make note of any abnormalities you may find. Remember that this is within your scope of practice and, when in doubt, refer!

**Pure Tone Air Conduction Screening**

Pure tone air conduction audiometry is the behavioral procedure that is used to assess a person’s ability to hear sound via the normal mode of sound transmission. When using pure tones as a screening measure, we are not seeking a threshold for each frequency. Rather, a decibel (dB) level will be set, typically 15–20 dB HL, and a simple pass/fail paradigm is utilized (either the person responds to that specific level or a “fail” is indicated).

**Equipment**

Pure tone air conduction screenings can be carried out using a portable audiometer. As its name suggests, this device is easily carried from place to place and connects to any conventional electrical outlet. The portability and ease of use make it an ideal choice for conducting the air conduction screening.

Many different makes and models of audiometers are available (see Figure 11.4). The typical portable screening audiometer is capable of air conduction, and often bone conduction, testing, as well...
as some form of masking. Another type of screening audiometer, which employs a “picture-pointing” task, is the speech picture audiometer. An example of such a device is the Maico Pilot, shown in Figure 11.5. It is important to note that although the result obtained from such a device should not be the sole or primary basis for a “pass” result of a hearing screening, the information obtained may be useful when considered in conjunction with other screening test results.

It is important that you become familiar with the equipment before you begin your screening activity. You may need to get a brief overview of the device from a colleague, by contacting the manufacturer, or from a local audiologist. Regardless of the specific screening audiometer you may be expected to use, all have certain features and controls in common. Some of these standard features and routine considerations are described below.

Equipment that is used for the measurement of hearing is specialized, expensive, and delicate. As such, care must be taken to insure that it is functioning properly. First, it is important to realize that temperature extremes and careless handling can be damaging to the equipment; because many employment opportunities include travel, these devices should not be left in a car in areas where temperature extremes are common. Proper maintenance and storage is a must. Second, every audiometer (as well as other audiometric equipment) is required by regulations (OSHA and ANSI national standards) to be properly serviced by receiving electroacoustic calibrations on at least an annual basis. When a piece of audiometric equipment undergoes its annual electroacoustic calibration, a dated sticker is placed on the instrument (or on its carrying case) to verify that this requirement is complete; it will also indicate the date that it is due to be re-calibrated. Before using any piece of equipment, you must first verify its calibration is current; remember, do not use any audiometer that does not have a valid dated calibration sticker.

Familiarization with Equipment Components

The following list of components will be found on most any audiometer, regardless of make or model:

- A transducer is simply a device that transforms energy from one form to another form. Earphones and other sound transducers change the electrically generated sound into sound capable of being perceived by the individual you are testing. There are several types of transducers that you may find connected to your portable device (e.g., standard earphones, insert earphones, or noise reduction earphones). Regardless of the specific type or style being used, they are typically color coded red and blue for the right and left ears, respectively. Also note that earphones are calibrated for the particular audiometer they are attached to; this means that you must not switch the earphones from one audiometer to another. The results obtained under such conditions may not be valid.

- Your portable device will have a switch that controls the power of the audiometer. The exact location of this switch will vary from model to model. A common error is to think that if the device is plugged in it is automatically “on”. In most all cases, this is not true.
- The **frequency** switch is the control that allows the tester to select the test frequency in **Hertz (Hz)**. There is typically a (+) to increase the frequency and a (–) to decrease it; there will also be an indicator displaying the frequency numerically. Frequencies on the portable audiometer will typically range from 125 Hz through 8000 Hz for air conduction testing.

- The **attenuator** is the “dial” that controls the intensity or loudness of the sound in dB HL. Most attenuator dials vary sound level in 5 dB steps, with a range of approximately –10 dB HL through +110 dB HL (more or less depending on the particular frequency).

- The **output switch** allows the tester to select either the right ear or left ear; it will also allow selection of “air” or “bone.” The screening typically performed by the SLP will involve choosing “air” for air conduction testing using traditional or insert earphones.

- The **interrupter switch**, also known as the presentation switch, is the “button” or switch that allows the tester to present the sound to the patient. Another control that will be used in conjunction with the interrupter switch is a dial that can be set to “norm off” or “norm on.” When we select the “norm off” position, the sound will be off and we will need to press the interrupter to cause sound to be presented to the earphones; this is typically the method used in hearing screenings. Alternatively, we could select “norm on” position, which will generate a constant tone through the earphone and so pressing the interrupter will stop (interrupt) the sound from being sent to the earphones.

- If your machine has a masking dial, it is advised that you make sure that it is set to the “off” position. As an SLP, even if you were to be aware of the need for masking to be used, you would not be the person responsible for its administration.

- If you are using a spondee audiometer, the controls will be specific to that device, which will include limited functionality as compared to a standard portable audiometer.

### Equipment Preparation: Daily Biological Calibration/Listening Check

A **biological calibration**, also known as a **listening check**, is a required procedure that is performed daily in order to identify potential problems that may periodically arise that, in turn, affect the functioning of the equipment and the validity and reliability of the test results. Whether you are an audiologist, SLP, school nurse, or any other qualified or designated individual, the audiometer must be checked on a daily basis and at any additional time during the day when a problem or inconsistency is suspected. In order to perform the daily biological listening check, the following steps should be taken:

- Plug the audiometer into the electrical socket and turn the power switch to “on.”
- Check that all wires are securely and appropriately inserted into their proper ports.
- Visually inspect the earphones. For traditional earphones, make sure they are firmly connected to the headband. Check for any obvious cracks or splits of the rubber cushions and the wires as well.
- Place the earphones on yourself and perform the listening check as follows:
  - Set the intensity dial (attenuator) to a comfortable loudness level (this will likely be approximately 50 dB HL), set the frequency dial to 1000 Hz, and present the sound. Starting with the right ear, gently move the earphone cords around, listening for any crackling or inappropriate interruptions in the sound presented. Switch to the left ear and repeat the process.
  - Present a tone to each earphone and make sure that the tone comes out the proper side; remember, red is for the right ear and blue is for the left ear. Then, without
pressing the presentation switch, listen for any inappropriate electrical “hum”; repeat this for both earphones. There should be no “hum” in the earphones when there is no sound being presented.

- Lower the intensity dial to 0 dB HL and press the tone presentation switch (first in one ear and then in the other); similarly to the previous step, one should listen for extraneous noises; there should be no clicking sound when the switch is pressed down.
- Gradually vary the sound intensity from minimum to maximum (one ear at a time), making sure that as you raise the intensity on the dial, that the corresponding sound coming out of the earphone will increase appropriately as well. Be alert for any “dead spots” while you are manipulating the sound.
- Set the intensity dial to maximum. WITHOUT presenting any tone, listen for any electric hum or buzzing that may beappropriately generated at high intensity levels.
- When all steps are finished, remove the earphones.
- Be aware that the purpose of this biological listening check is merely to identify “gross” equipment malfunctions that can compromise the validity and reliability of the screening test results. If something does not sound right to you, do not use that piece of equipment until an equipment calibration expert has checked it out.
- Never put your client’s care or your own reputation, license, and certification at risk by using an audiometer that you suspect is not working properly!

**Test Environment**

As discussed above in the section on screening test environment, the room choice for the pure tone hearing screening is of maximum importance. While it is recognized that most SLPs in practice do not have access to a sound-treated acoustic environment, the room that you use to perform the hearing screening should be as quiet as possible. The site should be chosen carefully—that is, away from sources of background noise.

Remember that any adverse acoustic condition can have a negative influence on the screening test results. Finally, if an acceptably quiet environment cannot be found, or if noise levels unexpectedly increase, and your client fails the hearing screening, do NOT pass the client. It does not matter how “sure” you might feel that the excessive noise is the reason for the failure; you must never pass a client who did not respond to sound at the predetermined level of testing. Likewise, never raise the intensity of the screening level in an attempt to overcome the influence of background noise on the screening process. You can always either rescreen the individual or refer them for a complete audiologic evaluation.

**Client Preparation and Instructions**

Preparing your client for the screening activity is an important part of the process, and it involves making decisions regarding how you will administer the instructions to the client and what the expected response mode will be; for example, some clients will be able to raise their hand or push a button in response to a sound, while others may need the activity simplified into a “game.” Some of the factors that you will need to consider in your preparation will include chronological age, developmental level of functioning, cognitive impairments, dementia, and physical limitations. Be aware that verbally explaining the screening process and/or activity instructions may be counterproductive for some populations. For example, clients who are at a very young preschool level of functioning may be more successful if they are shown what to do, rather than being instructed verbally. If you are working with an elementary-level population, this preparation may include a “show and tell”-type activity to the class as a whole, which will serve to introduce the group to the equipment, the activity, and the expectations.
For an adult population, this may simply be verbally instructing the client regarding what you will be asking of him or her. All such preparations and instruction should be specifically tailored to your client's individual needs.

What follows are some general guidelines for different age ranges. The suggested instructions and response modes are based on the abilities typically associated with each (developmental) age range. Remember that, when making decisions about your screening protocol, you should take all available information into account about your client. If you start with a level of instruction that is unsuccessful, and perhaps beyond your client’s capability, you can always revert to an activity that is at a lower developmental level. A rule of thumb when determining which test procedure to use is to start high (developmentally) and work low (developmentally). Refer to the details and examples below.

Children Younger than 24 Months

In very young children, behavioral screening is not typically carried out using the equipment and methodology described in this section. While behavioral hearing testing is a routine and achievable goal for those younger than 2 years of age, it is often completed in a more acoustically controlled environment with audiologists who specialize in such testing. The SLP can perform objective screening procedures and may be required to do so as part of early intervention services. Keep in mind that children in this age range may fall within the scope of Early Hearing Detection and Intervention (EDHI) programs, and that activity is addressed in a separate chapter in this textbook.

Children Between 2 and 3 1/2 Years of Age

Screening of children in this age range needs careful consideration. Clients who are between approximately 2 and 3 1/2 years of age may be capable of conditioned play audiometry (CPA, as described below) as long as the “game” and instructions are modified to the simplest possible form. A good rule of thumb in this population is “less is more.” For example, instead of verbally explaining that “every time you hear these beeps, you are going to drop this block into the bucket,” you will likely have greater success using pantomime. In pantomime, the examiner illustrates the act of listening, then hearing the tone, and finally responding; theatrical demonstrations are suggested! Another typical behavior of children in this range is that they are sometimes reluctant to wear the earphones. Note that hand raising and verbal responding are generally not options with this population; therefore, the very simplest of “play” techniques is implemented. This technique of modifying the CPA activity to its very simplest form is referred to as a modified play technique; a suggested conditioning sequence follows:

- Show the child the earphones. Try comparing them to the earphones or earbuds of an iPod or other such device. You might even try calling the earphones your “special listening hat.” Encourage the child to wear the phones, but be aware that some children may be tactilely defensive or simply fearful and refuse to put them on. For the reluctant child, be as encouraging as you can; however, if a child is extremely resistant, it is ill advised to force the issue. In such a case, it may be best to refer for a complete evaluation to an audiologist who specializes in the assessment of young children.
- Once you have the earphones on the child, you will need a game at hand. The game may be blocks and a bucket, or a similar “simple” task. Remember: The simpler the activity, the better.
- Place a block in the child’s hand, and then with your hand over the child’s hand, say, “When we hear the beep, we’re going to drop the block into the bucket. Let’s try one together.” Note that it is generally more productive to “state” rather than to “ask”; if you ask a child if he or she wants to listen and
play a game, you are giving the child permission to say no.

- Present the sound at a moderately loud level (approximately 50 dB HL) and together you put the block in the bucket using a hand over hand technique. You will repeat this a few times (keeping you intensity moderately loud) until you sense that the child is responding to the sound. Once the child appears ready, you can say, “Okay, now you’re going to try this all by yourself.”
- Play this “game” with the child, always remembering to minimize verbal instruction and maximize gesture and enthusiasm.
- For a child who is seemingly not making the connection between the auditory stimulus (the beeping sound) and the desired response (the dropping of the block), switching to an exclusively pantomime approach of instruction may assist in helping the child understand the task. Remember that excessively wordy explanations may be a counterproductive approach, particularly with the language-impaired child.
- If after a few attempts the child does not condition to respond to the tone, refer the child to an audiologist for a complete audiological evaluation.

Preschool, Pre-Kindergarten, and Kindergarten

Children in the range of approximately 3 to 5 years of age will often benefit from a demonstration along with very some simple verbal instructions. Note that some older individuals and even geriatric patients may fall into this category, should there be some special needs as mentioned above. It is also useful to remember that some individuals who fall into this category may have language comprehension problems; therefore, keeping your instructions as simple as possible is advisable.

The methodology that is most often successful in the 3- to 5-year age range is CPA. The CPA technique turns the screening test into a game for the child. The older children in this age range are generally able to participate in almost any game, whereas the younger children in this range need the task to be modified into a simpler game. A common game employed for this type of screening is one where a child drops a block into a container every time a sound is heard.

- Set the earphones on a surface (e.g., a table), not on the child’s ears.
- With the earphones set on the table, not on the child’s ears, demonstrate the procedure. Using the audiometer, set the frequency to 1000 Hz, the attenuator to approximately 90 dB HL, and the output to either one of the earphones.
- Gain the child’s attention and say: “This is what you are going to hear. Every time you hear these beeps, you are going to drop this block into the bucket.” Then, tell the child, “Let’s practice.”
- Practice with the child by presenting a tone; after the tone is presented, you will drop the block with the child using a hand over hand technique. Do this several times until the child understands the “game.” Remember, the earphones are set on a table during the conditioning process, not yet on the child’s ears.
- Note that if you are doing this sort of “training” with a group of children, be careful regarding which child will go first. The reason is that when the child “plays the listening game” and has fun with the activity, the rest of the children will usually have fun and anticipate playing the game. Alternately, if the first child begins to cry, it may create something akin to a domino effect!

Older Children Through Adulthood

Older children through adulthood, those approximately 5 or 6 years of age and older, may be conditioned to respond to standard “hand raising” technique. That is, you may instruct the client to listen very carefully to the sounds and, every time they hear a sound, no matter how faint the sound is, they
are to raise a hand (or push the response button). It is worthwhile mentioning that children who are in the younger end of this age range (5 years of age) may begin the screening session by raising their hand appropriately, but the conditioned response may wane in its reliability as the screening procedure progresses. When this occurs, the SLP may need to recondition the client or may find it is helpful to developmentally modify the response task to a lower level, such as dropping a block in a bucket.

**Test Sequence**

Having decided upon the developmentally appropriate level of instruction and response mode (game or hand raising) for your client, the following sequence of steps is recommended:

- The earphones have been successfully placed on your client’s head, with the red earphone on the right ear and the blue earphone on the left ear; the headband should be adjusted so that each earphone fits snugly against the ear. You may need to remove glasses and/or earrings. If screening very young children, earphone placement should be carefully monitored because the band of the earphones is fashioned based on the size of an adult head, not a child’s. Proper placement of the headphones is critical; make sure that the diaphragm of the earphone (the center dime-sized area) is immediately covering the opening of the ear canal.

- The pure tone screening guidelines put forth by ASHA recommend that a screening be done to identify hearing loss of 20 dB HL or greater in the speech frequencies of 500 Hz through 4000 Hz. Therefore, the ideal screening session will utilize the following frequencies: 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, and 4000 Hz in each ear. Note that the ability to successfully screen the frequency of 500 Hz is dependent on the test environment being very quiet; otherwise, this frequency will be eliminated. Ideally, your client will ultimately respond at no greater than 20 dB HL to each of the tones in each ear. The order of presentation will be right ear first at 1000 Hz, then 2000 Hz, 3000 Hz, 4000 Hz, and lastly 500 Hz (if the test environment is sufficiently quiet). After completing all of the frequencies in the right ear, you will proceed to the left ear in the same frequency order.

- Be careful when you are presenting tones not to find yourself stuck in a pattern where you present the tone at exactly the same time interval (for example, every 5 seconds). Varying the timing in between your presentations will help prevent false responses. Remember that a false-positive response that can result in the serious error of passing an individual who actually has a hearing impairment. Another behavior to avoid includes looking up in an attempt to make eye contact with the client each time you present a tone. This may visually “cue” the listener to the fact that you have just presented a sound, to which they will respond, whether they heard it or not—again resulting in a false-positive result.

- In order to appropriately condition the individual being screened to the response modality, the initial intensity level will be approximately 50 dB HL (starting at 1000 Hz), and each presentation will be held for a full 2 seconds (no less). The level of 50 dB HL “should” be sufficiently loud for a listener with normal hearing to perceive and respond to the sound. If there is no response at this level, you can make the tone louder by 10 dB or 20 dB; if there is still no response, you should re-instruct the client on how to respond to the tone appropriately. If there is still no response, discontinue testing, and refer the client for a full audiological evaluation.

- When you are certain that your client hears the sound, you will lower the intensity by 10 dB to a presentation level of 40 dB HL; each time you get a response you will lower the dB level by 10 DB each time to gradually
accustom the client to listen to a decreasing intensity level. When you successfully get a response down to a level of 20 dB HL, you can then move on to the next frequency. Note that, in very young children, you may need to work in 5-dB steps in order to keep them focused on responding to softer and softer sounds.

- Move on the next test frequency, but keep your intensity dial at 20 dB HL. There is no need to raise the intensity back up to 50 dB HL, as you did for the first frequency tested if the conditioned response of the client remains. If the client responds satisfactorily to this frequency at 20 dB HL, then simply move on to the next frequency and again remain at 20 dB HL and present the next tone.
- If the client does not respond to a subsequent frequency at the 20 dB HL, you may have lost your conditioned response. Raise the intensity by 10 dB increasingly; when you get a response you have confidence in, you can gradually lower the intensity again until you successfully reach the desired level of 20 dB HL. In very young children, the mere fact that there was a frequency change may cause them to lose the response pattern and they may need to be reconditioned at a higher intensity level, or reinstructed that they are still to respond even though the tone is different.
- When you have completed the right ear, you will switch to the left ear; you may start again at 1000 Hz while the intensity remains at 20 dB HL. If there is no response, simply raise the intensity to 50 dB HL and then follow the same procedure as just described. Again, in the very young child, the fact that you have changed ears may cause them to lose their response pattern and they may need to be reconditioned or reinstructed.
- Overall, if the client’s response pattern is unreliable, or if you are simply not convinced of the repeatability and reliability of that response pattern (for whatever reason), simply discontinue the screening. If this is first time you are attempting the screening activity on a very young or special needs child, you may wish to rescreen the child in the near future. If this is the second screening, refer to an audiologist for assessment.

Pure Tone Screening Results: Criteria and Recommendations

- As you test each frequency you will record the responses on a hearing screening form; see Appendix 11.A for an example of such a form. In each box you will place either a check mark (√) to indicate that there is a response or an “x” to indicate that there is no response. Any other mutually agreed-upon screening form and markings may be used as well.
- There is a simple pass/fail response criterion—that is, if any client fails to respond at 20 dB HL at any one frequency in either ear, this is considered a “failure.” To be clear, even a response obtained at 25 dB HL is not a sufficiently sensitive response and warrants a failure.
- Failures of this hearing screening require a referral to an audiologist for a complete evaluation and/or to a physician for a medical examination.
- A recommendation of rescreening hearing in 1 to 2 weeks may sometimes be appropriate, particularly when screenings are done in the very young ages and at the beginning of the school year. However, if suspicion of hearing loss exists, an immediate referral for a complete diagnostic audiologic evaluation can be made without the need for a rescreen.

Otoacoustic Emissions Screening

Otoacoustic emission screening is a nonbehavioral method of screening hearing and an ideal choice in populations when a traditional pure tone screening (the kind using response patterns such as hand
raising or play audiometry technique) would not yield reliable results. Clients of all ages and developmental levels can be successfully screened with this procedure. Another advantage to using otoacoustic emissions as a screening procedure is the time-effectiveness of the measure. In the time it may take to merely condition an individual to respond to a pure tone air conduction, a nonbehavioral screening can be wholly completed using an OAE screening device.

**Equipment**

Like all other audiometric equipment, the OAE screening device (see Figure 11.6) is an expensive and complex instrument. It can be damaged by excessive temperatures, rough handling, and being dropped. Each unit must be serviced and undergo an electroacoustic calibration on at least an annual basis. When completed, a dated sticker is placed on the instrument (or on its case) to verify this requirement has been met; it will also indicate the date that it is due to be recalibrated. Before using any piece of equipment, you must first verify its calibration is current; remember, do not use any piece of equipment that does not have a valid dated calibration sticker. An example of an otoacoustic emission screener is also shown in Figure 11.6.

**Familiarization with Equipment Components**

While there are various manufacturers and models of OAE equipment, they will share common elements. The following is intended to guide you in familiarizing yourself with the equipment:

- You may wish to contact either the manufacturer’s representative or a local audiologist for assistance in learning about your equipment. Your screening device will have been programmed by the manufacturer and a screening protocol may be further set by a consulting audiologist based on screening criteria for a specific population. The screening results will appear on the digital readout of the device. Some devices will also have the ability to print the results of the screening to be placed in the client’s records.
- The power supply of the device is typically a rechargeable battery and/or adaptor cord. Prior to any planned screening, check that your device has a full charge.
- The probe assembly consists of a probe tip attached to one end of a wire (approximately 3 to 4 feet in length) or directly interfaced with the body of the device. There is usually a clip on the wire portion of the assembly that permits it to be clipped to the client’s clothing to secure it for testing if there is a separate probe tip assembly.
- Ear tips, sometimes called probe tips or covers, go over the probe assembly prior to insertion in the client’s ear; these help ensure that the probe fits “snuggly” into the person’s ear canal. Probe tips are usually disposable, but the same tip can be used for both ears of the same client, and may also be the same tip used for performing tympanometry (with some equipment manufacturers). It is noteworthy to mention that after you finish the first ear, be sure to check the probe tip for any wax that might have been gathered from the first insertion before you put the probe into the second.
ear for testing. It is also important to know that not all individuals have ear canals that are the same size and a different sized probe tip may be needed for each individual ear.

- Once the probe tip is placed snugly into the client's ear canal, the preset program will need to be initiated typically using a "start" or "run test" button on the device. The OAE screening sequence will then run automatically based on the preset parameters.

**Equipment Preparation**

The steps involved in preparing the OAE screening test equipment are less extensive than that of the pure tone air conduction screening preparation; however, they are no less important.

- Turn on the equipment.
- Check your calibration sticker to ensure that the calibration date is current.
- Ensure that the probe assembly is properly connected and check the probe tip for any lodged wax or debris, as this may negatively impact the accuracy of the screening procedure and results.
- To assure proper function, perform an initial screening on a coworker or colleague known to have normal hearing sensitivity, or on yourself. This would be the equivalent of the daily biological check on the pure tone screening equipment. Double-checking the appropriate function of your screening equipment prior to use is always a prudent practice.

**Test Environment**

The acoustic characteristics of the physical environment you choose are as important for the OAE screening procedure as they are for pure tone air conduction screenings. Remember that the measurement of OAEs involves detecting very “soft level” sounds that are emitted from the inner ear; the presence of background noise will prevent, or at least impede, the process. Therefore, take care in the selection of the environment you will use for the screening activity; make sure that it is away from areas with high levels of background noise. As cautioned above, if an acceptably quiet environment cannot be found or if noise levels unexpectedly increase, and your client receives a fail or refer result on the screening, never pass the person. Even if you “feel certain” that the failure was the result of extraneous noise, your responsibility is to refer the individual for a retest or a full audiologic assessment.

**Client Preparation and Instructions**

Client preparation and instruction for an OAE screening is far simpler than what is required for behavioral screening test methods such as pure tone air conduction audiometry. In fact, as pointed out above, OAE screenings can be completed in far less time than behavioral measures. Hence, there is little difference between the expectations of the average adult versus the very young child. A few concerns that are worthy of consideration follow below.

- Internal/biological noise, as well as environmental, must be kept at a minimum. This means that excessive noise from chewing, sucking, crying, resistance, or movement in general will interfere with the screening process just as much as background noise. Therefore, both types of noise must be avoided; ideally, your client will remain as still as possible during this procedure.
- As with the visual inspection, screening while asleep may prove more successful for certain populations. However, this might not be possible for most SLPs; refer your client to an audiologist if you are unable to perform the OAE screening. Any assessment of speech and language skills for the clients whose hearing status has not been checked should be interpreted with caution.
- For the more amenable client, you can simply instruct the individual to be calm and not to move around. As indicated in the pure tone air conduction screening section above, a young child—even if pleasant and cooperative—may
do better without “wordy” explanations. A technique that has been found to be successful in many instances is to merely tell the child that you are going to draw a picture of his or her ear. When the test sequence is complete, show him or her the screen and praise him or her for drawing a pretty picture with his or her ear (whether he or she passed or not).

Test Sequence

Regardless of which specific manufacturer and model of OAE screening equipment you are using, the screening process itself will be very similar, if not identical.

- In an effort to minimize the time a client will wait for you to get organized, have all equipment and other supplies at hand (e.g., OAE screening device, toys, forms, etc.).
- Seat the client comfortably in a chair or on a parent's lap.
- Remember to follow your facility’s recommendations and guidelines for cleanliness and universal precaution prior to and following testing.
- Visually inspect in and around the ear. Look for overt indications of abnormality, such as excessive wax, external otitis, ear pits, ear tags, microtia, and the like. Also make note of any redness or sensitivity to touch, and refer accordingly.
- If an otoscope is available, nondiagnostic inspection the ear canal is advised. The goal is not to arrive at any conclusions, but merely to look and make note of any gross abnormalities you may find. Remember, this is within your scope of practice.
- Select a probe tip (cover) that is at least as large as, or a little larger than, the client's ear canal opening. The largest tip that will fit the canal will likely create a better seal; this will not increase discomfort for the client. Note that even experienced audiologists sometimes have to try a few different tips before they get the right one for an individual. Selecting the appropriate size is a skill that comes with time and experience.
- Push the tip firmly and securely over the probe.
- With one hand, pull the client's pinna in such a way that the ear canal opens wide (this is usually up and back for an adult and down and back for a child). With your other hand, place the probe into the client's ear canal and gently rotate the probe clockwise and counterclockwise, then let go of the pinna. The probe should stay “seated” in the ear canal. Do not hold or push the probe in place during testing.
- If necessary, clip the probe assembly wire to the client's collar to help prevent it from pulling out of the ear canal.
- Begin the procedure by pushing the start button, or as otherwise indicated on the instructions of your specific device. Most screening units will then run automatically with no need for further action on the part of the tester. When the test is complete, which will be typically less than 30 to 45 seconds, the display screen will indicate pass or fail/refer.
- Remove the probe from the first ear. Check the probe tip to make sure there is not wax or debris clogging it, and then repeat the process for the other ear.

OAE Screening Results: Criteria and Recommendations

- If visual and/or otoscopic inspection reveal any obvious or suspected abnormalities, an immediate referral to a physician or other healthcare provider must be made.
- There is a simple pass or fail/refer criteria utilized for screening OAE tests.
• If a client passes, no referral is indicated. However, if any questions or concerns persist on the part of the professional, the client, the parent, and/or primary care giver, an immediate referral for a complete audiologic evaluation should be made.

• If a client fails the OAE screening as indicated with by a “fail,” “refer,” “?,” “red light,” or any response other than a clear “pass,” a referral for a complete audiologic evaluation and otoacoustic examination must be made. This finding will be recorded on the screening form (see Appendix 11.A).

• It is imperative to remember the theoretical principles behind otoacoustic emissions, and that a response is only a direct statement about the health of the certain structures of the ear. It does not necessarily follow that a client’s functional hearing is normal as well. Only behavioral hearing tests are a direct measure of a person’s hearing ability. While the presence of the OAE response is most often consistent with a certain level of hearing, it must be remembered that under certain conditions, a hearing loss may simultaneously exist with the presence of an OAE result. Therefore, it is important to remember that even if the OAE screening results are a “pass,” any questions or concerns warrant a referral for a complete audiologic evaluation.

**Tympanometry Screening**

Tympanometry is a nonbehavioral test of middle ear function, meaning that it does not require the active participation of the individual. The results of this screening yield information regarding the health of the patient’s ear that can assist in the medical diagnosis of pathology by a physician.

As you will see in the information that follows, there are many similarities between tympanometry screening and OAE screening—not only in the nonbehavioral nature of the test, client preparation, but the equipment used as well. These similarities have led to hybrid devices that are capable of performing both OAE and tympanometry screenings; sometimes they run in an automatic sequence. Other more traditional devices perform tympanometry screening alone.

**Equipment**

Figure 11.7 and Figure 11.8 provide examples of screening tympanometers. Like all other audiometric
equipment, these devices are expensive and complex, easily damaged, are sensitive to extreme temperatures, and require annual calibration. Always check that the tympanometer has a current calibration sticker with the last date of calibration clearly indicated and that date is within one calendar year of the date of use.

Familiarization with Equipment Components

While there are various manufacturers and models of tympanometry screening equipment and combined (hybrid) tympanometry with OAE screening, and they will share common elements. The following is intended to guide you in familiarizing yourself with the equipment.

- You may wish to contact either the manufacturer’s representative or your local audiologist for assistance in learning about your equipment. Your screening device will have been programmed by one of these professionals; the screening results may be displayed in any one of several ways and it will depend not only on the manufacturer and model, but on whether it is tympanometry only or a combination device. The power supply options may vary, while most devices typically work off of a rechargeable battery and/or adaptor cord. Prior to any planned screening, check that your device has a full charge.

- The probe itself will also vary, sometimes significantly. Some devices have a probe assembly that consists of a probe tip attached to one end of a wire (approximately 3 to 4 feet in length) that interface with the body of the device (see the type of wire shown in Figure 11.6. Alternately, there may be a probe that is integral with the body of the device (see Figure 11.7). Given the wide variety of options, it is strongly advised that you seek guidance from another professional who is familiar with the equipment and its functionality or contact the equipment’s manufacturer.

- When there is a wired probe connection to your devices, there will often be a clip on the wire portion of the assembly that permits it to be clipped to the client’s clothing to secure it for testing.

- Ear tips, sometimes called probe tips or covers, go over the probe assembly prior to insertion in the client’s ear; these help ensure that the probe fits “snuggly” into the person’s ear canal. Probe tips are usually disposable, but the same tip can be used for both ears of the same client. However, after you finish the first ear be sure to check for any wax that might have been gathered from the first ear, before you put the probe into the second ear for testing.

- The other component of the unit of which you should be aware is the start button. Unlike pure tone air conduction, the tympanometry or tympanometry/OAE combination screening sequence will run automatically.

Equipment Preparation

The steps involved in preparation of the screening test equipment, whether tympanometer alone or tympanometer/OAE hybrid, are less extensive than that of the pure tone air conduction screening preparation; however, they are no less important.

- Turn on the equipment.

- Check your calibration sticker to ensure that the calibration date is current.

- If you have a wired type of probe assembly, ensure that it is properly connected to the body of the device. For all types of probes, check that the probe tip is clear of any/all debris as this may negatively impact the accuracy of the screening procedure and results.

- To assure proper function, performing an initial screening on a coworker, colleague, or yourself—someone known to have normal middle ear function—would be the equivalent of the daily biological check on the pure tone screening equipment. Double-checking the appropriate function of your screening
equipment prior to use is always a prudent practice.

**Test Environment**

The acoustic characteristics of the physical environment you choose for all audiometric screenings are important. While background ambient noise levels are not specified as they are for pure tone and OAE testing, care should be taken nonetheless. Remember that the measurement of tympanometry is often combined in a single sequence that includes OAEs, which involves detecting very “soft level” sounds that are emitted from the inner ear and thus requires that background sound be sufficiently low to permit reliable measurements. Therefore, take care in the selection of the environment you will use for the screening activity. As cautioned above, if an acceptably quiet environment cannot be found or if noise levels unexpectedly increase, and your client receives a fail or refer result on the screening, never pass the person on the assumption that the background noise was the sole cause of the failure.

**Client Preparation and Instructions**

Client preparation and instruction for tympanometry and hybrid tympanometry/OAE screening is far simpler than what is required for behavioral screening test methods, such as pure tone air conduction audiometry. In fact, as pointed out above, these screenings can be completed even if the individual is asleep, and in far less time. Hence, there is little difference between the expectations of the average adult versus the very young child. A few concerns that are worthy of consideration follow below.

- Internal/biological noise, as well as environmental, must be kept at a minimum. This means that excessive noise from chewing, sucking, crying, resistance, movement in general, etc., will interfere with the screening process just as much as background noise. Therefore, both types of noise must be avoided; ideally, your client will remain as still as possible during this procedure.

- For a client who is very young, tactiley defensive, and/or simply difficult to test regardless of age or reason, screening during a sleep cycle may prove more successful. For the practicing SLP, this may not be possible. Should your best efforts at keeping your client calm be unsuccessful, refer the client to an audiologist for a complete evaluation. Remember, if this occurs and you continue on with your scheduled speech-language evaluation, be sure to “interpret with caution” any assessment results for the clients whose hearing status has not been checked.

- For the more amenable client, you can simply instruct the individual to be calm and not to move around. As indicated in the pure tone air conduction screening section above, a young child—even if pleasant and cooperative—may do better without “wordy” explanations. Again, the technique of simply telling the child that you are going to draw a picture of their ear applies.

**Test Sequence**

Regardless of which specific manufacturer and model of tympanometry screening equipment you are using, the screening process itself will be very similar, if not identical. Note also that regardless of whether your screening is only tympanometry or the addition of an OAE screening as well, the time factor for the screening test to be administered is still very minimal, likely less than 1 minute per ear.

- In an effort to minimize the time a client will wait for you to get organized, have all equipment and other supplies at hand (e.g., OAE screening device, toys, forms, etc.).
- Seat the client comfortably in a chair or on a parent’s lap.
- Remember to follow your facility’s recommendations and guidelines for cleanliness and universal precaution prior to and following testing.
- Visually inspect in and around the ear. Look for overt indications of abnormality, such
as excessive wax, external otitis, ear pits, ear tags, microtia, and the like. Also make note of any redness or sensitivity to touch, and refer accordingly.

- If an otoscope is available, nondiagnostic inspection of the ear canal is advised. The goal is not to arrive at any conclusions, but merely to look and make note of any gross abnormalities you may find. Remember, this is within your scope of practice.
- If there are any signs of occluding or excessive cerumen, infection, pus, draining ear, etc., your client should immediately be referred to a physician for medical assessment as well as an audiologist for full evaluation. Do not proceed under these conditions.
- Select a probe tip (cover) that is at least as large as, or a little larger than the client's ear canal opening. The largest tip that will fit the canal will likely create a better seal; this will not increase discomfort for the client. Note that even experienced audiologists sometimes have to try a few different tips before they get the right one for an individual. Again, the proper size selection for an individual probe tip will come with time and experience.
- Push the tip firmly and securely over the probe.
- With one hand, pull the client's pinna in such a way that the ear canal opens wide (this is usually up and back for an adult and down and back for a child). With your other hand, place the probe into the client's ear canal and gently rotate the probe clockwise and counterclockwise; then let go of the pinna. The probe should stay “seated” in the ear canal. Do not hold or push the probe in place during testing.
- If the probe assembly is separate from the device itself, clip the probe assembly wire to the client's collar to help prevent it from pulling out of the ear canal.
- Begin the procedure by pushing the start button, or as otherwise indicated on the instructions of your specific device. Most screening units will then run automatically with no need for further action on the part of the tester. When the test is complete, which will be typically less than 10 seconds, the results will be displayed on the screen of your device. Many devices will also allow the printing of the screening results.
- Remove the probe from the first ear. Check the probe tip to make sure there is no wax or debris clogging it, and then repeat the process for the other ear.

**Tympanometry Screening Results: Criteria and Recommendations**

- Results of the tympanogram screening (for most devices) are quite straightforward. There is typically a box on the display screen with a shaded or outlined area that will be indicative of the “normal” range of functioning.
- If the “peak” on your client's tympanogram tracing falls inside of this normal area, it can be considered a “pass.” However, consideration must also be given to observations made during visual inspection; assuming that there are no other “red flag” concerns (e.g., redness of the ear or other concerning visual observations), you will mark this on your screening form by writing “pass” or another agreed-upon marking to indicate the person has passed the screening and there are no concerns. In this case, no referrals are in order.
- If your client's tympanogram tracing is clearly abnormal, with either no peak at all or nearly no peak, this is a “failure” and should be marked on your screening form as such. This result required an immediate referral to a physician, followed by a referral to an audiologist.
- At times your client's results may show what might be described as a “near normal” tracing; for example, there is a peak but it is at the borderline of either the pressure or compliance reading (near the outer edges of the box.
or shaded area). In this case, retesting prior to the next therapy session may be an appropriate recommendation. If you do not routinely see this client for therapy, as may be the case for a speech-language evaluation session, then a referral to a physician is in order.

- Record the “Pass” or “Fail” results on your hearing screening form (Appendix 11.A).
- Always err on the side of caution; any questionable tympanometric tracing requires referral to a physician and/or audiologist.
- If your client will not allow you to approach him/her (as may happen with a fearful or tactilely defensive child), even after trying you best to establish a friendly rapport, it is wise to simply try another day. It is counterproductive to force this procedure on an individual if you desire to obtain results at a future date.
- Lastly, remember that regardless of the tympanogram result, if there are any signs of discharge, physical abnormalities, wax or other foreign bodies in the ear canal, a referral to a physician is strongly recommended.

### Screening for Handicap

Ideally, a screening for handicap is done as a supplement to the screening for a hearing disorder and impairment. There are instances, however, when this type of screening may be useful. You may encounter cases when screening for hearing impairment cannot be completed or will not yield useful information. Let us take the example of a client referred for a speech-language evaluation who is recovering from a stroke, has a long-standing history of hearing loss, and wears a hearing aid. Conducting a hearing screening (using pure tones or OAEs) will not provide useful information. Remember, a hearing screening employs a pass/fail criterion; someone with a known hearing loss will fail the screening, which we already know because of the client’s history. In such a case you will automatically refer for a complete audiolologic evaluation in order to learn if the stroke has caused further damage to his or her hearing status. Regardless of this, you may also wish to use a handicap screening tool to get a general idea of impact that the hearing loss may be causing on the individual’s quality of life.

As pointed out earlier, all clients require an audiolologic screening in order to rule out or identify risk for an auditory impairment, regardless of the reason for the referral. The screening methods presented above, individually or in combination, assist the professional in identifying those clients who are potentially at risk for the presence of an auditory disorder (physical anomaly) and/or impairment (hearing loss) as the primary or comorbid cause of the apparent speech-language deficit. It is equally important to administer a screening to identify those clients whose impairments cause concomitant handicap, often referred to quality of life issues. While the screening for handicap may yield useful information in all populations, it may be particularly useful in the adult and older adult populations, due to their reluctance to admit difficulties hearing and frequent failure to follow through, even if acknowledged. Additionally, the information obtained from these screening tools can be very useful for all age and disorder populations in determining the appropriate recommendations for follow up evaluations for your clients.

The tools suggested below are only meant as screening measures for handicap; they are not intended to serve as a thorough and exhaustive assessment of your client’s estimation of the disability or handicap they may experience. Should concerns arise as a result of this type of screening, the clinician is advised to seek out the vast array of self-assessment scales, questionnaires, and inventories, by age and disorder population, that have been designed to more thoroughly assess the impact of auditory impairment of life function. Remember, whether you are functioning as an SLP or audiologist, having an idea of how your patient views the impact of his or her condition in terms of disability or handicap will provide you with important information and guide you through the intervention planning process.
Equipment/Tools

Screening for handicap does not require the sophisticated electronic equipment that is necessary when screening for the presence of disorders and impairments. The equipment necessary for a screening of handicap is typically scales and questionnaires that are valid and reliable.

Administration typically requires a “paper and pencil” response format and space to conduct the interview. Each of the screening tools below is most often administered by asking the patient and/or family member a few questions and marking the answers on the appropriate form. Some of the tools mentioned below have the option of going to the specific website and filling out the form online; the results are then often available to be printed out, downloaded, or emailed.

Screening Tools for Children (Preschool through High School)

Each of the following paper and pencil tools are specifically meant to be used as screening measures that can quickly identify those at risk for adverse effects of hearing loss in a variety of different contexts. These and many additional tools can be accessed through the Supporting Success for Children with Hearing Loss website, directed by Karen Anderson, PhD, at www.successforkidswithhearingloss.com/tests/.

- Preschool S.I.F.T.E.R (Anderson and Matkin) is meant for children aged 3 through 5 years.
- S.I.F.T.E.R (Elementary) focuses on children from grades 1 through 5.
- Secondary S.I.F.T.E.R is a questionnaire for middle- and high-school students.
- Audiology Self-Advocacy Checklist–Middle School.

Screening Tools for Adults and Older Adults

Screening tools for adults and older adults differ in the line of questions posed versus the younger population. The line of questions focus on the type of challenges encountered by this age group and can lead the SLP to identify specific difficulties. As stated previously, many of these questionnaires are pen and paper while others can be completed in an online format. In some cases, having both the client with hearing loss complete the form as well as a close family member can yield important information regarding the perception of the hearing loss on the family dynamic as well as the individual impact of the loss on the individual.

- Hearing Handicap Inventory for Adults–screening version (HHIA-S; Newman, Weinstein, Jacobson, & Hug, 1991). This tool is a screening version of the full-length inventory addressing the social and emotional impact of hearing loss in those individuals younger than 65 years of age.
- Hearing Handicap Inventory for the Elderly–screening version (HHIE-S; Ventry & Weinstein, 1982). This tool, which is shown in Figure 11.9, is a screening version of the full-length inventory addressing social and emotional consequences of hearing loss in the older adult (older than 65 years of age).
- Self-Assessment of Communication (SAC; Schow & Nerbonne, 1982). This tool may be used with all adults; it provides a brief query into the impact of hearing loss in various communication situations. There is a paper and pencil version, or users may also take this brief screening questionnaire by going to http://www2.isu.edu/csed/audiology/profile/sac.shtml.
- Significant Other Assessment of Communication (SOAC; Schow & Nerbonne, 1982). This tool is the companion of the SAC above, and it is specifically designed as a screening that can be filled out by a client’s significant other (partner).
- Abbreviated Profile of Hearing Aid Benefit (APHAB; Cox & Alexander, 1995).
This tool is a shortened version of its forerunner, and consists of 24 test items that explore how a person perceives his/her ability to function without versus with hearing assistance technology.

### Test Environment

According to the Audiologic Screening Guidelines (ASHA, 1997), any environment that is conducive to interview and protects patient confidentiality is sufficient to be used for disability screening.

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**Figure 11.9** Screening version of the Hearing Handicap Inventory for the Elderly (HHIE-S).

procedures. Because these tools are not measuring a person’s functional hearing ability, ambient noise levels may exceed the ANSI (2008) specifications. Caution must be taken, however, to select an environment with minimal background noise in order to reduce distractions and facilitate the screening process.

**Client Preparation, Instructions, and Test Sequence**

Given the varied and numerous handicap tools available for use in this type of screening, there is no single set of instructions and sequence of test steps that will be appropriate to all. The general preparation will include finding an appropriate testing environment and situating the client and/or parents and family members comfortably. Most of the tools mentioned will be administered by interview, paper and pencil response format, or computer-based response mode. The specific tool(s) chosen for this screening will dictate the specific instructions to be administered. When choosing a tool to use, consideration should be given to the overall cognitive function of the individual being interviewed. If the language level of the tool is not appropriate for the individual to comprehend the content of each question an accurate response will not be obtained.

- If your client is wearing hearing aids or uses any other type of assistive listening device, inspect the device for use and function. Check to make sure that the batteries are working and perform a listening check on the device to assure it is free of static or other acoustic distortions of sound. Make sure the device is not generating feedback (high-pitch whistling sound) when sitting in the client’s ear. You may wish to refer to the guidelines provided in this text on performing an appropriate check on hearing aids and assistive listening devices. Do not assume that just because the hearing aid(s) is/are in the client’s ears that it is/they are functioning properly.
- Make sure that your client is comfortably seated. If you will be reading the questions to the client, make sure that he or she is sitting in full view of your face so that speechreading cues can be utilized.
- If you are conducting an interview, you will write down the client’s responses on the appropriate form. If your client is using the paper and pencil or online response format, make sure that the necessary skills are in place for them to complete the task. Be alert and available for any questions or problems that may arise.
- Using the HHIE-S as an example (see Figure 11.9), either the interviewing clinician or the client himself/herself will answer each question with a response of “yes,” “sometimes,” or “no.”

**Handicap Screening Results and Recommendations**

Using the results of these screening tools in combination with the hearing disorder and impairment methods described earlier will add clarity and confidence to your overall screening results and recommendations.

The first thing you will want to do is to score the test results. The instructions provided with your specific screening tool will direct you on how to score and interpret the results obtained. Using the HHIE-S as an example, scoring is completed by giving four points for each “yes” response, two points for each “sometimes” response, and zero points for each “no” response. Refer again to Figure 11.9. The overall raw score is then calculated and compared to the interpretation guidelines provided at the bottom of the form; referrals are made as indicated.

Any time a client fails a screening based on visual inspection, otoscopy, pure tone air conduction, otoacoustic emissions, or tympanometry, a referral must be made to an audiologist and/or medical specialist as indicated. Adding the screening for handicap may provide necessary guidance.
on how the suspected (or known) impairment is impacting the client socially, emotionally, or situationally. There are also times when a client passes the screening for hearing impairment, yet concerns persist. In such cases, the handicap screening results may serve to clarify those concerns and provide direction for appropriate recommendations and follow-up. Never assume that the degree of hearing loss and its impact on quality of life will be the same for each individual you serve.

Additional Screening Considerations and Questions

Documentation

Regardless of the age range, population, and facility type that you are working within, you will need to accurately and appropriately document your screening, the results, and recommendations for follow-up. If you are in a preschool, elementary, or secondary school setting, there will be state and local district requirements with which you will need to become familiar and follow. Alternately, you may be working in an acute care, subacute care, or long-term facility; they too will have applicable procedures and guidelines. All clinicians are strongly advised to become familiar with all such regulations to ensure compliance.

Can I Send the Results Home?

The answer to this question will depend on the specific guidelines that you are required to follow (see above). If you are working with a child within a local school system, you may be required to send this information through another professional such as the school nurse, a social worker, or the principal. Depending on the procedures of your school, you may be sending the screening form, or you may have a summary letter instead. Figure 11.10 shows an example of a summary letter that may go home to parents, regardless of who is actually responsible for the communication.

What Should (and Should Not) Be Said to Clients and/or Parents and Family Members?

One must be mindful of the fact that what you have just completed is a screening. Again, the results are either “pass” or “fail/refer.” When counseling a client, parent, or family member regarding the results, caution must be used when discussing the results. Statements like, “I believe there is a hearing loss” or “My testing shows that your child does not hear well” should be avoided. If there is an obvious medical condition such as drainage from the ear or excessive/occluding ear wax, a recommendation for medical follow-up can most certainly be made. If a “fail/refer” result is obtained, a recommendation for follow-up with a medical doctor or audiologist should be recommended. As a rule of thumb, the words hearing loss, as a diagnostic term, cannot and should not be used.

What about Liability?

As it has been referenced numerous times in this chapter, screening for hearing loss is within the scope of practice for the SLP. You should be aware of the liability policy your place of employment or agency holds for you. Many practicing SLPs also choose to hold individual policies as well. Regardless, you are liable for your practices and the results you generate. Screening results that are released to a client, school system, or other agency may be referenced in other reports generated by those facilities as well. When releasing results, make sure they are clear and concise. A disclaimer statement on any paper forms may include, “For screening purposes only; these results are not intended to diagnose any disease or disorder.” Remember to never use the words diagnosis or hearing loss when releasing screening results.
Figure 11.10  An example of a summary letter that may be used to send home to parents or guardians with the results of the screening test.
SUMMARY

The speech-language pathologist should be confident with the skills necessary to perform a screening for the presence of hearing loss as a standard of practice. When done in a comprehensive manner, a screening should include superficial inspection of the outer ear, tympanometry, and either a behavioral or nonbehavioral measurement of hearing sensitivity. The results never go beyond two options: “pass” or “fail/refer”. In either case, it is important that the SLP follow up with the client, parent, or family member to assure they are pursuing the appropriate recommendation when a problem is suspected.

DISCUSSION QUESTIONS

1. What is the difference between a diagnostic test and a screening measure?
2. What are the four possible results of a screening?
3. Describe one objective screening measure and one behavioral screening measure. When would you choose one versus the other?
4. List three confounding elements that would preclude accurate screening results.
5. When should you make an allowance for ambient noise while doing pure tone screenings? When should you not make an allowance for ambient noise?
6. Research one hearing handicap questionnaire for a school age child and one for an adult. What questions might you find most helpful in designing a treatment plan for a 11-year-old girl with a moderate hearing loss in an inclusive educational setting? What questions might you find most helpful in designing a treatment plan for a 60-year-old male with a precipitously sloping hearing loss employed in an executive capacity?

REFERENCES


Recommended Readings


Hearing Screening Form

Name: ________________________________________________________________________ Date of Test: __________

Date of Birth: ________________ Screener: _______________________________________________________________

Otoscopic: Normal Abnormal
___________________________________________________________________________________________________
___________________________________________________________________________________________________

Tympanogram: Normal Abnormal
___________________________________________________________________________________________________

Otoacoustic Emissions:

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<th>Ear</th>
<th>TEOAE</th>
<th>DPOAE</th>
<th>Comments</th>
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Pure Tones: (at 20 dB unless otherwise noted)

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Results and Comments:  Pass  Fail  Rescreen  Refer
___________________________________________________________________________________________________
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___________________________________________________________________________________________________
___________________________________________________________________________________________________

Put check mark (✓) in boxes patients respond. Put x mark (x) in boxes if patients don’t respond.

DPOAE = distortion product otoacoustic emissions; TEOAE = transient-evoked otoacoustic emissions.
Chapter 12

Hearing Aids and Cochlear Implants

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Key Terms

- Behind-the-ear (BTE) hearing aid
- Bimodal hearing amplification
- Bone-anchored hearing aid (BAHA)/Bone-anchored hearing system (BAHS)
- Cochlear implant (CI)
- Completely-in-canal (CIC) hearing aid
- Conventional hearing aids
- Direct audio input (DAI)
- In-the-ear (ITE) hearing aid
- Invisible-in-canal (IIC) hearing aid
- Middle ear implant (MEI)
- Telecoil
- Temporal cues

Objectives

- Gain a historical perspective of hearing aids from pre-electric to current day digital devices.
- Identify the different styles of hearing aids available to address hearing loss including devices worn on the ear, in the ear, and those that are surgically implanted.
- Illustrate the tools needed to troubleshoot and maintain hearing aids.
- Describe the integral parts of a cochlear implant.
- Develop the ability to troubleshoot and maintain the components of a cochlear implant.
Introduction

Hearing loss presents communication challenges across many listening conditions and to varying degrees. The impact of a hearing loss on an individual’s ability to function day to day will vary from person to person and situation to situation. Because each person is unique in how he or she will cope with hearing loss, many factors should be considered in order to determine the appropriate interventions needed to improve a person’s function and quality of life. These factors include skills related to communication, social interaction, independent functional capacity, vocational needs, and academic needs.

First and foremost in this process is the purchase of hearing aids. These devices provide personal amplification to address the specific configuration and severity of hearing loss as a component of a comprehensive treatment process. The style of the hearing aid—behind the ear or in the ear; large or small; type of signal processing; large device controls, regular controls, or no controls at all; large batteries or small; and whether the battery compartment is easily accessible or locked—are just a few considerations that need to be taken into account by the audiologist or hearing aid dispenser during the hearing aid fitting process. The more thorough this process is, the higher the likelihood that the patient will be successful with the device(s). The first step to being a successful hearing aid user is to be a hearing aid user. Unfortunately, when this process is not followed, hearing aids remain in their boxes, on dressers, or in drawers, providing none of the intended benefit.

Hearing aid technology is just one option for managing a hearing loss. When the loss is so severe that little to no benefit can be derived from the use of a conventional hearing aid, a cochlear implant may be recommended as the device providing the optimal benefit for the individual with hearing loss.

Historical Background

Perhaps the first hearing aid in use was the hand cupped behind the ear. This “aid” to hearing is still in use today, and sometimes is the preferred method of amplification for some. Early pre-electric devices to assist in the enhancement of sound can be traced back to the seventeenth century. Ear trumpets and cones of the day were designed to rest above the ear and collect and transmit sound to the ear canal.

Through the subsequent centuries, this method of collecting sound and channeling it to the ear via a tube was a common design. Devices ranging from larger tabletop units to ear trumpets and cones (Figures 12.1 through 12.3) can be traced through the Victorian era. At the time, society placed a great importance on hiding hearing loss, because it was seen as a disability (Healthy Hearing, 2011).

The second industrial revolution greatly changed the face of technology around the world. Hearing aids were no exception to technological advancements during this time period. Famous for his invention of the telephone, Alexander Graham Bell (Figure 12.4) played a pivotal role in the invention of the hearing aid. Bell’s grandfather, father, and brother worked in the study of elocution and clarity of speech, which culminated in some of the earliest publications regarding the correction of speech disorders. The invention of the phonetic alphabet is
seeking to amplify the hearing ability of his beloved wife and his mother (Winefield, 1987). The Alexander Graham Bell Association for the Deaf and Hard of Hearing, located in Washington, D.C., continues to support individuals with hearing loss and their families today.

Advancements by another famous inventor of the time, Thomas Edison (Figure 12.5), brought the world closer to the invention of the electric hearing aid. Although not deaf himself, he was quoted as stating, “I have not heard a bird sing since I was 12 years old.” In contrast to Bell, Edison saw hearing loss as an advantage, allowing him to concentrate on his inventions by blocking out what he referred to as “the babble of ordinary conversation” (National Park Service, 2016). It was Edison’s invention of the carbon transmitter, which, used in combination with an electric current, transformed a weaker signal into a stronger signal, thus paving the way for an electronic device to amplify sound.

Several companies, including George P. Pilling and Sons of Philadelphia and Kirchner and Wilhelm of Stuttgart, Germany, combined the technologies from Bell and Edison to produce devices that amplified sound for individuals with hearing loss. In 1898, the Dictograph Company, also the inventors of the classic-style rotary phone, introduced the first commercial carbon-type hearing aid. In 1899,
Miller Reese Hutchison, working for Akouphone in Alabama, patented the first practical electrical hearing aid, which used a carbon transmitter and battery. This aid for the hearing impaired was so cumbersome that it had to sit on a table. It sold for $400 (Miller, Vandome, & McBrewster, 2011; Watson, 2013).

In an effort to reduce the weight of hearing aid devices, the vacuum tube hearing aid was introduced during the 1920s. These units were smaller and lighter, making them easier to carry. As manufacturers were able to create smaller vacuum tubes, hearing aids also could be reduced in size. By the end of World War II and through the late 1940s, more advances in hearing technology were emerging and hearing aids continued to be reduced in size for wearability. Transistors replaced vacuum tubes in hearing aids, and improvements to hearing aid function and structure continued (Mills, 2011).

**Vanity, Thy Name Is Hearing Aid**

The inherent desire by many to hide hearing loss has had a significant influence on hearing aid manufacturing. Even with pre-electric devices, trumpets and domes were designed with size and “invisibility” in mind (see Figure 12.6).

This desire for invisibility drove advances in electronic hearing aids through the twentieth century as well. During the middle part of the century, once technological advances reduced the size of electric devices from the top of the table to the top of the ear, the push to create a smaller, less visible hearing aid sparked the creation of some fascinating devices (Figures 12.7 through 12.9). Multiple options were offered, including hiding the devices in clothing and accessories. Attempts were even made to hide hearing aids in pieces of furniture.

For individuals with a significant degree of hearing loss, the microphone and receiver had to be placed sufficiently apart to decrease feedback (a high-pitched whistling sound) caused when the two are placed in close proximity during high levels of amplification. Although not as cosmetically appealing, the body aid became the common style of hearing aid for severe and profound hearing losses (Figures 12.10 and 12.11). Attempts were made to create camouflaged cases for these devices,
in the form of a woman's pressed powder make-up compact and flesh-toned case appropriately sized to fit inside a man's shirt pocket (Figure 12.12).

**Analog Technology**

The development of the microprocessor during the 1970s made it possible to consider miniaturizing the circuitry for wearable hearing aids (Mills, 2011). From this point to the present, the technological advances came at a rapid pace.

Conventional analog hearing aids were the primary device of choice through the late twentieth century. These devices were manufactured with circuitry that provided amplification based on the person's degree of hearing loss. Hearing aid manufacturers/distributors would provide large notebooks with the specifications of each hearing aid produced by their company. Hearing aids were selected based on manufacturer, then on specifications of gain (volume), output (maximum power of the aid, also...
known as SSPL90), and frequency response (adding and subtracting base and treble sounds). Potentiometers (small dials inside of the devices) allowed for adjustment and minor changes in the amount of volume, SSPL90, and frequency response by the professional fitting the device for the comfort of the user.

Digital Technology

Bell Telephone Laboratories introduced digital hearing aid technology, the current technology used today, during the early 1960s. The ability to digitize a sound wave and analyze it via a computer chip for clarity and specificity made the technology very desirable for hearing aid manufacturers. However, due to the physical space needed to house the technology, the overall size of a digital system was not practical at the time to fit into wearable hearing aids. A second drawback to the technology was a slight, but noticeable, time delay while the digital signal was being processed through the computer chip.

By the 1980s, a fully digital hearing aid encompassing real-time processing technology was invented. It was not until 1987, however, that the first commercially available digital hearing aid was introduced. This was a body-worn hearing aid that required an earpiece connection. Customers viewed this style as a flashback to the technology of the 1950s. Although not well received by consumers, it allowed other hearing aid manufacturers to develop systems that would be more aesthetically appealing to the public. By 1989, the first behind-the-ear version of a hearing aid with digital processing of an analog signal was introduced for research. Since that time, numerous advancements and improvements have been incorporated into the hearing aids, and the first fully digital behind-the-ear (BTE) style hearing aid was available in 1995 for field testing by audiologists. Demand for this product was so strong that the first fully digital BTE hearing aid was commercially available one year later in 1996 (Healthy Hearing, 2011).
Conventional Hearing Aids

Personal hearing amplification includes both hearing aids and implantable devices. Conventional hearing aids are considered personal listening devices that provide frequency-based amplification to manage hearing loss. Once the specifics of an individual’s hearing loss have been defined by an audiologic evaluation, these devices are customized to address the deficit. These devices are commercially available for purchase through dispensing audiologists, hearing aid dispensers, and (although not encouraged by this text) even mail order. Implantable devices (discussed later in this chapter) are obtained through medical facilities via consultation with otolaryngology/otology practices and in collaboration with an audiologist (National Institute on Deafness and Other Communication Disorders [NIDCD], 2016).

Hearing aids are made up of three primary parts: a microphone, an amplifier, and a receiver or speaker. Sound from an individual’s environment enters the microphone. The microphone then changes the sound's energy into a form that the amplifier can recognize. The amplifier, which connects to a speaker, takes the information from the microphone, processes and amplifies the sound, and sends it to the receiver, which in turn channels the amplified sound into the ear (NIDCD, 2016). Hearing aids use batteries as their energy source.

Conventional Hearing Aid Styles

The styles of devices in common use today vary greatly from the hearing aids used in the mid-twentieth century. Devices of the twenty-first century include a variety of options in terms of size and capability to more efficiently address the personal needs of the individual with hearing loss.

Behind-the-Ear (BTE) Hearing Aids

A behind-the-ear (BTE) hearing aid is a device that is worn over the top of the ear. All components of the traditional BTE hearing aid are housed in the casing that sits on the ear. An ear hook on the top of the hearing aid is connected to an earpiece called an earmold that is placed into the ear canal (Figure 12.13). An earmold is custom molded to the specific shape of the individual’s ear dimensions. Plastic tubing runs through the earmold and is then attached to the earhook of the hearing aid.

Sound travels from the hearing aid through the earhook, tubing, and earmold and into the ear. Earmold shapes are chosen with specific consideration given to the severity and configuration of a hearing loss. For example, an individual with a severe to profound hearing loss may need an earmold that fills the entire concha of the ear, whereas a less-severe hearing loss may have a more open concha area (Figure 12.14).
In some cases, the BTE hearing aid is connected to a thin tube, which may have a small plastic dome on the end that sits in the ear canal. This alternative type of BTE is referred to as an open-fit BTE (Figure 12.15). The open-fit BTE replaces the earhook and traditional tubing to earmold with a thin open tube incorporating a dome on the end. The more commonly used open-fit BTE is the receiver-in-the-ear (RITE) or receiver-in-canal (RIC). This unit removes the receiver component of the hearing aid from the enclosed casing and places it at the end of thin tubing. A dome is placed over the receiver, which sits just inside the entrance to the ear canal.

**In-the-Ear (ITE) Hearing Aids**

An in-the-ear (ITE) hearing aid is custom molded to fit the shape of the individual’s ear. These are one-piece amplification devices with all components housed in a hard shell shaped to the contours of the individual’s ear. Three styles of ITE hearing aids are available based on the hearing aid user’s degree of hearing loss and cosmetic preference. The first device fills the entire concha portion of the outer ear completely and is generally referred to as a full-shell ITE (Figure 12.16). The second ITE, referred to as a half-shell, fills only half of the concha portion of the outer ear (Figure 12.17). The third device, referred to as an in-the-canal (ITC) hearing aid, is smaller than the half-shell device and can only be seen in the opening of the concha (Figure 12.18).

**Completely-in-Canal (CIC) and Invisible-in-Canal (IIC) Hearing Aids**

The completely-in-canal (CIC) hearing aid and invisible-in-canal (IIC) hearing aid are also custom molded to fit the shape of the individual’s ear; however, these are designed to be inserted deeper into the ear canal to be less noticeable. These devices are characterized by a small line of filament with a small ball attached so that the user can grasp the ball between two fingernails to remove the device from
Anatomy of a Conventional Hearing Aid

Conventional hearing aids have a variety of standard and special functions to allow flexibility in their sound enhancement capabilities as well as for maintenance and ease of use. These features give the hearing aid user options to manage the sound in a variety of situations, and can include power source options, on-off switches, volume controls, push-button controls, direct audio input circuitry, and telecoil circuitry.

Power Source Options

All hearing aids draw from a power source. This power source is in the form of button-style batteries that come in a variety of sizes. The larger the battery is, the greater potential power storage capacity and the longer it will last. Conversely, the smaller the battery, the less power and life it will have. Hearing aids that provide high levels of amplification, such as in the case of severe to profound hearing loss, often use larger #675 or #13 button batteries, while devices designed for lesser degrees of hearing loss may use a smaller #312 or #10 battery. Larger BTE-style hearing aids can accommodate a larger battery size, whereas CIC or IIC devices will use only the smallest of batteries. Hearing aid button batteries are color coded based on their size—#675 are blue, #13 are orange, #312 are brown, and #10 are yellow. This color coding makes for ease of purchase and distinction between sizes. Conversely, button batteries for other devices such as watches and timers do not carry the same color coding.

A hearing aid user's ability to manipulate smaller size batteries should be taken into consideration during the hearing aid selection process. An older adult may want a cosmetically appealing hearing aid but may not have the dexterity to change very small batteries. For ease of management, some hearing aids come with a magnetic accessory tool to aid in manipulating small batteries (Figure 12.21).
Button battery safety should also be taken into consideration. All hearing aid batteries are small and round, similar to many medications and types of favorite candy. If a hearing aid user (a small child, an individual with cognitive impairment, or those with low vision) is at possible risk for swallowing hearing aid batteries, a tamper-resistant battery door can be installed on the device upon request. Button battery warning literature can also be provided to the guardian of a patient to heighten awareness to this risk. All hearing aids are packaged with literature from the manufacturer detailing battery precautions as well as the emergency contact information for poison control.

On–Off Control Switch

An on–off control switch is an option that allows the user to manually turn the hearing aid on or off. These can be in the form of a small sliding switch or incorporated into a volume control wheel. In the case of many digital hearing aids, the on–off function is controlled by opening the battery door. When a hearing aid does not have an on–off switch, once a battery has been inserted the unit is turned on by closing the battery door. To turn off the hearing aid, the wearer opens the battery door to deactivate the battery.

Volume Control

A volume control allows the individual to raise or lower the overall volume of sound around them. This means both speech and background sounds are raised or lowered equally. These controls are sometimes found as a wheel on the hearing aid; in some cases they are a toggle switch or a push button. However, not all hearing aids have the option of a volume control. This typically depends on the size of the hearing aid and whether there is room internally for the circuitry.

Telecoil Circuitry

A telecoil, also referred to as a T-coil, is circuitry found inside many but not all hearing aids. This magnetic coil is designed to pick up and connect wirelessly to an external magnetic signal. Telecoils are most often found in the ITE- and BTE-style hearing aids; however, many of the smaller CIC styles typically do not have enough room to accommodate the circuitry. Activation of the T-coil can be through a switch on the hearing aid specifically designated for the T-coil feature (Figure 12.22) or by using a program button that has been activated when the aid is programmed through a computer at the time of dispensing (Figure 12.23; Morris, 2001). Many digital hearing aids also come with an option for an auto-telecoil that activates automatically.
when the hearing aid is placed in close proximity to a telephone receiver. In this case the user does not have to use a switch.

The telecoil was originally designed to make sounds clearer to the listener over the telephone, but it can now be used with multiple assistive listening devices when activating the magnetic hearing loop (or induction loop) of the device. The telecoil will pick up an electromagnetic signal only, in contrast to the hearing aid microphone, which picks up all sounds (Morris, 2001).

Direct Audio Input

Direct audio input (DAI) can be found in the form of cords that connect directly into the hearing aid, providing a direct audio cable connection between the hearing aid and an external auditory device (Figure 12.24). Specific DAI circuitry may also be included in many BTE hearing aids. It allows an external source or device to be connected directly to the hearing aid as an input that bypasses the microphone; for example, a hearing aid with DAI can allow direct access to a television, telephone, computer, MP4 player (and the like), microphone, or assistive listening device to allow a signal to be sent directly into the hearing aid. DAI is not available on smaller ITE, ITC, or CIC hearing aids, because these hearing aids are typically not large enough to accommodate the necessary circuitry.

The DAI connects with the aid through a special connection. The circuit connection can be found on the bottom of the hearing aid or on the back portion of the BTE case. Some hearing aids have a dedicated connection; others use a “boot” or “shoe” that is snapped onto the end of the aid and electronically connects the source to the aid through three tiny brass dots on the underside of the BTE.

The DAI boot (or other connector) may use a wire and a mini-plug to plug into the audio source (Tye-Murray, 2009), or it may even have a tiny FM radio receiver attached to the boot with no wires required (Figure 12.25). The signal is typically improved because it goes directly into the hearing aid. Some hearing aids allow the microphone to be active along with the DAI. In some instances, the hearing aid’s microphone is disabled, thus eliminating the amplification and input of background noise. Continued activation of the microphone while the DAI circuitry is engaged allows the listener to access environmental information as a secondary input.
Frequency Lowering Technology

Frequency lowering technology is now being made available in more hearing instruments to address significant mid- to high-frequency hearing losses. This technology was initially introduced in transposition hearing aids in the early 1990s by AVR Sonovation, but is now widely available by most hearing aid manufacturers.

Patients with sharply sloping or precipitous hearing loss often do not have audibility of the high-frequency speech sounds. These individuals often complain that they can “hear” but not “understand” what someone is saying. High-frequency speech sounds provide a great deal of subtle speech information including grammatical information and temporal cues. Temporal cues include inflectional information related within a conversation to emphasize emotion or connect the spoken word with the meaning or feeling behind it. These higher frequencies help to improve an individual’s general perception of speech (Ross, 2011).

Frequency-lowering technology is the general term now used to incorporate a variety of hearing amplification fitting philosophies to address the problems of middle- and high-frequency hearing loss that cannot be effectively reached by traditional hearing aid settings. Through programming options found in the hearing aid manufacturer’s software, this function can be turned on or off depending on the needs of the hearing aid wearer. The term “frequency lowering” has been developed in response to the various ways hearing aids are designed to move high-frequency speech and environmental sounds into lower frequency areas. Additional terms include frequency compression, frequency translation, and frequency transposition. The difference between these terms depends upon the philosophy of the manufacturer and how they manage the high-frequency speech signals (Scollie, 2013).

The concept of frequency lowering involves taking unaidable or inaudible higher frequency sounds and moving them into a speech region that the cochlea could pick up, recognize, and potentially use. For example, if a high-frequency consonant such as /s/ is provided to the individual at a mid frequency it may allow the listener to hear a signal that she or he would otherwise not be able to hear. It will not be the same as the actual sound, but it would be more available. Prior to having access to this technology, the audiologist or hearing instrument specialist would often turn up the gain in the high frequencies in order to access this information. This created an increased potential for feedback and did not assure that the individual had access to the sounds that the hearing aid was attempting to access.

Bluetooth Compatibility

Bluetooth technology is now being incorporated into many new hearing aids to allow wireless connectivity to a variety of Bluetooth-enabled devices.
Hearing aid manufacturers provide different wireless options, including remote control–type devices that allow audio output to stream from the device directly into an individual’s hearing aid (Figure 12.26). With the appropriate devices, even hearing aids without Bluetooth capability have the ability to connect to landline telephones, televisions, cell phones, computers, MP4 players, and the like.

**Hearing Aid Care, Maintenance, and Troubleshooting**

As with any other form of electronic assistive technology, a hearing aid must be in good working condition to be of benefit to the user. Although an individual with hearing loss will hopefully already have amplification when he or she enters into a therapeutic relationship with a speech-language pathologist, in order for the hearing aids to benefit that individual, they must be functioning appropriately. The assumption should never be made that a device or devices are working simply based on the fact that they are in the individual’s ear(s).

Bringing hearing aids to a speech-language therapy session is only the first step in guaranteeing that they are in good working condition. Basic daily hearing aid maintenance can ensure that hearing aids are working properly and efficiently. There are several different cleaning and maintenance tools that can assist in monitoring the hearing aid’s function and keeping hearing aids clean, free of debris and wax, and clear of moisture. These tools include the following:

- A hearing aid listening tube to listen to the hearing aid (Figure 12.27). A parent, guardian, or spouse with normal hearing should become accustomed to listening to the device’s output. Signal distortion and static can be confounding factors to clear amplification.
- A hearing aid air blower to remove any moisture buildup in the earmold tubing or in the earmold itself, and to assure patency of the tubing (Figure 12.28).
- A battery tester to determine if the battery is good or has completely discharged (Figure 12.29).
- Wax removal tools to remove any cerumen or debris from the earmold of a BTE device or from the vent and/or receiver tube of an ITE device (Figure 12.30).

Only the tools provided by the hearing aid manufacturer should be used to clean ITE devices. Features of these tools, such as the loop of wire at the...
end of the wax removal tool, are specifically measured and designed so as not to do damage to any internal components of the device. Additional tools can sometimes be used (see below), but the hearing aid user should always refer to the reading materials that accompany a device or are available from the manufacturer online for further instruction.

- A microfiber cloth can be used to remove any debris from the device itself. Hearing aids should never be washed with soap and water (Figure 12.31).
- A hearing aid dehumidifying kit removes moisture buildup from the circuitry of the hearing aid itself. This is especially important in humid climates or during the summer when the weather is warm. Because a hearing aid touches the body, it is subject to absorbing moisture from the body itself. Placing a hearing aid in a dehumidifier overnight draws the moisture from the device, significantly prolonging the life of the circuit
board (Figure 12.32). Most hearing aid manufacturers recommend that the battery of the hearing aid be removed and the earmold of a BTE device be detached prior to placing the hearing aid into the dehumidifying unit.

- A waterproof storage box is another option for individuals who spend time involved in sports activities or around water (Figure 12.33). In many instances, hearing aids are removed when the user participates in sports (e.g., swim team) or other recreational activities.

Cases can be attached to gym bags or backpacks as a visual reminder that hearing aids should be put away properly when not in the ear. Waterproof boxes are also sand proof, which makes them a nice addition to the beach bag as well. Hard plastic construction makes it easy to put an individual's name and telephone number on the box in case it should become lost or misplaced.

Routine care and maintenance of hearing aids should be reinforced by the speech-language pathologist, and in some cases may need to be retaught during the therapeutic sessions. However, it should ultimately become a responsibility of the patient or primary caregiver of the individual with hearing loss.

**Troubleshooting**

The speech-language pathologist working with a deaf or hard-of-hearing individual should be comfortable performing basic troubleshooting when a hearing aid is not functioning properly. Although not every malfunction of a hearing aid can be anticipated, the following are common problems that may be encountered and can be resolved with some easy troubleshooting tips (see Figures 12.34 through 12.42).
Common Problem: Hearing Aid Is Dead

- **Check for a dead battery.** Replace if necessary.
- **Earmold (BTE) or receiver tube (ITE) is completely blocked with cerumen or other matter.** Remove wax with a wax-cleaning tool. Hairspray can also easily clog a microphone. Individuals should be advised to finish using all hair care products before putting their hearing aids on.

Common Problem: Hearing Aid Is Emitting Feedback.

- **Volume of the hearing aid is turned up too high.** Review the recommended volume settings with the individual or guardian. Turn
If the hearing aid is programmable with no volume control, this conversation should take place with the audiologist or hearing aid dispenser.

- **Earmold is not seated properly in the concha portion of the outer ear.** Remove and reseat earmold.
- **Earmold is too small for the ear.** Children can grow out of their earmolds as quickly as every 3 months during periods of extreme growth spurts. Older adults can lose the rigidity of the pinna, causing loosening of the fit. The individual must return to the audiologist or hearing aid dispenser to have new earmolds made or, in the case of an ITE, the device recased.
- **Earmold tubing/ear hook has cracks or holes.** Tubing becomes stiff over time as it absorbs...
natural oils from contact with skin. To determine if there is a crack or hole, place one finger over the receiver of the hearing aid or the hole at the end of the earmold. If the feedback continues, it suggests a hole somewhere in the earmold tubing or earhook. The individual must return to the audiologist or hearing aid dispenser to have the tubing replaced.

- **There are cracks in the ITE casing.** Over time the plastic housing of an ITE can become brittle and is subject to cracking. Again, place one finger over the receiver hole of the device. If the feedback continues, it suggests a crack in the casing. The individual must return to the audiologist or hearing aid dispenser to have the device recased.

### Common Problem: Signal Is Distorted or Intermittent

- **The earmold has moisture buildup or partially occluding cerumen.** Inspect the earmold. Use an earmold hearing aid air blower to dry moisture buildup and/or a wax loop to remove cerumen. Hearing aid air blowers cannot be used on ITE devices, but the hearing aid should still be checked for cerumen, which should be removed if necessary.
- Use a listening tube to inspect signal clarity. On occasion, the individual may have complaints regarding the signal clarity, which may not be a problem with the hearing aid at all, but rather a change in hearing loss. If a problem with the signal cannot be identified by an unimpaired listener, the individual should immediately be referred back to his or her audiologist.
- If the complaint is persistent during hot and humid times of the year, recommend use of a hearing aid dehumidifier to draw moisture from the circuit board.

When counseling the individual with hearing loss and/or the family members, encourage daily cleaning and maintenance of the device(s) when they are removed from the ear(s).

## External Bone Conduction Hearing Aids and Implantable Hearing Devices

A bone conduction hearing aid is a device that is considered preferable amplification when a conductive or mixed type of hearing loss (occurring due to disorders of the outer/middle ear) is identified and neural hearing (cochlear and beyond) is intact. This type of hearing aid bypasses the outer and middle ears, eliminating the need for an earmold. It can also address individuals with single-sided deafness/unilateral hearing loss.

Headband-style bone conduction hearing aids (Figure 12.43) were frequently used in the mid-twentieth century, when middle ear infections were more common and very difficult to treat (Ross, 2000). Years ago, when a person had a problematic conductive (outer and/or middle ear) pathology that precluded the use of an earmold (perhaps due to drainage or atresia/microtia), a bone conduction (externally fit) hearing aid was used.

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**Figure 12.43** Bone conduction hearing aid.  
Courtesy of authors: Deborah Welling/Carol Ukstins.
Bone-Anchored Hearing Aids (BAHAs) or Bone-Anchored Hearing Systems (BAHS)

A newer option for such hearing losses is the bone-anchored hearing aid/bone-anchored hearing system (BAHA/BAHS), which can be worn externally or surgically implanted. Bone-anchored hearing systems are being used to address conductive and mixed hearing loss as well as for those with single-sided deafness (SSD). These units are basically a logical progression of the older-style bone conduction device. The BAHA involves surgically anchoring a screw into the skull behind the ear, to which an external device is connected, and directly stimulating the cochlea by bone conduction (Figure 12.44; Ross, 2000). These devices can also be used externally on children, using a band to secure the device without surgery and implantation (Figure 12.45).

Bone-anchored hearing systems have three primary components: an abutment, an implant, and an external sound processor. The implant is a fixture that is implanted into the skull. The abutment protrudes through the skull so that the processor can be attached to it. A microphone picks up the sound and transmits it to the implant. The implant works using the skull’s natural bone conduction properties to vibrate the bone of the head and trigger a response in the cochlea, bypassing the outer and middle ear systems.

Troubleshooting a BAHA/BAHS

Troubleshooting the BAHA/BAHS starts with checking the battery. Make sure it is placed correctly in the battery compartment. Checking the battery with a battery tester is always recommended. If the problem is the battery, it may cause the unit to sound weak, intermittent, or distorted, or to have no sound at all. If the battery is inserted correctly, ensure that no other external objects such as eyeglasses are interfering with the unit. If the unit sounds intermittent or distorted, it may have been exposed to moisture. If this is the case, place the unit in a hearing aid dehumidifier overnight. In some instances, the magnet that holds the processor in place with the abutment may be weak. If this is the case, the magnet may need to be changed. The patient should be referred back to his or her audiologist.

Middle Ear Implant (MEI)

The middle ear implant (MEI) is basically a hearing aid, but one in which the receiver or the entire hearing aid is inserted into the middle ear (Ross, 2000). For sensorineural hearing loss it delivers vibratory mechanical energy to the small bones (ossicular chain) located in the middle ear and then sends mechanical energy to the cochlea at the round window via motion of the stapes. Devices
for conductive or mixed hearing losses that involve damaged or a poorly functioning middle ear system send mechanical energy directly to the cochlea through direct bone conduction, circumventing the three tiny bones (ossicular chain) in the middle ear.

**Cochlear Implants**

Cochlear implant devices, the candidacy for implantation, and the habilitation/rehabilitation of individuals with cochlear implants are the subject of full textbooks, coursework, and continuing education opportunities for professionals already in practice. The intention of this section is to provide the reader with an overview of the device itself as an amplification option for individuals with hearing loss. It is not, by any means, intended to be inclusive of the information needed to provide services to those with cochlear implants.

A **cochlear implant (CI)** is a surgically implanted device that can enhance hearing and speech abilities for individuals with severe to profound hearing loss who demonstrate limited benefit from traditional hearing aids. The Food and Drug Administration (FDA) in the United States regulates candidacy criteria for cochlear implantation in both children and adults. Readers are encouraged to use online resources such as the American Speech-Language-Hearing Association’s committee on cochlear implants and the FDA website itself for review of candidacy criteria.

Cochlear implant devices have also been used to address some individuals diagnosed with auditory neuropathy syndrome disorder. Additional trends in cochlear implantation include binaural implantation and hybrid cochlear implants, which take into consideration residual hearing of the individual with hearing loss.

A cochlear implant system is made up of an external speech processor, a transmitting coil and wire, and an internal receiver/stimulator. The receiver (which is magnetic) is surgically implanted into the temporal bone above the mastoid process, and the stimulator (or electrode array) is surgically inserted into the cochlea.

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**Figures 12.46A** An ear level cochlear implant internal and external view. Courtesy of MED-EL Corporation, USA.

**Figures 12.46B** An off the ear cochlear implant external view only. Image courtesy of Cochlear Americas, © 2017.

Some external speech processors look similar to a conventional BTE-style hearing aid, resting on top of and behind the pinna, and attaching via a cord to the transmitter coil, which magnetically attaches itself to the internal receiver (Figure 12.46A). Newer models house the processor “off the ear,” which may be cosmetically more appealing to the user (Figure 12.46B). The external cochlear implant
device (speech processor) picks up sound from the environment via a microphone. It then selects and arranges the sounds based on the preset programs (called maps) specific to the cochlear implant user. That signal is then sent to the internal transmitter via the transmitter coil, which receives signals from the speech processor and converts them into electric impulses. The transmitter then sends them to the electrode array, which collects the impulses from the stimulator and sends the message along to the central auditory pathway. Cochlear implants' power source is typically a rechargeable battery pack or replaceable #675 button-type batteries.

Just as today's hearing aids use remote control units, use of a remote may allow changing programs or other critical features of CI processor function. This has provided more access to interface with computers with proprietary software for programming, allows multiple programs within the CI, allows for telephone compatibility, and allows for input to other accessories, such as assistive listening devices. Cochlear implants that allow the user to wear his or her device in the water are also currently available. Historically, cochlear implants, just like any electronic device, would need to be removed if an individual wanted to shower or go swimming. Advances in technology now allow for adequate waterproofing of the external apparatus so individuals can partake in water-based activities while amplified. Refer to Figure 12.47 for an image of the Nucleus Aqua+ cochlear implant device by Cochlear Americas Corporation.

As the manufacturers of cochlear implants gain a more extensive understanding of the benefit of assistive technology in the development of spoken language skills, many are granting the choice of accessories, which accompany the purchase of a new implant. The speech–language pathologist should work closely with the individual's cochlear implant center to find out what accessories, such as a streaming device or auditory training system, have been included with the individual's purchase of their implant package.

Cochlear implant candidacy has also progressed to be considered as potentially beneficial for hearing losses that are of a lesser degree than profound. Newer technology now allows specific models of cochlear implants to preserve residual low-frequency hearing and are believed to improve word understanding in noise and increase music appreciation (Dorman, et al., 2009). On March 20, 2014, the FDA approved the distribution of hybrid cochlear implants. These newer cochlear implants use acoustic amplification (similar to hearing aid technology) to preserve low-frequency hearing that is still available at the same time as using traditional cochlear implant technology to allow access to mid- and high-frequency sounds that are missing. The technology works by separating frequencies into groups of sound by low and high frequencies as they are picked up by the microphone on the processor. The electrodes that have been implanted as a component of the CI then take the mid- and high-frequency sound information and send it to the brain. The patient's lower frequency hearing
is picked up and managed through the acoustic component of the CI, thereby preserving the lower frequency sounds within the hearing system.

**Monitoring and Troubleshooting Cochlear Implants**

Monitoring the function of a cochlear implant on a daily basis is essential to ensuring proper amplification and benefit. Checking the components of the CI for dirt and moisture will help to ensure that it is working well. Using a soft cloth, you can wipe the processor, coil cable, ear hook, covers, and mic lock cables. Placing the processor in a dehumidifier nightly will help to remove any moisture from the unit.

There are many things that can cause a CI not to function properly. Monitoring earphones (see Figure 12.48) are available from the manufacturer and allow you to listen to the processor to determine if the sound is clear and free from humming or buzzing sounds, intermittent sound, or distorted speech. In some instances, interference from radios or TV transmission towers, security alarms, and mobile phones may be causing the distortion. In many cases, if a processor is not functioning properly, it will need to go back to the clinical mapping audiologist for servicing. Having extra parts on hand will also allow you to interchange battery packs or batteries in the units, cables and/or cords connecting the processor to the magnet, and transmitters or headpieces. Manufacturers of cochlear implants have guidelines for troubleshooting specific to their products.

Basics for troubleshooting CIs include the following:

- Check the batteries and replace if needed. If the CI uses a rechargeable battery pack, a backup battery pack should also be available. It should be noted that even a rechargeable battery pack will eventually reach the end of its energy life. Some CI processors include light indicators to provide a visual alert when the batteries are low.
- Check the cables on the CI, as these can become frayed or worn over time. In some instances, the cables may be kinked, causing the signal to distort or cut off altogether. In small children, the cables may even show chew marks and the wires may have been chewed through. Having spare cables will allow you to replace these as needed.
- If the processor is not functioning properly, turn it off and wait approximately 10 seconds, turn it on again. Rebooting the device may reset a software malfunction. However, many times malfunctions related to the processor must be repaired by the manufacturer.

**Bimodal Hearing Amplification**

For individuals with bilateral hearing loss, the amplification options depend on the severity of the hearing loss as well as medical and age considerations. Bimodal hearing amplification has become more popular, with some cochlear implant users opting to use a hearing aid on the nonimplanted ear. In some cases, bilateral implantation is not possible due to medical complications, while in other cases it...
is a choice not to pursue bilateral implantation. The
term “bimodal” refers to using two different types
of hearing assistance technology between the ears.
In some instances, a hearing loss is not significant
enough to require a cochlear implant, but still poses
a problem with speech and environmental percep-
tion. A traditional hearing aid can be placed on the
nonimplanted ear to create more balanced hearing.
This helps to provide the localization and lateraliza-
tion of speech and sound cues. An asymmetric pre-
sentation of sound would potentially have an impact
on an individual’s ability to judge the direction of a
sound source during daily activities including work,
driving, crossing roadways, and determining the
direction from which someone is speaking. Addi-
tional difficulties are often seen as reduced speech
intelligibility, especially in background noise.

Additional Warnings for CI Users
The components of a cochlear implant device are
both internal and external. While some may be
familiar with the overall workings of the device, it
should not be assumed that everyone knows what
a cochlear implant is or how the components of the
device interface. Therefore, manufacturers caution
cochlear implant users to identify themselves when
passing through theft and electronic detection sys-
tems such as those in airports or security check-
points. Electrostatic discharge (i.e., static electricity)
can cause damage to the electronic components
or corrupt the program in the speech processor.
CI users should always consult with their med-
cal facility prior to any electrosurgery, diathermy
(magnetic resonance imaging and the like), and/or
neurostimulation therapy. Typically, individ-
uals are issued a Cochlear Implant Identification
Card, alerting government agencies and emergency
medical personnel to the presence of an implanted
device. Cochlear implant users should always be
familiar with the “Warnings and Precautions” fact
sheet provided with their specific brand of cochlear
implant. Reviewing this information with your cli-
ent and his or her family/caregiver during a speech
and language therapy session may prove to be useful
in preventing damage to individual CI components
or to the device as a whole.

SUMMARY
A component of any auditory intervention program
for hearing loss includes a wide variety of amplifi-
cation choices. There are several different styles and
technology options for hearing aids, including those
worn in the ear and on the ear. When hearing aids
are not appropriate, alternatives may include surgi-
cal placement of instrumentation to stimulate the
auditory system. As a practicing speech-language
pathologist, one must have a working knowledge
of the individual components of these devices
and develop the ability to determine their appro-
priate functioning. The ability to troubleshoot a
hearing aid, BAHA, or CI is a vital skill that every
speech-language pathologist must possess.

DISCUSSION QUESTIONS
1. Why are age, cognitive ability, and dexterity
   important considerations when choosing a
   hearing aid?
2. A client on your caseload has a hearing
   aid. She complains that it is not always
   working and sounds “weird.” Describe the
steps you would take to troubleshoot this device.
3. Discuss the indications for considering a BAHA as an instrument of choice for a patient.
5. Write two therapy goals that address an individual’s ability to maintain his or her hearing instrument. Does your client have a hearing aid, BAHA, or cochlear implant?
6. What troubleshooting technique would you use if your client says each of the following:
   a. “My hearing aid just stopped working.”
   b. “I can’t make out what you are saying, things just sound fuzzy.”
   c. “Why do I keep hearing this whistling sound?”
   d. “Huh? What? I can’t hear you.”

REFERENCES

CHAPTER 13

HEARING ASSISTANCE TECHNOLOGY FOR CHILDREN AND ADULTS

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KEY TERMS

Assistive listening devices (ALDs)
Auditory training device
Captioned telephone (CapTel)

Classroom audio distribution system (CADS)
Digital modulation (DM) technology
Hearing assistance technology (HAT)

Reverberation
Telecommunication device for the deaf (TDD)
Teletype device (TTY)

OBJECTIVES

• Review the common, commercially available hearing assistance technology.
• Identify appropriate use of assistive and alerting devices.
• Describe the functionality of the variety of devices available based on patient need.
• Define the specialized listening devices available for classroom instruction.
• Summarize hearing assistance technology available to service individuals with hearing loss for a variety of uses.
Introduction

Technological advancements in personal hearing amplification are by no means the only advances that have taken place in providing hearing assistance for individuals with hearing loss since the inception of a hearing aid. Safe to say, if an individual is using a hearing aid alone, they are failing to take advantage of numerous other devices that allow access to sound. Many of these devices can significantly improve the quality of life for deaf and hard-of-hearing individuals and provide better access to speech and environmental sounds. Along with these, technological advancements bring a host of additional options to amplify the world of sound. Computers and phones have become more sophisticated and offer increasing opportunities for individuals to communicate with others, attend school, and work remotely. Hearing assistance technology (HAT) provides access to more sophisticated personal and ancillary amplification devices, allowing the connection to other people and technology. Through the use of hearing assistance technology, individuals with hearing loss now have more options and opportunities for communication across multiple situations.

Hearing Assistance Technology (HAT)

Hearing assistance technology includes a variety of devices that help an individual with or without hearing loss communicate more effectively in adverse listening situations. For individuals with hearing loss that significantly limits their ability to access auditory events, amplified and/or visual alerting systems are also available. This technology includes assistive listening devices (ALD), personal and group listening systems, alerting devices, and area hearing loop systems.

Assistive Listening Devices (ALDs) and Auditory Trainers

A Word on Terminology

The term hearing assistance technology encompasses all technology used to enhance the auditory environment of a listener, regardless of whether that person has a hearing loss. Frequently, the term auditory trainer is used to make the distinction between a device used by an individual with hearing loss to “train” their auditory system to listen and attend versus one that merely enhances the auditory environment (“assistive listening device”). However, these terms often, perhaps incorrectly, are used interchangeably. Similarly, the term FM system refers to a device that transmits its signal via an FM radio signal (described in detail later in this chapter). However, the term FM system is frequently used in the educational realm to refer to any device placed in a classroom that enhances classroom acoustics, regardless of how that signal is transmitted through the air. For the purpose of this chapter, we will be specific with the terminology as follows:

- **Assistive listening device** will be used to refer only to a unit with a limited amount of gain (volume) that is used for individuals with auditory attention difficulties within the classroom or for those with minimal hearing loss.
- **Auditory training device** will be used to refer only to a unit designed to train an impaired auditory system. These devices have high levels of gain that must be adjusted to meet the needs of a specific hearing loss or are coupled directly to the hearing aid, taking on the amplification and acoustical characteristics of that device. It is in the best interest of the user to have an auditory training device selected and fit by an audiologist.

The way in which each device sends the signal from the transmitter to the receiver will also be specified, as well as how the receiver is coupled to the individual user. The speech-language pathologist working with assistive technology is encouraged to use the proper terminology when referring to a specific device. This assists in more accurate knowledge transfer between professionals and assures that the proper device is selected based on the needs of the individual. Again, the reader is encouraged to meet and consult with her or his local audiologist, the individual’s clinical audiologist, or an educational
audiologist whenever possible regarding assistive
devices, their selection, and proper use.

The devices described in this section are
designed to modify or enhance an auditory signal. When hearing alone, or when hearing aids, cochlear
implants, or bone-anchored hearing aids/bone-
anchored hearing systems (BAHA/BAHSs) are not adequate to manage in a specific listening environ-
ment, a wide variety of devices designed to enhance
the primary speaker should be considered. Personal
devices work with earphones, hearing aids, cochlear
implants, and bone-anchored devices to provide
more direct access to a speaker. Whether the indi-
vidual has a hearing loss or other disorder of audi-
tory attention, these devices play an important role
in increasing the signal-to-noise difference, thus
making the speaker’s voice louder than the back-
ground noise and more accessible to the listener.

Group devices are designed to work in larger areas
including classrooms, theaters, meeting and con-
ference rooms, courtrooms, museums, and other
group-gathering facilities. These devices fall into
several categories, including frequency-modulated
(FM) amplification systems, digital modulation
(DM) FM amplification systems, induction loop
systems, and infrared systems. Whether personal
or group, assistive device or auditory trainer, there
are three main components that make up a system:
a transmitter that includes a microphone, a signal
transmitting modality, and a receiver.

**Personal Systems, Classroom Audio Distribution Systems (CADS)/Sound Field Technology**

Background noises can include a myriad of sound sources. Internal and external noises have the poten-
tial to complicate the listening environment and the speech message, especially for a child in a learning
environment. Environmental noises may include
heating, ventilation, and air conditioning systems
(HVAC); student and teacher movement; desks and
chairs scraping on the floor; fans blowing; fish tank
filters; hamster wheels; and computers, to name just
a few. Additional sources of noises are generated
outside the classroom in the hallways and include
office announcements through the loudspeakers,
schedule bells ringing, conversations, class move-
ment, and noise generated from classrooms on the
floors above or below. External noises might include
students on the playground; parking lot noises; traf-
fic noise, if the school is located near busy roads;
lawn mowers and maintenance machines; nearby
railroad crossings; and airports. It is safe to say that
classrooms are very noisy places in which to learn.

Acoustic barriers to communication in the class-
room can make listening and learning more compli-
cated for an individual with hearing loss, (central)
auditory processing disorder, and issues with audi-
tory attention. Personal FM/DM amplification sys-
tems allow the individual to hear, listen, and attend
to the teacher more directly, as if she or he is stand-
ing close by. These systems are designed to manage
the impact of background noise, reverberation, and
distance factors that can degrade or alter the speech
message being presented. This allows the teacher
to move around the classroom while the individ-
ual continues to hear the teacher’s voice at the same
level and without interference from noises that may
be between the teacher and the individual.

**Personal FM/DM Systems**

Frequency-modulated systems are used to transmit
a speaker’s voice or a specific sound source directly
to an individual. The frequency transmission for
FM devices is regulated by the Federal Communica-
tions Commission (FCC), which has designated
the bandwidths near 72 MHz and 216 MHz to be
used only for FM systems (Tye-Murray, 2009).
Adaptive digital modulation (DM) FM technology
has recently been added to the FM market as a sig-
nal delivery system for such technology. **Digital modulation (DM) technology** works similarly to
FM technology, but the audio signals are digitized
and packaged in very short digital bursts of code
and broadcast several times at different channels
between 2.4000 and 2.4835 GHz. This frequency-
hopping technology avoids interference issues,
and repetition of the broadcast ensures correct reception.

An FM/DM receiver device can couple directly to the ear via earphones, induction loop, or earbuds, or couple through a hearing aid, cochlear implant, or BAHA/BAHS (Figure 13.1 and Figure 13.2). These devices are often found in academic settings to allow a student direct access to a teacher’s voice while diminishing the effects of background noise, reverberation impact (the echo effect when sound bounces off hard surfaces), and the impact of distance between a listener and speaker or sound source. Personal FM/DM devices are available from several manufacturers and in numerous forms of connectivity. Some devices are used as an assistive listening device for individuals with minimal hearing loss (where hearing aids may or may not be required) or when auditory attention issues are being addressed in the classroom.

Figure 13.2  FM receiver with induction neck loop.
Courtesy of Oticon Inc.

An additional receiver option available for an individual is a desktop or tabletop speaker unit used to provide amplification in close proximity to the listener (Figure 13.3). These tabletop devices can easily move with a student from classroom to classroom (e.g., students who are in inclusive settings, pulled out to resource rooms, or departmentalized). These devices are the unit of choice when a student is unwilling or unable to tolerate earphones, or when the device needs to be out of reach (e.g., multiply impaired children or children with autism spectrum disorder). Personal FM/DM assistive listening devices are also available in the form of ear-level units, which may be more cosmetically appealing to adolescents and teenagers because they draw less attention to the use of such a system (Figure 13.3 and Figure 13.4).

Figure 13.3  A personal FM/DM auditory training device is available for individuals with hearing loss (Figure 13.5). These devices come with many different coupling options. Connectivity decisions are based on a number of variables, including type of hearing aid and preferred methodology adopted by the school or facility. Personal FM/DM auditory training devices can be used by both children in a classroom and by adults in a variety of settings. Connecting hearing aids directly to FM/DM systems, referred to as direct audio input (DAI), can be accomplished in one of three ways: using an audio
shoe or audio boot, an integrated FM/DM system, or a dedicated FM/DM system. Certain hearing aids have been designed to work directly with specific FM/DM systems, typically manufactured within the same company. An integrated FM/DM system includes the receiver circuitry within the actual hearing aid. A dedicated FM/DM system allows the receiver to attach directly to the hearing aid, cochlear implant, or bone-anchored hearing device without the use of an audio shoe/boot. When a hearing aid is not manufactured by the same FM/DM manufacturer, an audio shoe or audio boot is used as an interface connector for the hearing aid to receive the signal from the receiver (Figure 13.6).

FM systems can transmit signals up to 300 feet and can be used in many public places. However, because radio signals are able to penetrate walls, each transmitter is assigned an FM channel on
which to operate and send the signal to the receiver. The devices are paired or linked according to the frequency on which the transmitter operates (Figure 13.7). Frequencies can either be preset by the manufacturer or be set by the facility using the devices. To ensure there is no cross-contamination of signals when using the analogue FM device in a facility, each classroom or meeting hall must use a different frequency band on which to communicate. An assigned staff member typically tracks these frequencies to assure that each channel is used only once in a single building.

DM systems do not require specific programming of channels. These devices are designed to search for the most available or open frequency within its transmitting frequency range and sync or connect a receiver with a DM transmitter. DM systems are also resistant to electromagnetic interference that can in some cases interfere with traditional FM devices.

**Induction Loop Coupling for Personal FM/DM**

People with hearing aids, cochlear implants, and bone-anchored hearing systems with telecoil circuitry also have the option of using an induction loop FM system that can be worn around the neck (a neck loop; see Figure 13.8) or behind their aid or implant (called a silhouette inductor). The telecoil circuit picks up a magnetic signal from the induction loop and transmits the signal to the hearing aid. Individuals whose hearing aids or cochlear implants have a telecoil may also wear a silhouette inductor to change an infrared signal into a signal recognized by a telecoil circuit (Figure 13.9).

**Classroom Audio Distribution Systems (CADS)/ Sound Field Systems**

Traditional sound field systems (Figure 13.10) are designed to provide an increased signal-to-noise ratio
transmitter changes sound into a light signal that is then sent to a receiver. The receiver changes the light signal back to a sound signal. These signals can be distributed through wall-mounted speakers that are spaced to disperse the sound evenly throughout the room, through a ceiling-mounted speaker, or through a freestanding speaker placed strategically in the classroom to disperse the sound evenly. The infrared signal cannot pass through walls or be used in direct sunlight.

**Induction Loop Systems for Sound Fields**

Induction loop systems are another type of sound field system that is used in large meeting halls and commercial theaters. Although less frequently used in educational facilities, induction loop systems allow large groups of hard-of-hearing individuals to connect via the telecoil circuitry of their personal hearing aids or cochlear implants. Induction loop systems create an electromagnetic field that is picked up by the telecoil. In a large room such as a theater, a thin loop of wire is placed around the room. The hearing aid user activates his or her telecoil and the signal is picked up and directed into his or her hearing aid. This can directly connect the listener through his or her hearing aid telecoil to a variety of audio sources including public address systems (National Institute on Deafness and Other Communication Disorders (NIDCD), 2011).

The **classroom audio distribution system (CADS)** is the newer terminology used to describe classroom-based sound enhancement systems. The goal or emphasis of a classroom audio distribution system is sound distribution, not necessarily amplification. CADS provide improved acoustic accessibility to a speaker or external audio system throughout a classroom or specific listening environment. These devices disperse sound with the greatest improvement in amplification noted closer to the physical system itself. There are different versions of CADS, including flat panel units, all of which distribute sound outwardly from speaker source. They do not
provide equal sound distribution as would a traditional sound field system. CADS are not typically intended as public address systems, but to enhance the primary signal in the acoustic environment to allow enhanced auditory access. In general, CADS improve speech recognition in noise for children with hearing loss and also for children and adults with normal hearing (Wolfe et al., 2013).

Portable sound field systems or CADS (Figure 13.11) are also available to use when a full classroom-based sound field system is not required or not practical. These systems are in the form of column speakers and can use FM, DM, or infrared technology. These units can stand on the floor, be elevated on a desk or shelf, or wall mounted. They are more compact than traditional sound field systems and can be moved as needed.

Digital modulation and infrared systems operate in the same transmitter–receiver fashion, still using a column-type speaker, but, unlike older FM technology, no frequency planning to specific classrooms is required.

Remote Hearing Aid Technology

Most hearing amplification devices are now Bluetooth compatible, allowing the user to connect with Bluetooth-enabled devices (Figure 13.12). This includes most cell phones. Remote hearing aid technology allows a patient to stream a variety of external audio sources directly into her or his hearing aids. These devices include small remote microphone systems and television streaming units, and also include the ability to control hearing aids through cell phones with and without cell phone applications. If the individual’s hearing aid does not have Bluetooth capability built into the device, a remote device is needed to activate the Bluetooth connections. For many of the newest hearing aids, access to Bluetooth technology...
no longer requires external streaming connection
devices, as this functioning is built into the internal
electronics of the device itself. Cell phone apps pro-
vide the hearing aid user with more control over his
or her listening environment and in specific listening
situations.

There are a variety of additional types of remote
devices that can be used with Bluetooth-compatible
hearing devices. Remote microphone units can be
placed on the lapel of an individual who is speak-
ing or lecturing, or clipped to a central location in a
small group to stream an audio signal directly into
hearing instruments. There are also devices that can
be attached directly to the telephone or television
that allow the audio signal to stream directly into
the hearing instruments. This provides the listener
with control over the volume of the television or
phone. The direct stream of the signal is pro-
vided via the Bluetooth signal and sent through the
hearing instruments, which are configured specifi-
cally to address the individual’s hearing loss. Blue-
tooth devices with the ability to stream audio signals
directly into the hearing amplification also provide
an alternative to using an FM/DM device.

Assistive Technologies for
Sound Enhancement and
Alerting Devices

Although the advanced digital technology found in
hearing aids provides greatly improved communi-
cation ability, there are still times when the hearing
aid, BAHA/BAHS, or cochlear implant alone is not
enough. Hearing and distinguishing speech in noisy
situations, when watching television, or over the
telephone may still be challenging. In addition, we
depend on a variety of devices to help us function in
our environments and alert us to dangers or audi-
tory events. In our auditory environment, a door-
bell alerts us to a visitor and a fire or smoke alarm
lets us know there is danger; however, these devices
may not be sufficiently loud to provide an alert to a
person with a significant degree of hearing loss. As
technology has advanced, a wide range of devices
are now available to enhance signals from audio
devices as well as to alert individuals who are deaf
or hard of hearing to sounds in their environment
(NIDCD, 2011).

Television Amplification

There are currently several options for television
amplification systems. Such amplifiers plug directly
into the television and use FM or infrared signals
that are transmitted to the listener (Figure 13.13).
Some devices use an induction loop worn around
the listener’s neck with the signal transmitted via the

![Figure 13.13](Infrared personal television amplifier. Courtesy of Sennheiser Electronic Corporation.)
telecoil in the hearing aid. As mentioned previously, hearing aids that are Bluetooth compatible have the option to patch into the television using auxiliary devices.

Closed Captioning

Closed captioning for television programs allows the viewer to read the text and sounds related to the audio portion of a program. This feature is typically controlled by the user’s television remote control. All televisions now sold with screens of at least 13 inches must have built-in closed captioning reception technology; however, it should be noted that the individual using closed captioning must have a certain level of reading ability to use this functionality appropriately. An individual with hearing loss must not only have a reading ability commensurate with the content of the program she or he is watching, but also have the ability to read the captioning at the speed of conversational speech and the visual acuity to see the text. Therefore, when recommending closed captioning to a hard-of-hearing or deaf individual, the speech-language pathologist is advised to take into consideration the individual’s receptive language abilities, as well as his or her ability to read and comprehend written text at a rapid rate and any potential visual issues. A common misconception regarding closed captioning is that if the program is age appropriate for the individual, he or she will be able to comprehend its content using the closed captioning feature of their television.

Telephone Amplifiers

Telephone amplifiers and amplified telephones in the form of landline units (Figure 13.14) and units that attach to an existing landline-based unit used to be the only options available for individuals having difficulty on the telephone. These devices allow the listener to increase the speaker’s voice using a volume control (Figure 13.15) and also have a built-in visual alerting system, typically a flashing light, to indicate that there is an incoming call. As mentioned previously, with more extensive use of Bluetooth technology, more hearing devices have the capability to stream a telephone call directly into an individual’s personal hearing technology. Many hearing aids can now be controlled using a cell phone with smart technology. Using Bluetooth streaming, these hearing instruments allow the wearer to answer and make phone calls without the need for picking up her or his phone. For binaural hearing instrument users, this allows them to hear through both devices simultaneously.
Hearing aids that have telephone coils but not Bluetooth technology can be paired with a neck loop apparatus that converts a Bluetooth signal to a telecoil signal, which transmits into the hearing aids. These devices are especially useful with mobile phones, which typically come enabled with Bluetooth technology but have advanced away from magnet telecoil technology (Figure 13.16).

**Teletype Device (TTY)/Telecommunication Device for the Deaf (TDD)**

The teletype device (TTY) and the telecommunication device for the deaf (TDD) are both systems of communication via the telephone using typed messages instead of speaking and listening. While not precisely the same device, the terms TTY and TDD are often seen together and the terms used interchangeably. Regardless, in both cases, in order to use this system both parties must have a device. The older style TTY is typically very large and has a keyboard for typing out messages and a display to read the incoming message. TDDs are considerably smaller, even portable, but function in a similar fashion (Figure 13.17). The Deaf community has used the phrase TTY for so many years that the terms TTY and TDD are often used interchangeably (Gallaudet, 2016). This allows a phone conversation to be typed and read rather than spoken and heard. Some units also have printer capabilities to print messages for a hard copy. The TTY/TDD system can also be used if one party does not have a device by calling the Telecommunications Relay Service (TRS). The speaker’s message is typed by a third-party operator so that the individual with the TTY/TDD can read the message. This national service is available free of charge, 24 hours a day, 365 days a year, by dialing 711.

Although texting is now the choice of many individuals versus using a TTY/TDD, these devices are still used throughout the country. In fact, many of our common texting abbreviations came out of the TTY/TDD messaging era of deaf telecommunication.

**Video Relay Service Devices (VRS)**

As an alternative to the TTY/TDD or TRS, video relay service (VRS) was developed to allow individuals with hearing loss who utilize sign language to communicate directly over the telephone (Figure 13.18). This system provides the individual...
with hearing loss with the ability to communicate using video devices. Such devices can also be linked with a TRS operator called a communications assistant (CA). This CA uses sign language to translate oral conversation into sign and vice versa. The system is facilitated by an Internet connection and requires that the CA be a qualified sign language interpreter. There is no typing or written text. The service can be accessed by either the user with hearing loss or a hearing individual, and is typically provided through a toll-free phone number via an Internet connection.

**Captioned Telephone (CapTel)**

The captioned telephone (CapTel) system is a type of telephone that provides a display of written text or captions along with the audible telephone conversation—in essence, a dictation of everything the caller says (Figure 13.19). Similar to a TTY/TDD device connecting with a TRS, a captioned telephone uses an intermediary operator to key an auditory message into the visual display (Figure 13.20). This allows the user to hear and see what the speaker is saying simultaneously (Figure 13.21).

**Real-Time Communication Options**

The capability to communicate face to face over the Internet is becoming more popular in the deaf community as a way of interacting visually in real time. Some applications allow multiple parties to
communicate simultaneously. Computers connected to the Internet can access services such as Skype, FaceTime, and the Oovoo application. A universal serial bus (USB) device (Figure 13.22) is available to visually alert a deaf or hard-of-hearing individual so she or he can see the simulated ring that indicates a call is coming through.

**Visual Listening Systems and Note-Taking Service**

For a student with hearing loss, listening in general can be fatiguing. Different lecture formats may require an individual to listen and respond, and/or listen and write information down. This is seen daily in secondary schools as well as colleges and universities as students are required to take notes from a verbal lecture format of instruction. The dual function of listening to a speaker and responding and/or taking notes or writing information down can be overwhelming as well as fatiguing. Information presented orally can be missed and/or misinterpreted. For these situations, special note-taking systems are available to assist the hard-of-hearing student, allowing him or her to focus on the auditory while also getting the information in a written format. For Deaf individuals, a sign language interpreter would facilitate communication between the instructor and the student. The Deaf student cannot simultaneously take effective notes and sustain visual attention to the sign language interpreter. Therefore, a secondary means to notetaking must be arranged.

The first system is communication access real-time translation (CART), also known as real-time captioning. A CART system requires special training because it uses a stenocode similar to the language coding used by a court stenographer. The caption writer or stenographer types what the speaker is saying into a stenotype device. This information is typically an abbreviated or condensed version of what is spoken, and is typed in an outline format. This is then translated into captions sent to an LCD projector or laptop computer. A software program with a dictionary of terms, as well as the accuracy of the typist, determines the accuracy of the translated stenographic codes.

The second method is a computer-assisted note-taking system (CAN). This system requires the typist to have good note-taking skills as well as the ability to type accurately and quickly. Additional special training is not required. This method is most often helpful for situations in which the listener...
needs basic information and some visual information to keep track of what is being presented, but is not completely dependent on verbatim transcription.

For both CART and CAN, the Americans with Disabilities Act (ADA) requires the educational system, business, or other public entity to employ an individual to provide the service, which can be costly. A newer software system option available for speech-to-text is the Interact-AS system (Figure 13.23). This delivers real-time captioning while also working with a wireless FM system. The system uses a form of dictation software for real-time captioning that translates full sentences and context as it is spoken. The individual sees the captioned information quickly, much faster than the older CART system. This also can provide a transcript of the lecture for review. The system does not require a specially trained individual to provide the transcription. A teacher or speaker can connect directly with the deaf or hard-of-hearing individual’s FM microphone, which then transmits to the listener’s computer where the transcript is generated. The transcripts can be retained for individual classes or lectures and saved to the listener’s computer as a Word or Google document.

**Lesson Capture Devices**

As technology advances, so does the ability to add additional functionality to existing equipment. Lesson capture devices allow for the recording of lecture format instruction for review at a later time. One such device (Figure 13.24) combines the ability to record the auditory lecture and pair it with visual material from an interactive white board. This information is stored via computer software and can be stored to a flash drive or uploaded to the Internet for future review on a password-secure site. This type of device also becomes very useful when students are absent. Missed classes can be viewed in their entirety when a student cannot attend the class. Figure 13.24 is not only an infrared CADS device, but also incorporates lesson capture.
A second, more affordable option is a smart pen (Figure 13.25). This device allows an individual to take notes on digitized paper using a specialized pen. The device records the lecture while simultaneously visually recording the location of the pen on the specialized paper. During the lecture, the pen records what is said based on the specific digital location on the paper. Regardless of the person’s note-taking ability, following completion of the lecture, the individual can return to her or his notes and review the auditory lecture using the device’s headphone jack. This jack can also be adapted to be used with DAI auxiliary cables and an individual’s personal hearing aids. Notes can also be uploaded to a computer or a tablet for review with the audio recording, for the purpose of making revisions and printing.

### Alerting Systems

Alerting or alarm devices use amplified sound, light, vibrations, or a combination of these to make the hard-of-hearing individual aware of an event occurring in his or her auditory environment. These visual alerting systems are used for various household devices, including doorbells, fire alarms, timers, and alarm clocks (Figures 13.26 through 13.32). When an auditory event occurs, a light flashes or a vibration is generated in the device, alerting the individual with hearing loss. In some instances, both a visual and a vibratory alert can be activated. Devices are also available to alert a parent or caregiver to a baby’s cry. In many instances, portable pagers can be worn or a lighted system can be connected in multiple rooms to respond in conjunction with a single alerting system (NIDCD, 2011).
Figure 13.26A   Baby cry alert transmitter.
   Courtesy of Sonic Alert.

Figure 13.26B   Baby cry alert receiver.
   Courtesy of Sonic Alert.

Figure 13.27   Vibrating alarm clock.
   Courtesy of Sonic Alert.

Figure 13.28   Vibrating wristwatch.
   Courtesy of Silent Call.
Summary

The combination of hearing aids with hearing assistance technology can greatly enhance the quality of life for an individual with hearing loss through a wide variety of technologically advanced devices and services. When considering which assistive technology is appropriate for a client, educational, recreational, and vocational lifestyles must be taken into consideration as well as that individual's perceived hearing handicap. For each situation, hearing assistance technology (HAT), assistive listening devices (ALDs), and alerting devices are available. As seen with the move toward Bluetooth technology, advances are rapid and one must keep abreast of the most up-to-date devices to enhance the auditory environment and assist the individual with hearing loss.
Discussion Questions

1. What HAT devices would be useful for a child with a cochlear implant in the fourth grade?

2. What assistive listening device might you recommend for a 17-year-old student who has significant difficulty with auditory attention? What elements are important to consider when selecting a device for an individual of this age?

3. Compare and contrast personal, desktop, and CADS/sound field amplification systems.

4. Research one type of alerting device. In what situation would this device be most beneficial? What difficult listening situation does this device overcome for a deaf or hard-of-hearing individual?

5. What assistive devices might be appropriate for a 70-year-old gentleman, living alone, with a severe presbycusis hearing loss? Describe his perceived hearing handicap in your answer.

References


CHAPTER 14

LAWS, STANDARDS, AND GUIDELINES

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KEY TERMS

Civil Rights of Institutionalized Persons Act (CRIPA)
Family Educational Rights and Privacy Act (FERPA)
Health Insurance Portability and Accountability Act (HIPAA)

Least restrictive environment (LRE)
Medicaid
Medicare
Occupational Safety and Health Act

Present levels of academic achievement and functional performance (PLAAFP)
Related services
Services plan
Standards

OBJECTIVES

• Gain a fundamental understanding and working knowledge of the laws governing individuals with disabilities, including those that govern deaf and hard-of-hearing individuals.
• Provide an overview of agencies and regulations that govern standards of practice in the field of audiology.
Introduction

A myriad of laws, regulations, and guidelines—on both the federal and state levels—impact the lives of adults and children with disabilities, including those who are deaf or hard of hearing. As we will examine in this chapter, these laws, regulations, and guidelines run the gamut:

- They mandate that institutions take preventive measures to guard against individuals incurring possible hearing loss.
- They affirmatively afford rights to individuals with disabilities to ensure that those individuals are on an even playing field with their non-disabled peers, whether at work, school, or another institution open to the public.
- They might simply require the regular maintenance and calibration of appropriate or necessary audiological equipment and supports.

This chapter will review some of the more prevalent laws, regulations, and guidelines of which the speech-language pathologist should be aware. Although this chapter will focus primarily on federal standards, the reader is also encouraged to review all applicable state or local legislation, regulations, and guidelines, given that the states may afford individuals even greater rights or protections than those set forth in federal law.

Individuals with Disabilities Education Act (IDEA)

In 1975, Congress enacted the Education for All Handicapped Children Act (“EHA”), which guaranteed a “free appropriate public education” to every child with a disability (as defined in that law) in every state across the country. The law was a federal legislative response to an increasing number of children with disabilities who were either excluded entirely from the education system or were only provided restricted access to the education system. As articulated in the EHA (EHA, 1975) itself, the four purposes of the law were: (1) “to assure that all children with disabilities have available to them... a free appropriate public education (FAPE) through an individualized education program (IEP), which emphasizes special education and related services designed to meet their unique needs”; (2) “to assure that the rights of children with disabilities and their parents... are protected”; (3) “to assist states and localities to provide for the education of all children with disabilities”; and (4) “to assess and assure the effectiveness of efforts to educate all children with disabilities.” The EHA established mandatory programs for children with disabilities from age 3 to 21, and its subsequent amendments supported extended protections to additional populations of children such as early intervention, refined procedures for discipline of special education children, and, most recently, emphasized preparation of students for vocational and transition programs. The 1990 amendments to the EHA revised the name of the law to the Individuals with Disabilities Education Act (IDEA), which imposes even greater obligations on state and local education agencies, and confers substantive and procedural protections to qualified persons.

Referral, Evaluation, Eligibility, and IEP Services

As a threshold matter, school districts have “child find” obligations under the IDEA that obligate them to locate, identify, and evaluate children suspected of having disabilities, including homeless children, highly mobile or migrant children, and wards of the state. This obligation even extends to parentally placed children in private schools located in the school district served by the local education agency (LEA).

Once a referral is made to the local education agency, a meeting is held at which a determination is made by appropriate persons on whether to evaluate the student. If evaluation is deemed warranted, any agreed-upon assessments must be “administered in the language and form most likely to yield
accurate information on what the child knows and can do academically, developmentally, and functionally, unless it is not feasible to so provide and administer” (IDEA regulations, 2006).

Consent by the parent/guardian/adult student/other qualified individual is required prior to the school district’s initial evaluation, as well as before the initial provision of special education services (if the parent refuses to provide consent, the school district will not be deemed to be in violation of the IDEA). The initial evaluation must be conducted within 60 days of receiving parental consent, unless a state establishes a different timeline for completion or certain exceptions allow the school to claim an excusable delay (e.g., the parent of a child refuses to produce the child for evaluation) (IDEA regulations, 2006).

Parents/guardians of special education students are afforded numerous rights and procedural protections under the IDEA regulations and corresponding state regulations. These rights include:

- A very detailed notice to be provided before the school proposes or refuses to initiate or change the identification
- Notice of evaluation
- Provision of FAPE
- Notice regarding specifying actions proposed or refused, and an explanation therefore
- A description of each evaluation procedure
- Provision of assessment reports
- Record or report used for the proposed or refused action, along with options considered and the reasons they were rejected
- A statement of all procedural safeguards
- Sources for parents to contact to obtain assistance

The notices must be written in language “understandable to the general public” or “in the native language of the parent or other mode of communication by the parent, unless it is clearly not feasible to do so.” If the native language or other mode of communication of the parent is not a written language, the IDEA regulations provide that the school must maintain “written evidence that it had taken steps to ensure that the notice was translated orally or by other means to the parent in his or her native language or other mode of communication, and that the parent understood the content of the notice” (IDEA regulations, 2006).

Also, with regard to the evaluation process, the IDEA regulations provide that a parent/guardian has a right to an “independent educational evaluation” at public expense by an evaluator not employed by the school district if the parent disagrees with an evaluation by the school district, unless the school district files a court application to show that its evaluation is appropriate. The school district may not impose “conditions or timelines” related to obtaining an independent evaluation and the criteria under which the independent evaluation is obtained, including the location of the evaluation and the qualifications of the examiner, must be the same as the school district uses when it initiates an evaluation. Once the independent evaluation is completed, it must be considered by the school district in any decision regarding the provision of FAPE to the student (IDEA regulations, 2006).

Under the IDEA, after the school district completes the initial evaluation process, the “IEP team” must convene to determine if the student is eligible for special education and related services. While the definition of “IEP team” varies from state to state, according to the IDEA federal regulations, the IEP team must include: (1) the parent(s); (2) not less than one regular education teacher of the child (if the child is, or may be, participating in the regular education environment); (3) not less than one special education teacher of the child; (4) a school representative who is qualified to provide or supervise the provision of specially designed construction to meet the unique needs of the child with a disability, is knowledgeable about the general education curriculum, as well as the availability of the school’s resources; (5) an individual who can interpret the instructional implications of evaluation results; (6) at the discretion of the parent or school, other
individuals who have knowledge or special expertise regarding the child, including related services personnel as appropriate; and (7) whenever appropriate, the child (IDEA regulations, 2006).

Under the IDEA regulatory framework, a student may be deemed eligible for special education and related services upon finding that the student has 1 of 13 conditions that designate that student as a “child with a disability.” For example, “specific learning disability” is defined as “a disorder in one or more of the basic psychological processes involved in understanding or in using language, spoken or written, that may manifest itself in the imperfect ability to listen, think, speak, read, write, spell, or to do mathematical calculations, including conditions such as perceptual disabilities, brain injury, minimal brain dysfunction, dyslexia, and developmental aphasia.” Expressly excluded from the federal regulatory definition of “specific learning disability” are “learning problems that are primarily the result of visual, hearing, or motor disabilities, of mental retardation, of emotional disturbance, or of environmental, cultural, or economic disadvantage” (IDEA regulations, 2006).

Other definitions of disabling conditions establishing eligibility for special education and related services that may be of interest to the reader include (IDEA regulations, 2006):

1. **Autism:** “A developmental disability significantly affecting verbal and nonverbal communication and social interaction, generally evident before age three, that adversely affects a child’s educational performance . . . Other characteristics often associated with autism are engagement in repetitive activities and stereotyped movements, resistance to environmental change or change in daily routines, and unusual responses to sensory experiences.”

2. **Deaf-blindness:** “Concomitant hearing and visual impairments, the combination of which causes such severe communication and other developmental and educational needs that they cannot be accommodated in special education programs solely for children with deafness or children with blindness.”

3. **Deafness:** “A hearing impairment that is so severe that the child is impaired in processing linguistic information through hearing, with or without amplification, that adversely affects a child’s educational performance.”

4. **Hearing impairment:** “An impairment in hearing, whether permanent or fluctuating, that adversely affects a child’s educational performance but that is not included under the definition of deafness in this section.”

5. **Multiple disabilities:** “Concomitant impairments (such as mental retardation-blindness or mental retardation-orthopedic impairment), the combination of which causes such severe educational needs that they cannot be accommodated in special education programs solely for one of the impairments, but not including deaf-blindness.”

6. **Speech or language impairment:** “A communication disorder, such as stuttering, impaired articulation, a language impairment, or a voice impairment, that adversely affects a child’s educational performance.”

If the student is found eligible for special education services, he or she is provided with an IEP that must include, among other things, a statement of the student’s present levels of academic achievement and functional performance (PLAAFP); measurable academic and functional goals; a statement of special education and related services and supplementary aids and services to be provided to the student, as well as program modifications or supports; an explanation of the extent, if any, to which the child will not participate with nondisabled children in regular classes and activities; and a statement of individualized appropriate accommodations necessary to measure the academic achievement and functional performance of the student on state and district assessments (IDEA regulations, 2006).

In order to receive funding under the IDEA, the IEP must be designed to confer FAPE in accordance with the standards of the state education agency and controlling law. In *Board of Education of the Hendrick Hudson Central School District v. Rowley*
(1982), the United States Supreme Court interpreted “free and appropriate public education,” finding that an IEP need not maximize the potential of a disabled student, but nevertheless must consider the potential of the student and provide “meaningful” access to education and confer “some educational benefit” necessary to satisfy IDEA. Certain federal courts have demanded a higher level of scrutiny. For example, United States Court of Appeals for the Third Circuit, governing Pennsylvania, New Jersey, Delaware and the Virgin Islands, has found that IDEA requires that an IEP confer more than “trivial educational benefit,” but rather must confer “significant learning” and confer “meaningful benefit,” and also noted that “when students display considerable intellectual potential, IDEA requires a great deal more than a negligible benefit” (Ridgewood Bd. of Ed. v. N.E., 1999). Nevertheless, this means that the school district is required, by law, to provide services that are “appropriate” for the child to gain meaningful educational benefit. However, many times, there may be a significant discussion at the IEP meeting between what the school district deems as appropriate and what the parents/guardians/advocate or others may desire as optimal.

Certain students may require additional home services (such as applied behavior analysis or related services) after school (extended day), or even on weekends or holidays if those services are required for the student to receive FAPE. As such, students may also be eligible for extended school year services (e.g., summer) if that additional instruction is required for the student to receive FAPE; and it must be tailored to the individual needs of the student, as opposed to a one-size-fits-all approach or a “that’s what we have available” program.

Along with the academic program, an IEP also may include related services that have been determined necessary to confer FAPE to the student. Related services are defined in the IDEA regulations as “transportation and such developmental, corrective, and other supportive services as are required to assist a child with a disability to benefit from special education.” These services include speech-language pathology and audiology services, interpreting services, psychological services, physical and occupational therapy, recreation, counseling, orientation and mobility services, school health services, and parent counseling and training.

Under the IDEA regulations, each school must ensure that hearing aids worn in school by children with hearing impairments are functioning properly and that external components of surgically implanted medical devices (including cochlear implants) are functioning properly. However, related services do not include the optimization of a surgically implanted device’s functioning (e.g., mapping), maintenance of that device, or the replacement of that device.

Other definitions of individual related services that may be of interest to the reader include:

1. **Audiology:** “Identification of children with hearing loss; determination of range, nature, and degree of hearing loss, including referral for medical or other professional attention for the habilitation of hearing; provision of habilitative activities, such as language habilitation, auditory training, speech reading (lip-reading), hearing evaluation, and speech conservation; creation and administration of programs for prevention of hearing loss; counseling and guidance of children, parents, and teachers regarding hearing loss; and determination of children’s needs for group and individual amplification, selecting and fitting an appropriate aid; and evaluating the effectiveness of amplification”

2. **Interpreting services:** “Oral transliteration services, cued language transliteration services, sign language transliteration and interpreting services, and transcription services, such as communication access real-time translation (CART), C–Print, and TypeWell when used with respect to children who are deaf or hard of hearing; special interpreting services for children who are deaf-blind; and assisting in developing positive behavioral intervention strategies”
3. **Speech-language pathology services:** “Identification of children with speech or language impairments; diagnosis and appraisal of specific speech or language impairments; referral for medical or other professional attention necessary for the habilitation of speech or language impairments; provision of speech and language services for the habilitation or prevention of communicative impairments; and counseling and guidance of parents, children, and teachers regarding speech and language impairments”

4. **Parent counseling and training:** “Assisting parents in understanding the special needs of their child; providing parents with information about child development; and helping parents acquire the necessary skills that will allow them to support the implementation of their child’s IEP or IFSP”

5. **Rehabilitation counseling services:** “Services that focus specifically on career development, employment preparation, achieving independence, integration in the workplace, and vocational rehabilitation” (IDEA regulations, 2006)

As IDEA has evolved, so have its standards on transition services, which have become more detailed and comprehensive. The 2004 IDEA amendments instituted a requirement that, beginning at age 16, an IEP include “appropriate measurable postsecondary goals based upon age appropriate transition assessments related to training, education, employment, and where appropriate, independent living skills.” Some states, such as New Jersey, require transition services to commence at age 14 (New Jersey Department of Education Special Education Code, 2006).

The IDEA regulations define transition services as “a coordinated set of activities for a child with a disability that . . . is designed to be within a results-oriented process . . . focused on improving the academic and functional achievement of the child to facilitate the child’s movement to post-school activities,” which must be based on the child’s individual strengths, preferences, and interests, including instruction, related services, community experiences, development of employment and other post-school adult living objectives, and, if appropriate, acquisition of daily living skills through functional vocational evaluation” (IDEA regulations, 2006).

**Least Restrictive Environment**

Additionally, IDEA requires that FAPE be provided in the **least restrictive environment (LRE)**, meaning that: (1) to the maximum extent appropriate, children with disabilities, including children in public or private institutions or other care facilities, are educated with children who are nondisabled; and (2) special classes, separate schooling, or other removal of children with disabilities from the regular educational environment occurs only if the nature or severity of the disability is such that education in regular classes with the use of supplementary aids and services cannot be achieved satisfactorily. This general rule applies with equal force to arrangements concerning the provision of nonacademic and extracurricular services and activities. Unless the IEP requires some other arrangement, the child should be educated in the school he or she would attend if not disabled. Further, the child should not be removed from education in age-appropriate regular classrooms solely because of needed modifications to the general education curriculum (IDEA regulations, 2006).

Although IDEA imposes least restrictive environment requirements and a preference for mainstream placements, the laws and regulations acknowledge that some students with disabilities may require additional instruction at home or at hospitals or institutions. Similarly, a private day school or even a residential placement may be appropriate if a student cannot “reasonably be anticipated to benefit from instruction without such a placement.” In that analysis, it must be determined whether the full-time residential placement is considered necessary for educational purposes, or whether the residential placement is a response to medical, social,
or emotional problems segregable from the learning process (IDEA regulations, 2006).

**Discipline of Special Education Students**

One common challenge for school administrators, parents/guardians, and educators/service providers is navigating the rules pertaining to the discipline of children eligible for special education services, as this cohort of students is afforded significant procedural and substantive protections under the law. As a result, IDEA disciplinary requirements may lead to friction between (1) school officials seeking to take swift action and utilize any flexibility in the disciplinary authority they possess, and (2) those parents or guardians who are aware of their child’s IDEA discipline rights and seek to interpret those rights broadly or expansively. It should be noted that these disciplinary protections apply to not only those students who are already classified, but those “potentially classifiable” students not yet deemed eligible for services, but for whom the parent or teacher has requested an evaluation or expressed concern in writing that the child is in need of services (IDEA regulations, 2006).

In general, school personnel may remove a child with a disability who violates a code of student conduct from his or her current placement to an appropriate interim alternative setting or suspension for not more than 10 consecutive or cumulative school days in a school year, to the extent those alternatives are applied to children without disabilities. More significant and substantial removals require additional actions, such as a “functional behavioral assessment” (an examination of when and under what circumstances the misbehavior occurs) and “behavior intervention services” or a “behavior intervention plan”—an outlined strategy based on rewards or consequences that attempts to reduce the instances of misbehavior (IDEA regulations, 2006).

Further, if the school has proposed significant discipline beyond the 10 days, a meeting must be held to conduct a manifestation determination, (i.e., “to determine whether the conduct in question was caused by, or had a direct and substantial relationship to, the child’s disability,” or if the conduct was the result of a failure to implement the IEP). If the conduct was a manifestation of the disability, the student must be returned to the previous placement (IDEA regulations, 2006).

Under three “special circumstances,” a school district may change a student’s program unilaterally: (1) if the student possesses a “weapon” (as that term is defined in the IDEA) in school or at a school function; (2) if the student knowingly possesses, uses, or sells a “controlled substance” (as that term is defined in the IDEA) in school or at a school function; or (3) if the student has inflicted “serious bodily injury” (as that term is defined, and a difficult standard to meet) in school or at a school function. All other significant changes of placement require either parental consent or a court application, including a 45-day interim alternative educational setting if the school contends that continuing the child’s placement is “substantially likely to result in injury to the child or to others” (IDEA regulations, 2006).

**Disagreements Under IDEA and Due Process Proceedings**

It should be no surprise that, on occasion, there may be disagreements between the parent/guardian and the school district regarding the identification, evaluation, or educational placement of a student, imposition of discipline or conclusions regarding the manifestation determination, or the content of an IEP necessary to confer provision of FAPE. If that occurs, in accordance with the IDEA regulations, a parent or school district may file a due process complaint with the state within 2 years from the date the parent or school “should have known about the alleged action that forms the basis of the complaint.” The parties may voluntarily participate in mediation before a state mediator, a “resolution” session without a state mediator, or proceed directly to an impartial hearing officer.
In Schaffer v. Weast (2004), the United States Supreme Court placed the burden of proof at due process hearings on the parent. Nevertheless, some states (e.g., New Jersey) have enacted laws, such as PL 2007 Chapter 331, Sec 1, placing the burden of proof on school districts to demonstrate that they have offered FAPE, thereby allowing a parent/guardian to proceed against the school district essentially on what may be a general allegation that FAPE has not been provided, without the need for an expert to explain the manner of the alleged deprivation or failure.

During the pendency of the due process proceedings, the child is afforded “stay put protection,” meaning that he or she remains in the current educational placement until the matter is resolved. Also, the court may award reasonable counsel fees to the parent or guardian who is a prevailing party in the litigation, or to the school district if it can demonstrate that the application was “frivolous, unreasonable or without foundation” or if it was brought to “harass, cause unnecessary delay, or needlessly increase the cost of litigation” (IDEA regulations, 2006).

Numerous issues may form the basis of a disagreement under IDEA and resultant due process filing. One area of disagreement that might form the basis of the complaint could be that the school has declined to evaluate the student, or, alternatively, has evaluated the student and found the student ineligible for special education services. Another area might be a parent/guardian’s disagreement with the proposed disabling condition (e.g., “other health impaired” vs. “emotionally disturbed”) or proposed program (“self-contained,” segregated special classes vs. a mainstream class). Additionally, the parent may challenge the type, frequency, or duration of a related service—for example, the parent may request more goals and objectives regarding emphasis on speech articulation or auditory processing services in the IEP, individualized speech rather than group speech, speech in a segregated area rather than in the classroom, speech three times a week instead of once a week, or speech for 40-minute sessions rather than 20-minute sessions.

In addition to seeking evaluations or a change in the proposed program, another mode of relief requested by a parent may be compensatory services or compensatory education if services were not provided as set forth in the IEP, if a parent contends the IEP was not designed to confer FAPE, or if an unlawful exclusion from school (through inappropriate discipline or for another reason) deprived the student of FAPE. If a student did not receive occupational/physical therapy or speech sessions for some reason through no fault of the student or parent, the school district might be compelled to make up the undelivered service sessions unless an alternate means of service is more appropriate or the student no longer requires the service. An award of compensatory education—such as additional instruction after school, during the summer, placement in a private school, or services continuing after the age of 21—is a court-recognized remedy that allows the student to make up for an earlier deprivation of FAPE (Carlisle Area School District v. Scott P., 1995).

Services Plan

A school district can also develop a services plan that sets forth the special education and related services that the district provides to parentally placed private school children with disabilities. Those services, however, are conditioned upon availability of funding pursuant to federal budgetary formulas and allotments, and are different than the services provided to the students in public schools, because the requirement of a free and appropriate public education does not apply to those students (IDEA regulations, 2006).

Early Intervention

Although school districts have the obligation to provide a free and appropriate education and provide an IEP that commences at age 3 and lasts until graduation or through the age of 21, Part C of the IDEA also mandates that states implement a “state-wide, comprehensive, coordinated, multidisciplinary,
interagency system that provides early intervention services for infants and toddlers with disabilities and their families.” An infant and toddler with disability is defined as an individual under 3 years of age who needs early intervention services because the individual is experiencing a developmental delay, as measured by appropriate diagnostic instruments and procedures, in one or more of the following areas: (1) cognitive development; (2) physical development, including vision and hearing; (3) communication development; (4) social or emotional development; (5) adaptive development; or (6) has a diagnosed physical or mental condition that has a high probability of resulting in developmental delay, including conditions such as chromosomal abnormalities, genetic or congenital disorders, sensory impairments, inborn errors of metabolism, disorders reflecting disturbance of the development of the nervous system, congenital infections, severe attachment disorders, and disorders secondary to exposure to toxic substances, including fetal alcohol syndrome (IDEA regulations, 2006).

Under this framework, states must implement a public awareness program and a comprehensive child find system, coordinated with multiple agencies and programs established under, among other enactments, the Head Start Act, Social Security Act, Child Abuse Prevention and Treatment Act, Developmental Disabilities Assistance and Bill of Rights Act, Family Violence Prevention Act, and various other state laws. After a multidisciplinary assessment of the child and family is conducted, a meeting is scheduled to determine if the child is eligible for early intervention services. Similar to other IDEA disputes, a parent has the option to appeal eligibility determinations by filing for due process or mediation (IDEA regulations, 2006).

If the child is deemed eligible, an Individual Family Service Plan (IFSP) is prepared that includes: (a) a statement of the child’s present levels of physical development (including vision, hearing, and health status), cognitive development, communication development, social or emotional development, and adaptive development; (b) a statement of the family’s resources, priorities, and concerns related to enhancing the development of the child as identified through the assessment of the family; (c) a statement of the measurable results or measurable outcomes expected to be achieved for the child and family, and the criteria, procedures, and timelines used to determine the degree to which progress toward achieving the results or outcomes identified in the IFSP is being made and whether modifications or revisions of the expected results or outcomes, or early intervention services identified in the IFSP are necessary; (d) a statement of the specific early intervention services necessary to meet the unique needs of the child and the family to achieve the results or outcomes identified, including the length, duration, frequency, intensity, and method of delivering the early intervention services and a statement that each early intervention service is provided in the natural environment for that child or service to the maximum extent appropriate; (e) identification of medical and other services that the child or family needs or is receiving through other sources, but that are neither required nor funded under this early intervention, and if those services are not currently being provided, a description of the steps the service coordinator or family may take to assist the child and family in securing those other services; (f) dates and duration of services; (g) identification of the service coordinator; and (h) transition from early intervention services. The regulations also require periodic review and evaluation of the IFSP, as well as transition to preschool and other programs prior to the child’s third birthday (IDEA regulations, 2006).

Audiology services are specifically included as a type of early intervention service within the federal regulatory definition, and include: (1) identification of children with auditory impairments, using at-risk criteria and appropriate audiolgic screening techniques; (2) determination of the range, nature, and degree of hearing loss and communication functions, by use of audiological evaluation procedures; (3) referral for medical and other services necessary
for the habilitation or rehabilitation of an infant or toddler with a disability who has an auditory impairment; (4) auditory training, aural rehabilitation, speech reading and listening devices, orientation and training, and other services; (5) services for prevention of hearing loss; and (6) determination of the child’s individual amplification, including selecting, fitting, and dispensing appropriate listening and vibrotactile devices, and evaluating the effectiveness of those devices. Speech-language pathology services are also listed as early intervention services, and include: (1) identification of children with communication or language disorders and delays in development of communication skills, including the diagnosis and appraisal of specific disorders and delays in those skills; (2) referral for medical or other professional services necessary for the habilitation or rehabilitation of children with communication or language disorders and delays in development of communication skills; and (3) provision of services for the habilitation, rehabilitation, or prevention of communication or language disorders and delays in development of communication skills (IDEA regulations, 2006).

Standards for Acoustics in the Classroom

Services under IDEA may be affected by the physical layout or construction of a classroom, often leading to such requests as follow-up observations by educational audiologists when, for example, a student with a central auditory processing disorder is moved to another location or program. It is fairly common for acoustics to vary from classroom to classroom, depending on, among other factors, the location of the building; the size, shape, and design of the classroom; and the construction composition of the walls, floor or ceiling. Further, each classroom is affected by background noise, whether the result of external sounds such as planes, trains, and automobiles; noises from the hallways or other classrooms, whether next door or on higher or lower floors; and building utilities and services, such as heating, ventilation and air conditioning (HVAC) units. All of these factors have an influence on the direct sound made by a teacher’s instruction and create reflected sound, and affect the classroom’s reverberation level and signal-to-noise ratio (e.g., the teacher’s voice as the [signal] to the background sound level [noise] at the target location, such as the student’s ear), which, in addition to speaker-to-listener distance, contribute to the listening environment. It is fairly self-evident that any of these factors can lead to missed instruction for all students, in particular non-native speakers or children with learning disabilities and hearing impairments (Guckelberger, 2002).

Family Educational Rights and Privacy Act (FERPA)

The IDEA incorporates the student privacy protections set forth in the Family Educational Rights and Privacy Act of 1974 (FERPA), which, among other things, protects the confidentiality of all students’ educational records and prohibits release without the written authorization of a parent or adult student, subpoena or at times under state law, a court order. Under FERPA, an educational record is defined as “those records, files, documents, and other materials which: (1) contain information directly related to a student; and (2) are maintained by an educational agency or institution or by a person acting for such agency or institution.” Thus, special education records, such as IEPs and evaluations, or service delivery logs, summary of contents, and anecdotal notes, fall within that definition.

Certain organizations, however, are listed as exemptions and allowed access to the records in any event, including: (1) other school officials, including teachers within the educational institution or local educational agency; (2) officials of other schools or school systems in which the student seeks or intends to enroll, upon the condition that the student’s parents be notified of the transfer; (3) certain designated government agencies or state and local officials or authorities to whom such information is
specifically allowed to be reported or disclosed pursuant to state statute; (4) organizations conducting studies for, or on behalf of, educational agencies or institutions for the purpose of developing, validating, or administering predictive tests, administering student aid programs, and improving instruction; (5) accrediting organizations in order to carry out their accrediting functions; or (6) parents of a dependent student (FERPA, 1974).

Section 504 of the Rehabilitation Act

The IDEA is often referenced as a funding statute (i.e., a statute that provides federal funding to public agencies such as school districts so that they can provide services to students with disabilities who fall within the designated disabling conditions). The next statute we will review is considered an “anti-discrimination” statute, which obligates certain affirmative actions to individuals with disabilities so that the end result will be equality of opportunity. Although considered by many in the school district environment as an alternative to the IDEA, the statute applies to both students and adults.

By way of brief history, shortly after the Civil Rights Act of 1964, Congress enacted the Rehabilitation Act of 1973 as a vehicle to extend protection to persons with disabilities. In particular, Title V of that act was fashioned to ensure that all programs receiving federal money would be accessible to persons with disabilities. Section 501 of the Act applies to federal employment hiring practices, and mandates an affirmative action plan for persons with disabilities; Section 502 applies to all federally funded buildings and public transportation to ensure full accessibility to persons with disabilities; Section 503 applies to employers who have a contract or subcontract with the federal government to require an affirmative action plan for employment of persons with disabilities; and finally, Section 504 prohibits discrimination against federally qualified persons with disabilities by federally assisted programs.

Application of Section 504

In pertinent part, Section 504 of the Act provides:

No otherwise qualified individual with a disability . . . shall, solely by reason of her or his disability, be excluded from the participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance or under any program or activity conducted by any Executive agency.

As far as “any program or activity” covered by the law, federal regulations implementing Section 504 were passed in 1977, applying the law to all entities receiving federal funds. Additional regulations cover public preschool, elementary, and secondary schools. In general, the program or services must be a “recipient of federal financial assistance,” including public school districts and other public or private agencies that receive federal financial assistance directly or through another recipient (Section 504 regulations, 1977).

Court decisions have extended application of Section 504 to, among other entities: private school placements approved by the state (P.N. v. Greco, 2003); parochial schools, through participation in national lunch and E-rate programs (Rosso v. Diocese of Greensburg, 2010); afterschool childcare programs (Conejo Valley, 1995), including a program providing afterschool care to children based in a public school but paid for through tuition (K.G. v. Morris Board of Education, 2007); and recreation programs where the school provided only facilities and distributed applications for the programs (Arlington County, 1990).

For purposes of Section 504, an “individual with a disability” is defined as an individual who has: (1) a physical or mental impairment that substantially limits one or more major life activities, (2) a record of such an impairment, or (3) is regarded as having such an impairment. A “physical or mental impairment” includes neurological; musculoskeletal; special sense organs; respiratory, including
speech organs, cardiovascular, reproductive, digestive, genito urinary, hemic, and lymphatic disorders; skin, and endocrine disorders; any mental or psychological disorder or cognitive impairment; organic brain syndrome; emotional or mental illness; and specific learning disabilities (Section 504 definitions, 1977).

An individual who “has a record of such an impairment” is defined in Section 504 as an individual who “has a history of, or has been misclassified as having, a mental or physical impairment that substantially limited one or more major life activities.” If an individual establishes that he or she has been subject to a prohibited action because of an actual or perceived physical or mental impairment, whether or not that impairment limits or is perceived to limit a major life activity, an individual meets the requirements of “being regarded as having an impairment” (Section 504 regulatory definitions, 1977).

“Major life activities” within the meaning of Section 504 include, but are not limited to, caring for oneself, performing manual tasks, seeing, hearing, eating, sleeping, walking, standing, lifting, bending, speaking, breathing, learning, reading, concentrating, thinking, communicating, and working. The term also includes “the operation of a major bodily function, including but not limited to functions of the immune system, normal cell growth, digestive, bowel, bladder, neurological, brain, respiratory, circulatory, endocrine and reproductive functions” (Section 504 regulatory definitions, 1977).

**Expanded Coverage and Broad Interpretations**

The Americans with Disabilities Amendments Act of 2008 (ADAAA) amended the Rehabilitation Act to include the ADAAA’s definitions of “disability.” As a result of that amendment, it was easier for an individual seeking the benefits of the law to claim that he or she had a disability, provided that the definition of disability was to be construed in favor of broad coverage, and adding “the question of whether an individual’s impairment is a disability under the ADA should not demand extensive analysis” (ADAAA amendments, 2008).

Although Section 504 does not define the term “substantially limited,” the amendments rejected the Equal Employment Opportunity Commission (EEOC) regulatory definition of “substantially limited” as “significantly restricted,” as well as the United States Supreme Court’s restrictive definition of “substantially limited” as “prevented or severely restricted” from performing the major life activity (Toyota v. Williams, 2002). The ADAAA amendments also rejected a Supreme Court decision that found that the determination as to whether an impairment substantially limits a major life activity is to be determined with respect to the ameliorative effects of mitigating or corrective measures (Sutton v. United Air Lines, 1999).

Accordingly, under the law, the ameliorative effects of medication, medical supplies or equipment, prosthetic limbs and devices, hearing aids and cochlear implants or other implantable hearing devices, mobility devices, oxygen therapy equipment and supplies, assistive technology, auxiliary aides or services, learned behavioral or adaptive neurological modifications, psychotherapy, behavioral therapy and physical therapy are all not to be considered if determining whether an impairment or disability “substantially limits a major life activity.” Additionally, any side effects of a mitigating measure can be taken into consideration in determining whether an individual meets the definition of a “disability.” Further, an individual cannot be required to use a mitigating measure (ADAAA amendments, 2008).

The ADAAA regulations provide that in making the “substantial limitation” determination, the individual’s ability to perform the major life activity should be compared to that of “most people in the general population.” Considerations may include the difficulty, effort, or time required to perform a major life activity, pain experienced when performing a major life activity, the length of time in which a major life activity can be performed, and/or the way an impairment affects the operation of a major
bodily function. The analysis should focus on the manner that the activity is substantially limited, as opposed to the outcomes the individual may achieve. The regulations illustrate, by example, that deafness substantially limits hearing; blindness substantially limits seeing; intellectual disability, cerebral palsy, cognitive impairment, obsessive compulsive disorder, major depressive disorder, bipolar disorder, schizophrenia, and autism substantially limit brain function; partially or completely missing limbs or mobility impairments substantially limit musculoskeletal function; epilepsy, multiple sclerosis, and muscular dystrophy substantially limit neurological function; and cancer substantially limits normal cell growth (ADAAA amendments, 2008).

**Discrimination Under Section 504 and Required Services**

An entity covered by Section 504 discriminates against a covered individual if, in “providing any aid, benefit, or service . . . directly or through contractual, licensing, or other arrangements, on the basis of handicap,” proceeds to, among other things: (1) deny a qualified handicapped person the opportunity “to participate in or benefit from the aid, benefit, or service”; (2) afford a qualified handicapped person “an opportunity to participate in or benefit from the aid, benefit, or service that is not equal to that afforded others”; or (3) “provide different or separate aid, benefits or services to handicapped persons . . . unless such action is necessary to provide [those] persons with aid, benefits, or services that are as effective as those provided to others.” Section 504 specifically provides that “a recipient to which this subpart applies that employs fifteen or more persons shall provide appropriate auxiliary aides persons with impaired hearing or vision, [which] may include brailed and taped material, interpreters, and other aids” (Section 504 regulations, 1977).

For example, an institution of higher learning covered under Section 504 is required to provide interpreter services to a deaf graduate student (Camenisch v. University of Texas, 1980). A hospital must provide an effective means of communication to a deaf patient and her deaf husband, otherwise it will be deemed to have denied the benefits of services to those individuals (Borngesser v. Jersey Shore Medical Center, 2001). A school district has been found to violate Section 504 by failing to name an eligible student the sole valedictorian (Hornstine v. Township of Moorestown, 2003) or by failing to provide support in honors or world language classes (Washington Township. School District-Sewell, 2006) if those services are required to have the students participate in those programs on an “even playing field” with nondisabled peers. Similarly, school districts cannot condition an eligible student’s participation in class, afterschool activities, or field trips on parent’s attendance. Hearing-impaired parents are deemed otherwise qualified individuals with disabilities for school-sponsored events, and thus are entitled to sign language interpreters for school activities concerning their child’s education (Rothschild v. Grottenhaler, 1990). Students attending private schools would be deemed otherwise qualified individuals if they meet the “essential eligibility requirements” for those services from the private school (St. Johnsbury Academy v. D.H., 2001).

In other areas, such as health care, for example, the Office of Civil Rights (OCR) has determined that hospitals must provide qualified interpreters and telecommunication devices for the deaf (TDD) to hearing-impaired clients, finding that “it would be extremely difficult for the health care provider to demonstrate in certain service settings that effective communication is being provided in the absence of . . . interpreters” (OCR, 1982). OCR has determined that critical points of inpatient or outpatient medical treatment and hospitalization include admission, explanation of medical procedures, when informed consent is required for treatment, and discharge (OCR, 1991). OCR has also determined that written notes given to the patient, or even interpreters not versed in American Sign
Language (ASL), will not suffice as effective communication for those deaf persons who use ASL, because its “idioms and concepts are not directly translatable into English” (OCR, 1991).

**Americans with Disabilities Act (ADA)**

Nearly 20 years after the Rehabilitation Act, the Americans with Disabilities Act (ADA) of 1990 expanded the rights of persons with disabilities to the private sector. Title II of the ADA, governing state and local government activities, requires that state and local governments provide people with disabilities an equal opportunity to benefit from all of their programs, services, and activities, including education, employment, recreation, and social services. In that regard, state and local governments are required to follow certain architectural barrier-free standards in new construction or alterations. (U.S. Department of Justice, 2009). State and local governments must also relocate programs or otherwise provide access in accessible older buildings, and communicate effectively with people who have hearing, vision, or speech disabilities. (U.S. Department of Justice, 2009). For example, persons who are deaf or hard of hearing may need to be provided with computer-assisted transcription services, assistive learning systems, auxiliary aides, or qualified interpreters who are able “to interpret effectively, accurately, and impartially, using any specialized vocabulary” (ADA regulations, 2008).

Similarly, Title III of the ADA, governing public accommodations, applies to businesses and non-profit service providers; privately operated entities offering certain types of courses and examinations, privately operated transportation, and commercial facilities such as restaurants, retail stores, hotels, movie theaters, private schools, convention centers, doctors’ offices, homeless shelters, transportation depots, zoos, funeral homes, day care centers, fitness clubs, and sports stadiums (ADA regulations, 2008). Not only must these public accommodations comply with basic nondiscrimination requirements that prohibit exclusion, segregation, and unequal treatment, they must also comply with ADA’s architectural standards and provide other access requirements, such as effective communication with people who have hearing, vision, or speech disabilities (ADA regulations, 2008).

Title IV of the ADA concerns telephone and television access for people with hearing and speech disabilities, and requires common carriers/telephone companies to establish telecommunications relay services (TRSs) 24 hours a day, 7 days a week. The TRS enables callers with hearing and speech disabilities who use a teletypewriter or text telephone (TTY)—a type of a telecommunication device for the deaf (TDD)—and callers who use voice telephones to communicate through a third-party assistant. The law is overseen by the Federal Communication Commission (FCC), which sets minimum standards for the TRS services (ADA regulations, 2008).

**Health Insurance Portability and Accountability Act (HIPAA)**

The Health Insurance Portability and Accountability Act (HIPAA) was enacted on August 21, 1996. Title II of HIPAA establishes policies, procedures, and guidelines for maintaining the privacy and security of individually identifiable health information and requires the U.S. Department of Health and Human Services (DHHS) to draft rules aimed at increasing the efficiency of the healthcare system by creating standards for the use and dissemination of protected health information (PHI), any information held by a covered entity within the meaning of the law that covers health plans, provision of health care, or payment for health care that can be linked to an individual (HIPAA regulations, 2002).

Covered entities may include healthcare clearinghouses, employer-sponsored health plans, health insurers, and medical service providers that engage in certain transactions. The confidentiality obligations are extended to independent contractors of
covered entities that fit the definition of business associates (HIPAA regulations, 2002).

HIPAA imposes very strict conditions on disclosure. Protected health information may be disclosed to facilitate treatment, payment, or healthcare operations without a patient’s express written authorization. All other circumstances require written authorization for disclosure, and even in that circumstance, the covered entity must make a reasonable effort to disclose only the minimum necessary information required to achieve its purpose. Covered entities do have an obligation to disclose protected health information when required to do so by law, such as reporting suspected child abuse to state child welfare agencies (HIPAA regulations, 2002).

Covered entities must take reasonable steps to ensure the confidentiality of communications with individuals. All disclosures of PHI, as well as privacy policies and procedures, must be documented. Further, a privacy official must be appointed, as well as a designee responsible for receiving complaints and training all members of the workforce regarding implementing procedures governing disclosure and confidentiality of protected health information (HIPAA regulations, 2002).

HIPAA also mandates that covered entities disclose protected health information to the individual within 30 days of request, and individuals are given the right to request that a covered entity correct any inaccurate information. Further, an individual who believes that his or her privacy rights have been violated by a covered entity can file a complaint with the Office of Civil Rights within the U.S. Department of Health and Human Services (HIPAA regulations, 2002).

Civil Rights of Institutionalized Persons Act (CRIPA)

The Civil Rights of Institutionalized Persons Act (CRIPA) was enacted in 1997 for the purpose of protecting person’s rights of health and safety while residing in an institution. CRIPA authorizes the filing of civil rights complaints with the Office of the United States Attorney General, which investigates questionable conditions of confinement and or imprisonment at state and local government institutions, such as county and state prisons, local municipality jails, holding cells in public courthouses, juvenile correctional facilities, publicly operated nursing homes, inpatient psychiatric institutions, and facilities serving residents with developmental disabilities.

Although the Attorney General’s office does not have authority under CRIPA to investigate isolated incidents or to represent individual institutionalized persons, it does have the authority to investigate and correct widespread infringement of rights in such facilities. Infringement of civil rights must cause “grievous harm,” or be proven by reasonable cause in such cases proved to be “egregious or flagrant,” or a “pattern or practice” (CRIPA, 42 USC, 1997).

Social Security Act: Medicare and Medicaid

In 1965, the Social Security Amendment Act to the Social Security Act of 1935, also known as Title XVIII of the Social Security Act, established the Medicare and Medicaid programs. These programs were originally administered through two agencies organized under the Department of Health, Education and Welfare, later renamed the Centers for Medicare and Medicaid Services, which is now located within the U.S. Department of Health and Human Services. Although both programs provide medical and health-related services to a designated cohort of individuals and have similar names, often leading to confusion, the programs are very different.

Medicare

Medicare is a social health insurance program that covers individuals 65 years of age or older, as well as individuals under age 65 with certain disabilities such as amyotrophic lateral sclerosis (ALS or Lou Gehrig’s disease) and end-stage renal disease (i.e., permanent kidney failure requiring dialysis
or a kidney transplant). Medicare has four different “parts” covering different services: (1) Part A, hospital insurance, covering hospital inpatient care, nursing home care, home health care, or hospice; (2) Part B, medical insurance, covering healthcare provider or doctor services, outpatient care, durable medical equipment, and home health care, as well as certain preventive services to help maintain health or prevent acceleration of certain diseases; (3) Part C Medicare Advantage, which offers health plan options run by Medicare-approved private insurance companies; and (4) Part D, Medicare prescription drug coverage, also run by Medicare-approved private insurance companies.

**Medicaid**

Medicaid is a health and medical services program available to qualified individuals with low incomes and limited resources. Although primary oversight of the program is administered at the federal level, each state administers its own program, and establishes its own eligibility standards; determines the type, amount, duration and scope of services, and fixes the rate of payment for services. To qualify for federal funding, however, all states must provide certain mandatory services, including, but not limited to, inpatient/outpatient hospital services; prenatal care; children’s vaccines; physician, nurse/midwife, family nurse, and pediatrician care; and family planning services and supplies. States may also provide certain Medicaid-approved optional services, such as diagnostic and clinic services, prescribed drugs and prosthetic devices, optometrist services and eyeglasses, rehabilitation and physical therapy services, speech pathology and audiology services, community-based care, and transportation services. Of particular relevance, “services for individuals with speech, hearing, and language disorders” is defined in the Medicaid regulations as “diagnostic, screening, preventive, or corrective services provided by or under the direction of a speech pathologist or audiologist, for which a patient is referred by a physician or other licensed practitioner of the healing arts within the scope of his or her practice under state law” (American Speech-Language-Hearing Association [ASHA], 2013).

**Special Education Medicaid Initiative (SEMI)**

Some state education agencies, such as the New Jersey Department of Education (DOE), have mandated that the local districts initiate appropriate steps to increase revenue generated from the Special Education Medicaid Initiative (SEMI) by maximizing participation in that program. New Jersey DOE regulations governing “fiscal accountability, efficiency and budgeting procedures,” for example, require that each school district or county vocational school district “strive to achieve” a 90% return rate of parental consent forms for all SEMI-eligible students in addition to mandated submission of documentation of services to students by Medicaid-qualified practitioners such as nurses, occupational and physical therapists, psychologists, social workers, and speech therapists. In that regard, speech therapists are required to submit a copy of their state DOE certification and either their past or present license, American Speech-Language-Hearing Association (ASHA) certification, or documentation that the equivalent educational requirements and work experience necessary for ASHA certification have been met. Speech correctionists, similar to occupational or physical therapist assistants, even though not Medicaid-qualified, can render services under the direction of Medicaid-qualified practitioners (New Jersey DOE regulations, 2008) (ASHA, 2004).

**American National Standards Institute (ANSI)**

The American National Standards Institute (ANSI), a not-for-profit 501(c)(3) organization founded in 1918, is the official organization representing the United States to the International Organization of Standardization (ISO), an international standard-setting entity located in Geneva, Switzerland.
Located in both Washington, DC and New York City, ANSI’s official mission statement reads: “To enhance both the global competitiveness of U.S. business and the U.S. quality of life by promoting and facilitating voluntary consensus standards and conformity assessment systems, and safeguarding their integrity.”

ANSI is a voluntary organization which oversees the creation and dissemination of a wide variety of norms and guidelines that regulate and certify many of the products and services around us. ANSI also provides monitoring and auditing programs to ensure that services are maintained (ANSI, 2013).

ANSI is an active part of our everyday lives. From audiological equipment to car design, from computer standards to wiring specifications, the establishment of a product standard allows goods and services to be uniform across all 50 states. In 2011, ANSI also began accreditation of health information technology (HIT). This accreditation process will allow standardization of the U.S. Department of Health and Human Services national medical data recording system, electronic health record (EHR) technology as a nationwide medical database for all American residents (ANSI, 2013).


For example, with regard to schools and education, in 2002 ANSI and the Acoustical Society of America (ASA) jointly developed a standard for acoustical design, ANSI/ASA S12.60-2002 Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools ANSI/ASA S12.60-2002 sets forth acoustical performance criteria for different categories of learning spaces, and establishes maximum limits for each. Under the standard, the maximum permissible reverberation time in an unoccupied, furnished classroom with a volume under 10,000 cubic feet is 0.6 to 0.7 seconds, and the maximum level of background noise allowed in the same classroom is 35 decibels. However, these standards are voluntary recommendations, unless adopted by state code or otherwise mandated on a local level (Acoustical Society of America, 2002).

**Occupational Safety and Health Act**

The *Occupational Safety and Health Act* of 1970 created the Occupational Safety and Health Administration (OSHA), an agency within the U.S. Department of Labor that was authorized to “assure safe and healthful working conditions for working men and women by providing training, outreach, education and assistance.” Among other things, OSHA regulations require that employers impose a “hearing conservation program” consisting of noise exposure assessment, audiometric testing, hearing protection, and staff development/training for employees exposed to noise at 85 decibels or above as an 8-hour time-weighted average sound level. OSHA also imposes an “employee alarm systems” standard that mandates emergency actions and alarm systems should be perceived by all employees—including those employees who are deaf or hearing impaired—thus requiring visual or flashing lights, instant messaging, vibrations, or similar alerting device options in the case of hearing-impaired employees OSHA, n.d.

**The Joint Commission**

A speech pathologist's job is not only the provision of services, but also the tracking of services delivered and efficient, complete record-keeping.
These obligations are not only essential for maintaining confidentiality and preparation for possible legal issues, they also are crucial for federal and state monitoring of the entities for which the speech pathologist is providing services. This may be the federal or state Departments of Education, or another agency may be conducting accreditation checks for the facility of employment.

For example, The Joint Commission, created in 1951 and formerly known as The Joint Commission on the Accreditation of Healthcare Organizations (JCAHO), is a federal nonprofit organization that accredits and certifies more than 20,000 healthcare organizations and programs across the United States. Many hospitals and healthcare organizations that receive Joint Commission accreditation must pass rigorous inspections of facility practices and adhere to certain performance standards.

In order to achieve Joint Commission accreditation, hospitals and medical facilities must prove they have strong, evidence-based practices, a strong commitment to patient outcomes, clinical care, and promotion of patient safety. An appointed group of Joint Commission members assigned to accredit the facility undertakes an extensive evaluation process. Joint Commission inspections can take several weeks to complete, at which time standards of practice are evaluated and scrutinized. A speech pathologist working in a healthcare facility at some time in his or her career will participate in a Joint Commission accreditation inspection (The Joint Commission, 2013).

**Summary**

In order for the field of speech-language pathology to maintain homogeneity, speech-language pathologists must be held to a high standard of practice. First and foremost is the professional’s ethical commitment to the profession. Following that, laws, guidelines, and standards direct our daily activities of quality service provision. We find these regulations and directives in a variety of places, depending on the professional setting. Whether it is in a school system or a medical center, laws, standards, and guidelines enable us to serve the public in a uniform fashion across the country. Our clients, students, and patients are afforded their rights as well, to assure that they are receiving the best of care possible. The symbiotic relationship between civil rights and standards of practice drive best practices within the field of speech-language pathology.

**Discussion Questions**

1. A parent/guardian disagrees with the school district’s determination of eligibility or proposed frequency of speech therapy. What law applies, and what are the parent’s rights? How can the parent/guardian demonstrate that more service or a different service is warranted?

2. A school district proposes suspending a deaf student for 20 days for failing to follow verbal directions. What are the student’s rights? What would the school have to demonstrate?

3. A hearing-impaired employee attends a professional development day and is unable to understand the presentation. What law
applies? What are the employee’s rights? What would be the employer’s obligations?

4. What is the difference between Medicare and Medicaid?

5. True or False: Federal laws and regulations are the only mandates that apply to the hearing-impaired population; once familiarity with them is mastered, there is no need to review state or local standards. Explain your answer.

References

45 CFR 160.164 Health Insurance Portability and Accountability Act
Americans with Disabilities Amendments Act (42 U.S.C. § 12101, et seq) 2008
New Jersey Administrative Code Title 6A Chapter 14 Special Education, Effective September 5, 2006

Recommended Readings

CASES

Arlington County (VA) Pub. Sch., 16 EHLR 1190
Board of Education of the Hendrick Hudson Central School District v. Rowley 632 F. 2d 945 (2d Cir. 1982).
Camenisch v. University of Texas, 616 F.2d 127 (5th Cir. 1980)
Carlisle Area Sch. Dist. v. Scott P., 62 F.3d 520 (3d Cir. 1995)
Conejo Valley Unified Sch. Dist., 23 IDELR 448 (1995)

Ridgewood Board Of Education. v. N.E., F.3d 238, 247 (3d Cir. 1999).
Rosso v. Diocese of Greensburg, 55 IDELR 98 (W.D. Penn. 2010)
Rothschild v. Grottenhaler, 907 F.2d 286 (2d Cir. 1990)
St. Johnsbury Academy v. D.H., 240 F.3d 163(2d Cir. 2001)

REGULATIONS

34 CFR 300.517  34 CFR 300.518  34 CFR 300.530  34 CFR 300.532
34 CFR 303.1  34 CFR 303.13  34 CFR 303.21  34 CFR 303.209
34 CFR 303.342  34 CFR 303.343  34 CFR 303.344  42 CFR 440.70
34 CFR 300.502  34 CFR 300.506  34 CFR 300.507  34 CFR 300.510
34 CFR 300.511  34 CFR 300.511

28 CFR 35.104  34 CFR 300.132  34 CFR 300.507  34 CFR 300.510
34 CFR 300.511

42 CFR 440.110  45 CFR 84.52  45 CFR 164.501  45 CFR 160.102
45 CFR 164.522  45 CFR 164.524  45 CFR 164.526  45 CFR 164.528
45 CFR 164.530  NJAC 6A:23A-5.3

STATUTES

29 USC 651  29 USC 794  20 USC 1232
42 U.S.C. § 1997 et seq.  42 USC 42642  42 USC 12101
42 USC 12102  42 USC 1395  NJSA 18A:46-1.1
Chapter 15

Understanding Auditory Development and the Child with Hearing Loss

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Key Terms

Auditory access  Comprehension  Hearing age
Auditory environment  Detection  Identification
Aural habilitation  Discrimination  Open-set assessment
Closed-set assessment  Functional auditory assessment  Telescope vocal development

Objectives

• Discuss how auditory skills develop in typically developing children with normal hearing.
• Understand and describe the relationship between listening and spoken language.
• Explain the elements that need to be in place for a child with hearing loss to learn language through audition, and the rationale for doing so.
• Describe functional auditory assessment and the tools and methods available to complete it.
Introduction

Spoken language acquisition happens for the typically developing hearing child in such an integrated, progressive manner that how the child receives, perceives, and processes the auditory sensory input from his or her environment may be taken for granted. In the case of children with hearing loss, a strong understanding of the impact of hearing loss on auditory spoken language acquisition is essential, as well as how to optimize the listening capacity and auditory skills development for the individual child who is deaf or hard of hearing. Just as for the hearing child, the mother language can be learned through the primacy of the auditory channel; the brain can learn to use an auditory signal that arrives through hearing instruments and auditory development can be followed. The concept that spoken language is primarily an auditory event underlies the practices of professionals who provide early auditory-based intervention and auditory–verbal education to children with hearing loss who are learning to listen and speak. How do we use our understanding of typical auditory learning to assist children with hearing loss to access the auditory code-cracking potential of their brains?

This chapter will present an overview of the following topics: auditory development in typically developing children with normal hearing, auditory development in children with hearing loss, a model for auditory work with children with hearing loss, the use of developmental hierarchies and checklists in tracking auditory skills, and functional auditory skills assessment tools. We will also provide several resources in Appendix 15-C.

Auditory Development in Typically Developing Children

In the past 20 years, there has been a great deal of research concerning the prenatal auditory environment and the earliest weeks and months of auditory development. These findings confirm the importance of paying attention to the earliest stages of auditory development (Boothroyd, 1997; Cole & Flexer, 2015; Estabrooks, MacIver-Lux, & Rhoades, 2016). There are several general assumptions that inform us about early auditory pathway development and ongoing auditory learning. First, we now assume the innate capacity of the human brain to perform categorical speech perception (Owens, 2016). Second, the timetable of auditory development needs to be considered from the formation of the auditory system in utero and the auditory experiences with sounds that are possible through the uterine wall. We can assume that, even before birth, a child is listening to its mother’s heartbeat and attending to mother’s voice, music, and other speech and nonspeech sounds, even stories that are loud enough to be heard (Saffran, Werker, & Werner, 2006). Third, research into auditory pathway development in utero and the first few years of life emphasizes the critical period for auditory neural pathway development (Sharma, Dorman, & Kral, 2005). Fourth, cross-linguistic research on auditory perceptual abilities of infants in the first days and weeks of life informs us that the neonate is indeed an amazing sound processor and can perform a larger variety of perception tasks than previously thought. Auditory abilities that are more complex than auditory awareness are already present at birth (Cole & Flexer, 2015; Welling, 2014). The presence of a hearing loss at birth, therefore, means that the auditory brains of these children have not benefited from diverse auditory input and listening practice, hence the crucial need for early detection and early intervention.

What do we know about auditory development and the typical child with normal hearing, and how does that inform us about the child with hearing loss? For the child whose hearing loss is detected early and who is able to access sufficient auditory input, we would want to follow a developmental model (Cole & Flexer, 2015; Moeller & Cole, 2016; Moeller, Ertmer, & Stoel-Gammon, 2016). It is useful to think about how the auditory–verbal link develops and how auditory input is linked to speech...
and spoken language output. The following is a useful way to conceptualize this:

**Input**

1. Auditory perception (ability of the ear to hear the speech signal)
2. Auditory processing (ability of the brain to understand speech and spoken language)

**Output**

1. Speech and spoken language organization (ability of the brain to organize speech and spoken language)
2. Speech and spoken language production (ability to produce nonmeaningful speech sounds and meaningful speech in spoken language)

As we observe children at various ages and stages of development, our observations of their speech and spoken language output can be an indicator of the auditory input they are receiving and how they are processing that input. If the auditory input is compromised, then spoken language output will be negatively impacted.

Table 15.1 contains a list of aspects of auditory development related to concurrent attainments in speech production and spoken language. This developmental information is a reference for later discussion of how listening and speaking can be developed in hearing loss. For further details the reader is referred to Owens (2016), Cole and Flexer (2015), Oller (1986), and Hall and Moats (1998).

**Auditory Development of Children with Hearing Loss**

Understanding the course of auditory development in the typically hearing child should inform best practices of speech pathologists, audiologists, teachers of the deaf, auditory–verbal therapists, early interventionists, and listening and spoken language specialists (Houston & Perigoe, 2010a, 2010b). Our challenge in working with children who are deaf or hard of hearing is to ensure early identification of hearing loss, early and consistent use of advanced hearing instruments, early access to auditory-based language learning in the home environment, and access to knowledgeable and skilled professionals (Paterson & Cole, 2010; Paterson & Perigoe, 2014a, 2014b, 2015a, 2016; Perigoe & Paterson, 2016).

Children born with hearing loss, even a minimal hearing loss, are at risk for not achieving all the essential auditory abilities outlined in Table 15.1. Early identification of hearing loss through newborn hearing screening, and the provision of early intervention programs and advanced hearing technologies, have played a part in changing our expectations of children with all levels of hearing loss and of the age of attainments. The mission of state Early Hearing Detection and Intervention (EHDI) programs is the detection of hearing loss by 1 month of age, diagnostic audiology and hearing aid wearing by 3 months of age, and enrollment of the child and family in an early intervention program by 6 months of age (Joint Committee on Infant Hearing, 2007). However, not all states are meeting this goal (Goshorn, Marx, Ward, & Paterson, 2015).

Early intervention, prior to 6 months of age, has been shown to afford children with hearing loss the opportunity to achieve language levels comparable to their hearing peers (Downs & Yoshinaga-Itano, 1999; Eriks-Brophy, Ganek, & DuBois, 2016; Yoshinaga-Itano, Sedey, Coulter, & Mehl, 1998). Failure to provide infants with hearing loss the early auditory input necessary for the development of their auditory brain centers (and subsequent skills in listening, spoken language, and literacy) has been dubbed a “neurological emergency” by Dornan (2009).

Auditory input is best accessed during the years of the greatest neural plasticity. The detrimental effects of auditory deprivation due to hearing loss have been well documented. Hearing loss can have a negative effect on the development of the child’s auditory system (Moore & Linthicum, 2007) and on the development of listening, speech, spoken language, literacy, and academic achievement (Blaiser & Culbertson, 2013; Ling, 2002; Paul & Whitelaw, 2011; Robertson, 2009).
### Table 15.1 Auditory–Verbal Development In Typically Developing Children with Normal Hearing

<table>
<thead>
<tr>
<th>Input: Auditory Development</th>
<th>Output: Speech Production/Spoken Language</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Prenatal</strong></td>
<td><strong>Auditory Experiences in Utero:</strong></td>
</tr>
<tr>
<td></td>
<td>- Typically developing child has 20 weeks of exposure to auditory stimuli prior to birth</td>
</tr>
<tr>
<td></td>
<td>- Infant emerges literally wired for sound</td>
</tr>
<tr>
<td></td>
<td>- Listens to mother's voice and environmental sounds (both from within and outside of the womb)</td>
</tr>
<tr>
<td></td>
<td>- Born with a preference for mother's voice</td>
</tr>
<tr>
<td></td>
<td>- Born with a preference for songs and stories heard in utero</td>
</tr>
<tr>
<td><strong>Birth to 3 months</strong></td>
<td><strong>Reactions to Sounds:</strong></td>
</tr>
<tr>
<td></td>
<td>- Startle reflex, eye blink/eye widening, cessation of activity, limb movement, head turn toward or away, grimacing/crying, sucking, arousal, breathing change</td>
</tr>
<tr>
<td></td>
<td><strong>Speech Perception Abilities:</strong></td>
</tr>
<tr>
<td></td>
<td>- Can identify individual phonemes</td>
</tr>
<tr>
<td></td>
<td>- Capable of detecting virtually every phoneme</td>
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<tr>
<td></td>
<td>- Prefers vowels</td>
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<tr>
<td></td>
<td><strong>Prosody/Suprasegmentals:</strong></td>
</tr>
<tr>
<td></td>
<td>- Prefers human voice</td>
</tr>
<tr>
<td></td>
<td>- Attentive to the rise and fall of intonation pattern</td>
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<tr>
<td></td>
<td>- Attends to patterns of speech</td>
</tr>
<tr>
<td></td>
<td>- Prefers native language to all others</td>
</tr>
<tr>
<td></td>
<td><strong>Identification:</strong></td>
</tr>
<tr>
<td></td>
<td>- Identifies mother's voice</td>
</tr>
<tr>
<td></td>
<td>- Prefers songs heard prenatally</td>
</tr>
<tr>
<td><strong>3–4 months</strong></td>
<td><strong>Prosody/Suprasegmentals:</strong></td>
</tr>
<tr>
<td></td>
<td>- Prefers utterances with intonation variation versus flat voice</td>
</tr>
<tr>
<td></td>
<td>- Discriminates high and low sounds</td>
</tr>
<tr>
<td><strong>4–7 months</strong></td>
<td><strong>Early Auditory Feedback Auditory Tuning In:</strong></td>
</tr>
<tr>
<td></td>
<td>- Listening to language for longer periods of time</td>
</tr>
<tr>
<td></td>
<td>- Shows awareness of environmental sounds</td>
</tr>
<tr>
<td></td>
<td>- Can be behaviorally pacified by music or song</td>
</tr>
<tr>
<td></td>
<td><strong>Speech Perception:</strong></td>
</tr>
<tr>
<td></td>
<td>- Recognition of mother's voice</td>
</tr>
<tr>
<td></td>
<td>- Reacts to vocal mood differences</td>
</tr>
<tr>
<td></td>
<td><strong>Localization:</strong></td>
</tr>
<tr>
<td></td>
<td>- Localization to sound begins to emerge from eye gaze to head turn to localization to specific sound sources (directly related to motor development)</td>
</tr>
<tr>
<td></td>
<td><strong>Auditory Memory:</strong></td>
</tr>
<tr>
<td></td>
<td>- Beginning of auditory memory (distinguishes between voices of familiar people vs. strangers)</td>
</tr>
<tr>
<td><strong>5 months</strong></td>
<td><strong>Early Auditory Comprehension:</strong></td>
</tr>
<tr>
<td></td>
<td>- Responds to own name</td>
</tr>
<tr>
<td></td>
<td><strong>Suprasegmentals/Prosody:</strong></td>
</tr>
<tr>
<td></td>
<td>- Discriminates own language from others with same prosody</td>
</tr>
<tr>
<td><strong>Reflexive:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Coos, gurgles, reflexive sounds</td>
</tr>
<tr>
<td><strong>Physical Response to Sounds:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Stilling, rhythmic movement, searching for sound's source</td>
</tr>
<tr>
<td><strong>Vocalization:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Goo sounds, laughter</td>
</tr>
<tr>
<td></td>
<td>- Quasi-resonant nuclei (QRN), immature vowel-like sounds</td>
</tr>
<tr>
<td><strong>Expanding Vocal Repertoire:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Vocal play</td>
</tr>
<tr>
<td></td>
<td>- Fully-resonant nuclei (FRN), vowel-like sounds, consonant-like sounds, consonant-vowel (CV) and vowel-consonant (VC) syllables emerge</td>
</tr>
<tr>
<td></td>
<td>- Plays with streams of sounds, intonational patterns, raspberries, squeals, loudness play</td>
</tr>
<tr>
<td></td>
<td>- Vocal turn-taking exchanges with parent</td>
</tr>
</tbody>
</table>

298 Chapter 15 Understanding Auditory Development and the Child with Hearing Loss
## Table 15.1  Auditory–Verbal Development In Typically Developing Children with Normal Hearing  (Continued)

<table>
<thead>
<tr>
<th>Input: Auditory Development</th>
<th>Output: Speech Production/Spoken Language</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 months</td>
<td>Correlation between achievements and speech perception and later word understanding, word production, and phrase production</td>
</tr>
<tr>
<td>Speech Perception:</td>
<td></td>
</tr>
<tr>
<td>• Preference for vowels ends</td>
<td></td>
</tr>
<tr>
<td>Early Auditory Feedback:</td>
<td></td>
</tr>
<tr>
<td>• Listens to self in vocal play</td>
<td></td>
</tr>
<tr>
<td>Auditory Identification:</td>
<td></td>
</tr>
<tr>
<td>• Begins to recognize own name and the names of family members</td>
<td></td>
</tr>
<tr>
<td>Reliable Localization:</td>
<td></td>
</tr>
<tr>
<td>• Begins to respond to directives</td>
<td></td>
</tr>
<tr>
<td>Selective Auditory Attention:</td>
<td></td>
</tr>
<tr>
<td>• Will divert attention from one activity to a more desirable activity based on auditory input.</td>
<td></td>
</tr>
</tbody>
</table>

### Vocalization:
- May produce recognizable vowels: /u/a/i/

The Sound with Meaning Connection:
The “melody is the message.” Child will interpret parents’ intention by listening and reacting to tone of voice change. Happens prior to word comprehension.

8–10 months

**Synaptogenesis:**
- Explosion of synaptic growth may be related to change in perception and production

**Phonotactic Regularities and Prosody:**
- Sensitive to regularities in word boundaries in infant-directed speech (IDS), even in another language
- Begins storing sound patterns for words, although no meaning yet

**Auditory Comprehension:**
- Begins to comprehend words

### Vocalization: Canonical “Babble”:
- Achieves strings of reduplicated and alternated syllable production; timing of syllable production sounds speech-like, stress patterns
- Vowels, consonants becoming distinct

**Increased Vocal Turn-Taking:**
- Once true babble attained, parents expect more speech-like utterances.

**Primitive Speech Acts (PSA):**
- Expressing intentions nonverbally

8–14 months

**Protowords:**
- Words invented by child, not adult, but have consistent meaning, such as “la-la” for blanket

9 months

**Speech Perception:**
- Prefers nonwords composed of high phonotactic components

**Auditory Attention:**
- Sustained auditory attention
- Will attend to auditory-based activities for increased periods of time

**Phonotactic Probabilities:**
- Predicting likelihood of certain sound sequences, listening preference for nonwords with high phonotactic probability versus those with low probability

### Intentionality: “I Know What I Mean”:
- Child attains cognitive/communication intents
- Achieves means–end concept
- Uses vocal/verbal means to achieve ends in combination with visual and gestural mechanisms

### Vocalization:
- Variegated babble: Adjacent and following syllables are not identical

(continues)
<table>
<thead>
<tr>
<th>Input: Auditory Development</th>
<th>Output: Speech Production/Spoken Language</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>9–12 months</strong></td>
<td>9–12 months: Speech to Communicate:</td>
</tr>
<tr>
<td></td>
<td>• Sound imitation of common household items and animals</td>
</tr>
<tr>
<td></td>
<td>• Distinct word approximations and in some cases early single word utterances take place of crying to fulfill wants and needs</td>
</tr>
<tr>
<td></td>
<td>• Verbal “nicknames” for distinct objects and people develop and remain consistent for that object or person</td>
</tr>
</tbody>
</table>

**10 months**

**Auditory Tuning In:**
- Narrows auditory attention and speech perception: tunes in to mother language, loses universal interest in all speech sounds

**10–16 months**

**Phonetically Consistent Forms (PCF):**
- Speech sounds that have sound–meaning relationships, such as “puda” for the family cat

**First Words:**
- Context bound
- Following the first word, during the next few months, children add an average of 8–11 words to their vocabularies each month

**11 months**

**Speech Perception:**
- Identifies allophones and word boundaries

**12 months**

**Speech Perception:**
- Hears word and consonant boundaries

**Ages 12–24 months: Exploring and Expanding**

**Listening: Auditory Comprehension**

**12–18 months**

**Early Auditory Comprehension:**
- Odd mappings of words
- Child attends to whole sentence
- Is able to follow commands
- Fully aware of the names for familiar objects and family members

**Auditory Environment:**
- Derives obvious pleasure from auditory activities like music, playing with friends, laughing, and being read to

**Auditory Experience:**
- Listening to speech for long periods of time is essential to the ultimate use of even single words

**Speech Production and Spoken Language**

**Overextension and Underextension of Words:**
- Language develops as a direct correlation of using that developing speech to ultimately gain a desired outcome through a communication interaction between the speaker and the listener

**Gradual Decontextualization (to 18 months):**
- Says first clear, distinct word and assigns that word to a single distinct object or person

**16–20 months**

**Fast Mapping:**
- Ability to learn words in one or few exposures

**18 months**

**Auditory Vocabulary:**
- Tremendous growth in vocabulary comprehension, 100–200 words understood

**First 50 Words Used: A First Language:**
- Growth in expressive ability
- Tremendous growth in one-word usage
## Table 15.1 Auditory–Verbal Development In Typically Developing Children with Normal Hearing (Continued)

<table>
<thead>
<tr>
<th>Input: Auditory Development</th>
<th>Output: Speech Production/Spoken Language</th>
</tr>
</thead>
<tbody>
<tr>
<td>18–24 months</td>
<td></td>
</tr>
<tr>
<td><strong>Auditory Localization:</strong></td>
<td>Word Spurt: Vocabulary Spurt:</td>
</tr>
<tr>
<td>• Will independently seek out a sound source in another room</td>
<td>• “Naming theory” seems to be a basis for noun usage, naming people, objects; occurs for most children when they hit the first 50 words mark</td>
</tr>
<tr>
<td><strong>Auditory Comprehension:</strong></td>
<td>• Will begin to sing along with songs or mimic the rhythm of a nursery rhyme</td>
</tr>
<tr>
<td>• Understands and follows verbal directions with two critical elements</td>
<td></td>
</tr>
<tr>
<td>• Begins to respond appropriately to “What, Where” questions</td>
<td></td>
</tr>
<tr>
<td><strong>Ages 2–3</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Listening</strong></td>
<td><strong>Speaking</strong></td>
</tr>
<tr>
<td>24–36 months</td>
<td></td>
</tr>
<tr>
<td><strong>Auditory Identification:</strong></td>
<td>Cognitive/Semantic:</td>
</tr>
<tr>
<td>• Will identify a sound and share that identification with another person with exuberance</td>
<td>• Two-word semantic relations, and three-word-plus utterances</td>
</tr>
<tr>
<td>• Desires to share auditory information with another person</td>
<td></td>
</tr>
<tr>
<td><strong>Auditory Memory:</strong></td>
<td><strong>Spoken Language and Play:</strong></td>
</tr>
<tr>
<td>• Will share auditory experiences from memory (left brain)</td>
<td>• Will hold a seemingly appropriate conversation with an inanimate object while playing</td>
</tr>
<tr>
<td>• Will sing complete or nearly complete songs from memory (right brain)</td>
<td><strong>Presyrntactic Period</strong></td>
</tr>
<tr>
<td><strong>26–32 months</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Phoneme Repetition:</strong></td>
<td></td>
</tr>
<tr>
<td>• Vocabulary size seems related to ability to repeat phoneme combinations, especially initial position in nonwords</td>
<td></td>
</tr>
<tr>
<td><strong>By 36 months</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Early Syntactic:</strong></td>
<td></td>
</tr>
<tr>
<td>• Recombination of two-plus-two word utterances</td>
<td></td>
</tr>
<tr>
<td>• Early multiple word utterances, correct word order</td>
<td></td>
</tr>
<tr>
<td><strong>Early Morphology:</strong></td>
<td></td>
</tr>
<tr>
<td>• “ing”</td>
<td></td>
</tr>
<tr>
<td><strong>Ages 3–4: Peers, Preschool</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Listening</strong></td>
<td><strong>Speaking</strong></td>
</tr>
<tr>
<td>3–4 years</td>
<td></td>
</tr>
<tr>
<td><strong>Auditory Memory:</strong></td>
<td>Pragmatics:</td>
</tr>
<tr>
<td>• Begins to show listening preferences for favorite stories or music and will follow simple aural commands</td>
<td>• Able to hold an appropriate turn-taking conversation with a peer; continuing to develop conversational competence</td>
</tr>
<tr>
<td><strong>Auditory Attention:</strong></td>
<td><strong>Cognitive Semantic</strong></td>
</tr>
<tr>
<td>• Development of sustained auditory attention for increasing periods of time</td>
<td><strong>Phonology:</strong></td>
</tr>
<tr>
<td>“Overhearing” or “Incidental” Learning Through Listening:</td>
<td>• Phonetic repertoire mastered for some phonemes</td>
</tr>
<tr>
<td>• Does not need to be involved in direct instruction or directly in a conversation to pick up on what is happening; uses words, expressions not directly taught</td>
<td>• Phonological processes occurring</td>
</tr>
</tbody>
</table>
### Table 15.1 Auditory–Verbal Development In Typically Developing Children with Normal Hearing (Continued)

<table>
<thead>
<tr>
<th>Input: Auditory Development</th>
<th>Output: Speech Production/Spoken Language</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auditory Feedback Mechanism:</td>
<td>Speaking</td>
</tr>
<tr>
<td>• Development of auditory feedback mechanism</td>
<td>• Precisely by rhyme</td>
</tr>
<tr>
<td>• Development of phonemic awareness and temporal processing</td>
<td>• Rhyme by pattern</td>
</tr>
<tr>
<td>Distance Listening:</td>
<td>• Alliteration</td>
</tr>
<tr>
<td>• Ability to search the auditory environment for information even if engaged in activity</td>
<td>• Increased morphological use, correct sentence word order</td>
</tr>
<tr>
<td>4–5 years</td>
<td>Early Syntactic Child:</td>
</tr>
<tr>
<td>Achieves Metalinguistic Ability Through Audition:</td>
<td>• Begins to produce increasingly complex sentences that adhere to spoken language rules</td>
</tr>
<tr>
<td>• Recognizes and can report when he or she hears someone make an error or slip of the tongue in spoken language</td>
<td></td>
</tr>
<tr>
<td>• Uses auditory cues in conversations to recognize prosodic, pragmatic, semantic and syntactic errors in adult and peer speech</td>
<td></td>
</tr>
<tr>
<td>Ages 5–6: Preacademic Readiness</td>
<td>Pragmatics/Discourse:</td>
</tr>
<tr>
<td>Auditory Developments</td>
<td>• Follows adult conventions for conversation mechanisms; able to take role as “conversational partner”</td>
</tr>
<tr>
<td>5–6 years</td>
<td>Preliteracy:</td>
</tr>
<tr>
<td>Auditory Attention:</td>
<td>• Syllable counting (50% of children by age 5)</td>
</tr>
<tr>
<td>• Development of an attention span for instruction, even if the topic is not of high interest</td>
<td></td>
</tr>
<tr>
<td>Auditory Memory:</td>
<td></td>
</tr>
<tr>
<td>• Stronger development for long-term auditory memory of linguistic information</td>
<td></td>
</tr>
<tr>
<td>Internal Auditory Feedback:</td>
<td></td>
</tr>
<tr>
<td>• Development of internal auditory feedback (reading voice in head); auditory self-correcting</td>
<td></td>
</tr>
<tr>
<td>7 years</td>
<td>Phonologic Awareness:</td>
</tr>
<tr>
<td>Assessable Auditory Processing Function:</td>
<td>• Expressive vocabulary</td>
</tr>
<tr>
<td>• Higher level auditory skills are mostly developed and intact: dichotic listening, auditory figure ground, selective auditory attention</td>
<td></td>
</tr>
<tr>
<td>Phonemic Awareness:</td>
<td></td>
</tr>
<tr>
<td>• Sound blending, sound symbol association</td>
<td></td>
</tr>
<tr>
<td>Prosody and Suprasegmentals:</td>
<td></td>
</tr>
<tr>
<td>• Ability to sense vocal sarcasm</td>
<td></td>
</tr>
<tr>
<td>• Ability to resist heavy accent and follow conversation (decoding and closure)</td>
<td></td>
</tr>
<tr>
<td>Auditory Lexicon:</td>
<td></td>
</tr>
<tr>
<td>• 14,000 words (approx.)</td>
<td></td>
</tr>
</tbody>
</table>
Table 15.1  Auditory–Verbal Development In Typically Developing Children with Normal Hearing  (Continued)

<table>
<thead>
<tr>
<th>Input: Auditory Development</th>
<th>Output: Speech Production/Spoken Language</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 years</td>
<td></td>
</tr>
<tr>
<td><strong>Auditory Processing Overload Strategies:</strong></td>
<td><strong>Phonologic Awareness:</strong></td>
</tr>
<tr>
<td>• Develops compensatory strategies when faced with the challenge of auditory processing overload</td>
<td>• Consonant cluster segmentation</td>
</tr>
<tr>
<td>• Uses volume independently to aid in focus and attention</td>
<td>• Deletion with clusters</td>
</tr>
<tr>
<td><strong>Auditory Attention for Music:</strong></td>
<td></td>
</tr>
<tr>
<td>• Begins to have an “ear” for music, auditory attention for musical instruction</td>
<td></td>
</tr>
<tr>
<td><strong>Auditory Developments Speaking</strong></td>
<td></td>
</tr>
<tr>
<td>9 years</td>
<td></td>
</tr>
<tr>
<td><strong>Auditory Input Primary for Instruction:</strong></td>
<td></td>
</tr>
<tr>
<td>• Auditory begins to become the primary input system for classroom instruction</td>
<td></td>
</tr>
<tr>
<td>• Higher level auditory visual integration skills for organization management like note taking</td>
<td></td>
</tr>
<tr>
<td>• End of the right ear advantage</td>
<td></td>
</tr>
</tbody>
</table>


Studies and intervention with children who have various levels of hearing loss can inform us about how hearing develops. Sharma and colleagues (2002a, 2002b, 2005, 2006) have studied severe to profoundly deaf children who received cochlear implants and confirmed that there is a critical period for auditory development. Children who received cochlear implants prior to 3.5 years of age developed “auditory brains” similar to those of hearing children; those older than 7 years of age did not.

Better speech perception and language skills have also been achieved by children who received cochlear implants early (Fryauf-Bertschy, Tyler, Kelsay, & Gantz, 1997; Kirk et al., 2002; Nicholas & Geers, 2006). The same type of improved outcome has been shown in studies of children who received auditory–verbal therapy (Estabrooks, MacIver-Lux & Rhoades, 2016; Rhoades & Duncan, 2010) from an early age. These children achieved language levels commensurate with hearing peers (Dornan, Hickson, Murdoch, & Houston, 2007; Duncan, 1999; Rhoades & Chisolm, 2000) or went on to mainstream education and higher education (Goldberg & Flexer, 1993, 2001).

Rationale for Teaching Language Through Audition

How is it possible to achieve spoken language outcomes as described in the previous section with children who are deaf or hard of hearing? First, and most important, typically developing children learn speech and spoken language through audition, and it is the most effective way to acquire this competence and performance (Cole & Flexer, 2015; Ling, 2002). Audition is so essential in this task that even a mild hearing loss can compromise spoken language learning (Flexer, 1995). It is possible for the child who is deaf or hard of hearing to acquire auditory spoken language because of the redundancy cues contained in spoken communication: communication context and intent, semantic content...
and noun–verb meanings, stress–time information, intonation patterns, word order regularity, phonotactic probability knowledge, reading body language, facial cues, tone of voice, and motivation to understand (Fry, 1978; Ling, 2002; Ling & Ling, 1978). We can give them access to the sounds of the speech input signal and, even if this not perfect, children with hearing loss can learn to fill in the gaps or “get the gist.” Auditory comprehension improves as the child learns to use linguistic cues and the rules of language (Ling, 2002).

Second, the link between speech perception and production (as presented previously) is vital. Table 15.1 demonstrates how the infant increasingly tunes in to the cues for speech, initiates the process of development of control of motor speech, and uses vocal/speech behaviors to communicate in year 1 of life. The child’s speech output in year 1 lags behind his or her auditory learning. First we listen, then we talk. Also, the infant’s anatomy and physiology for speech production need to develop to enable more mature sound imitation. This is coupled with the increasing use of immature, then more mature, vocalizations as a way to participate in communication with parents. There is evidence for a 15-month-old child with a severe hearing loss to telescope vocal development; within only 15 days of hearing aid wearing, she progressed from immature verbalizations to the production of the entire range of year 1 vocal behaviors (Paterson, 1992). This is evidence that a more biologically mature child was able to start catching up once her brain was able to access sound and spoken language input.

Audition assists speech acquisition. Children use hearing to help match their speech to adult models in their environment (Pollack, Goldberg, & Caleffe-Schenck, 1997). Children tend to talk the way they hear (Ling, 2002), so accurate input is needed for the child to develop appropriate speech and spoken language skills. The computer has been used as an analogy for this process; there is a saying from computer science: “garbage in, garbage out.” In other words, if the child does not have auditory access to the complete speech signal, his or her ability to process that information and then produce accurate spoken language is compromised. In this type of scenario, acquiring adequate speech and spoken language skills becomes an arduous task (Cole & Flexer, 2015; Perigoe & Paterson, 2016).

Third, most children with hearing loss can benefit from current hearing technologies. For children with profound losses, cochlear implants from an early age and appropriate auditory intervention have been shown to provide the auditory access needed for the development of listening and spoken language (Dornan et al., 2007; Eriks-Brophy, Ganek & DuBois, 2016; Nicholas & Geers, 2006).

Fourth, today the majority of children who are deaf or hard of hearing are using spoken language to communicate and are learning in regular education settings with typical hearing children (Gallaudet Research Institute, 2008; Luckner, 2010). We know that 92–96% of children with hearing loss have hearing parents; perhaps this is why most parents are choosing spoken language options (Mitchell & Karchmer, 2002). This trend means that many training programs are recognizing the need to adjust their models and curriculum (Paterson & Perigoe, 2016). Many deaf and hard-of-hearing students may be supported by professionals who do not have training in listening, speech, and spoken language development (Houston & Perigoe, 2010a, 2010b). In fact, there is federal awareness (Joint Committee on Infant Hearing, 2007) that there is a shortage of specially trained professionals who understand how to facilitate learning with advanced hearing technology with the birth to 5 years population. The same need exists to train flexible professionals who have a strong foundation of knowledge and skills in developing and maintaining development of listening and spoken language from birth through high school (Houston & Perigoe, 2010a, 2010b; Paterson & Cole, 2010; Paterson & Metz, 2016; Paterson & Perigoe, 2014b, 2016; Paterson, Perigoe, Rosa-Lugo & Knox, 2016).
What are some of the essential best practices and knowledge to ensure that each child with hearing loss can achieve optimal auditory development in the spoken language acquisition process? The following section will propose a framework for auditory skill development and suggest some tools for ongoing diagnostic assessment and auditory-based intervention.

## A Framework for Auditory Skill Development

A model for auditory work originally suggested by Hirsh (1970) as a framework for adult aural habilitation and popularized by Erber (1982), Ling (2002), Ling and Ling (1978), and others still forms the starting point for current models and hierarchies used for younger children with hearing loss.

Although the levels in Table 15.2 are often presented as a hierarchy of development, they do, in fact, overlap. It is critical that the child who is deaf or hard of hearing develops awareness of sound and attention to auditory input as a foundational skill; however, it should be remembered that, like children with normal hearing, children with hearing loss do not necessarily develop these skills in a strictly hierarchical manner. In other words, they are developing all four levels of skill—detection, discrimination, identification, and comprehension—at the phoneme level, word level, sentence level, and discourse level concurrently. For example, the child may be working on detection of sound over distance, developing his or her ability to identify by imitating and alternating syllables that begin with various consonants (phoneme level), discriminating between words that differ in voicing of the initial consonant (word level), and demonstrating comprehension by recalling three critical elements in a message (sentence level) and by identifying an object from several descriptors (discourse level). This is because a child may be developing skills at more than one level simultaneously (Cole & Flexer, 2015; Cole & Paterson, 1984; Paterson, 1982; Welling, 2014).

The expanded framework shown in Table 15.3 reflects this need for movement among all of the levels. We should not get stuck at the level of word discrimination, but move the child toward auditory comprehension of connected discourse. It can be used for assessment, goal setting, lesson planning, and intervention and incorporates the Hirsh (1970) and Erber (1982) levels with Ling’s (2002) speech production model (Paterson & Perigoe, 2015b, 2015c).

Typically developing children with normal hearing will develop listening skills within natural language contexts. Children with hearing loss may need more structured listening settings for the practice of such skills. Generally, the older the child and the less well he or she uses his or her hearing, the more structured or formal the intervention will need to be (Ling, Perigoe, & Gruenwald, 1981).

Today, we have infant learners who may follow a more typical auditory–verbal learning trajectory,
but we also still see children who are late starters. These may be children whose hearing losses were not detected until later, those with progressive hearing losses, those who develop hearing loss later, and those who (for whatever reason) start their auditory experience as toddlers or preschoolers. Auditory intervention may need to be more planned or structured for those who start later, while still being founded on a developmental, conversational model of spoken language acquisition (Cole & Flexer, 2015; Paterson, 1982).

We have found the Auditory Learning Guide (ALG), which Walker (2009) adapted from work by Simser (1993), to be helpful in setting goals across several auditory skill levels. The ALG is reprinted in Appendix 15-A at the end of this chapter, and should serve as a useful guide.

**Table 15.3** Framework for Developing Listening: Assessment, Goal Setting, Lesson Planning, and Intervention

<table>
<thead>
<tr>
<th>Sounds</th>
<th>Syllables</th>
<th>Words</th>
<th>Phrases</th>
<th>Sentences</th>
<th>Connected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonspeech Speech</td>
<td>Nonsegmentals</td>
<td>Content</td>
<td>Carrier</td>
<td>Increasing</td>
<td>Discourse</td>
</tr>
<tr>
<td></td>
<td>Segmentals</td>
<td>Function</td>
<td>Chunking</td>
<td>Syntactic</td>
<td>Conversation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Semantics</td>
<td>Clauses</td>
<td>Complexity</td>
<td>Narration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Morphology</td>
<td></td>
<td>Pragmatics</td>
<td>Explanation/Directions</td>
</tr>
</tbody>
</table>

| Detection       | Discrimination    | Identification   | Comprehension            |


maximal auditory access with appropriate hearing technology, develop skill in using the Ling Six-Sound Test (Cole & Flexer, 2015; Ling, 2006; Perigo & Paterson, 2016), provide an optimal auditory environment, and implement plans based on diagnostic information that incorporates the concept of hearing age or listening age.

**Auditory Access**

Ensuring that each child who is deaf or hard of hearing has optimal access to the speech signal through appropriate advanced hearing technology is a key principle of auditory-based learning approaches. What are the factors, protocols, assessment tools, and concepts involved in ensuring optimal auditory access? The factors include access to and consistent wearing of appropriate individual hearing instruments, monitoring of the child’s auditory learning through the hearing device(s), appropriate ongoing audiologic management, and sufficient auditory input of language.

Current medical treatments and hearing technologies are so sophisticated (with hearing aids,
bone-anchored hearing aids, assistive listening devices, auditory training devices, frequency-modulated/digital modulation (FM/DM) and sound field systems, cochlear implants, and brainstem implants) that the majority of children with hearing loss can be provided access to sounds across the entire spectrum of speech (Cole & Flexer 2015). Consistent use of appropriate hearing technology to provide this access is the critical first step in developing listening and spoken language in children with hearing loss. Cole and Flexer (2015) discuss this current availability of new hearing technologies as creating a new “acoustic conversation”—one in which children who are deaf or hard of hearing can function (with technology) as though they have only a mild or moderate hearing loss. Today, we can expect that children who use cochlear implant(s) well can achieve excellent vowel discrimination and discriminate the high-frequency bursts that enable place discrimination among /p, t, k/, as well as the high-frequency turbulent noise for perception and discrimination of fricatives, such as “sh” and /s/. On the other hand, it is now the child who is wearing hearing aids who may have no or little access to high-frequency speech information and who may struggle to make those same discriminations. Because a greater amount of speech information is concentrated in the higher frequencies, access to speech sounds above 2000 Hz is needed to make the fine discriminations necessary for processing speech (Killion & Mueller, 2010).

Daily Perceptual Check of Detection and Discrimination: The Ling Six-Sound Test

It has become common practice for parents and professionals working with children with hearing loss to perform a daily morning listening check of the child’s ability to detect or discriminate through their hearing instruments. The Ling Six-Sound Test (Ling, 2006) has become the established protocol. The sounds are arranged here in order, representing the lowest frequency of speech to the highest: /u/, /m/, /a/, /i/, “sh,” and /s/. These six sounds represent the frequency range of the entire speech spectrum. Some professionals have added “silence” as another sound to check for false-positive responses (Cole & Flexer, 2015). This test has become popularized, and various versions and explanations of usage exist, both in print (Ling, 1989, 2002, 2006) and online (Advanced Bionics, 2012; Cochlear Corporation, 2012).

Each child who is deaf or hard of hearing is a unique listener. It is possible to identify speech perception problems by noting any auditory confusion while doing the test. One known phenomenon can be diagnosed as in the following example. In the administration of the Six-Sound Test, you say the /u/ vowel and the child repeats /u/. Then, you say the /i/ vowel and the child says /u/, not /i/. You repeat this several times and the child still cannot discriminate the /i/ from the /u/. Why does this happen? The child is able to perceive both the low-frequency first formant (F1) and the mid-frequency second formant (F2) of /u/. However, /u/ and /i/ have a similar low-frequency first formant (F1), which is created by resonance in the pharynx. The second formant (F2) resonates in front of the tongue. The /i/ vowel is a high, front vowel and the tongue constriction creates a high F2 at about 2700 Hz. A child who cannot hear at this higher frequency will not be able to tell /u/ and /i/ apart; therefore, these two vowels will sound the same. This is an example of how knowledge of speech acoustics is essential for working with the child who is deaf or hard of hearing.

Understanding Acoustic Cues for Prosody and Redundancy in the Speech Signal

As we saw earlier in Table 15.1, infants tune in to the prosodic features of parent talk and begin to deduce meaning in context before they are developmentally able to focus on word boundaries. Auditory development in the earliest stages seems based on the “melody of the message” (Fernald, 1989). This is why babies like songs, rhythm, repetition, sing-song voices, and all the vocal variations that adults
use in infant-directed speech (Cole & Flexer, 2015; Owens, 2016). Infants do not start by listening for phonemes or suprasegmental features in isolation. In fact, it seems easier for them and for us as adults to tune in to the spoken message if there is more acoustic information to work from. The child with hearing loss needs the same opportunity to learn to deduce meaning from spoken input that is sufficiently long enough to convey essential prosodic information. As you can see in Table 15.4, prosody carries an enormous meaning load in English (Cole & Paterson, 1984), from the intonation contours that are created when we produce different sentence modalities, to the crucial stress-timing features that are a hallmark of English. The table indicates that acoustic cues for prosody are in the low- and mid-frequency range, where almost every child who is deaf or hard of hearing has auditory access. In fact, these prosodic cues are only available to us through auditory perception (Ling, 2002), and it is almost impossible to speech-read them. It is crucial that professionals working with all ages of children who are deaf and hard of hearing understand how prosody occurs and the important role it plays in auditory comprehension of connected discourse (Paterson, 1986).

Here is a quick exercise to help with the concept. The difference in meaning in the identical utterances listed in Table 15.5 is comprehended by the listener through attention to the redundant prosodic and linguistic cues. The meanings are:
1. **Possession**: Tell me who owns the object.
2. **Modify the noun**: Tell me which object.
3. **Identify the object**: Tell me what you own.

Linguistic cues: The word order creates the sentence pattern for transitive sentence and statement and helps the listener predict what information will follow. The pronoun *I* signals who (subject) and signals that a verb is coming; the verb *have* signals possession and that an object is coming; the adjective *blue* signals that a noun is coming. However, additional suprasegmental changes are produced that we listen to as prosodic cues: stress marking of the key word in the utterance (mostly a rapid intensity change with duration); intonation contour across the utterance, which signals sentence pattern as a statement; and interaction of duration and intonation pattern, which carries the tone of voice or attitude of the speaker (boasting, happiness, etc.). Try producing these utterances with a flat voice and then with appropriate prosodic features. See how much you rely on the acoustic cues to quickly identify, discriminate, and comprehend.

### Auditory Environment and Auditory Input

The term **auditory environment** has come into recent use to describe the child's listening situation, both in the home and, later, at school (Cole & Flexer, 2015). Once the family and child with hearing loss have gone through screening, diagnostic audiology, and fitting of amplification or cochlear implant, long-term habilitation or intervention provides the regularity of support for parent and child (Cole, Carroll, Coyne, Gill, & Paterson, 2004). One of the first goals is to help the parent understand the importance of creating an optimal auditory environment. This means more than just having the parent assess the noise in the environment. In addition to reducing background noise by turning off televisions, radios, and other electronic devices and machines, the parent can improve the child's auditory access by moving closer to the child. Reducing the distance from 6 feet to 3 feet increases the sound input to the child by 6 decibels (dB). Halving the distance again to 1.5 feet adds an additional 6 dB. Thus, sitting close to the child and being on the same level, perhaps side by side, can help improve auditory access. Ling refers to this as keeping the child “within earshot” (Ling, 1980).

### Overhearing or Incidental Learning

Children with hearing loss should first learn to listen in optimal conditions where the signal-to-noise ratio is good and the distance from the adult’s voice to the microphones of the child’s hearing technology
<table>
<thead>
<tr>
<th>Suprasegmental Features of Speech in Isolation</th>
<th>Prosodic Features as They Appear in Spoken Language</th>
<th>Acoustic Terms and Measurement</th>
<th>Acoustic Information Required to Perceive and Discriminate Speech Sounds/Prosody, Related to Audiogram</th>
<th>Anatomy and Physiology: Part(s) of the Speech System Involved in Production</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vocalization</strong></td>
<td>Overall vocal quality, timbre</td>
<td>Fundamental frequency, ( F_0 ): Measured in cycles per second (cps) or Hertz (Hz)</td>
<td>Male voice: 100–120 Hz</td>
<td>• Vocal folds</td>
</tr>
<tr>
<td></td>
<td>• Oral vs. nasal sounding</td>
<td></td>
<td>Female voice: 160–200 Hz</td>
<td>• Phonation</td>
</tr>
<tr>
<td></td>
<td>• Not harsh</td>
<td></td>
<td>Child voice: 300 Hz</td>
<td></td>
</tr>
<tr>
<td><strong>Duration</strong></td>
<td>Timing changes:</td>
<td>Duration: Measured in milliseconds (msec)</td>
<td>Voicing: 250 Hz</td>
<td>• Vocal folds, phonation</td>
</tr>
<tr>
<td></td>
<td>• Rhythm</td>
<td></td>
<td>500 Hz</td>
<td>• Breath/air flow</td>
</tr>
<tr>
<td></td>
<td>• Rate of speech</td>
<td></td>
<td>1000 Hz</td>
<td>• Dynamic force in lungs</td>
</tr>
<tr>
<td></td>
<td>• Pause patterns</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Juncture</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Intensity</strong></td>
<td>Stress marking:</td>
<td>Amplitude: Measured in decibels (dB)</td>
<td>Voicing: 250 Hz</td>
<td>• Vocal folds, phonation</td>
</tr>
<tr>
<td></td>
<td>• Marking primary stress in words</td>
<td></td>
<td>500 Hz</td>
<td>• Breath/air flow</td>
</tr>
<tr>
<td></td>
<td>Voice loudness variations:</td>
<td></td>
<td>1000 Hz</td>
<td>• Subglottal pressure variations</td>
</tr>
<tr>
<td></td>
<td>• Whisper</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Soft voice</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Normal conversational voice</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Loud voice</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Outdoor voice</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pitch</strong></td>
<td>Intonational contour variations:</td>
<td>Frequency: Measured in Hertz (Hz)</td>
<td>Voicing: 250 Hz</td>
<td>• Vocal folds, phonation</td>
</tr>
<tr>
<td></td>
<td>• Appear across utterances and sentences, and between sentences</td>
<td></td>
<td>500 Hz</td>
<td>• Breath/air flow</td>
</tr>
<tr>
<td></td>
<td>Each sentence modality has a unique intonation pattern:</td>
<td></td>
<td>1000 Hz</td>
<td>• Vocal fold tension</td>
</tr>
<tr>
<td></td>
<td>• Statement pattern</td>
<td></td>
<td></td>
<td>• Vocal fold mass changes</td>
</tr>
<tr>
<td></td>
<td>• Question pattern</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Command pattern</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Negative pattern</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tone of voice:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Affect: joy, sadness, sarcasm, etc.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Habitual vocal pitch:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Appropriate for age</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

is fairly close. Once the child begins to learn to listen and attach linguistic meaning to the speech signal, listening confidence grows. Then, the child who is deaf or hard of hearing can perceive, discriminate, localize, and comprehend from greater distances than earshot (Ling, 1980). The goal is to help the child learn how to acquire spoken language through listening. To do this effectively, the child needs to learn the cues for redundancy: prosodic patterns, phonotactic probabilities, context of the conversation, word and world knowledge, and knowledge of the rules of syntax. Today, we expect many of these children to also demonstrate spontaneous learning without direct instruction. The typical child with normal hearing develops the ability to learn through overhearing. In fact, it is suggested that overhearing or incidental learning accounts for a substantial amount of world knowledge, vocabulary development, and social awareness. Learning through distance listening and overhearing is a desirable goal for the child who is deaf or hard of hearing to achieve (Beck & Flexer, 2011; Cole & Flexer, 2015).

Talk Time: Amount and Quality of Input

The most important sensory input that the child receives is spoken language. This helps to establish skills for entry into the social world of communication. Abundant spoken language input is needed for the child to develop adequate spoken language skills. This was demonstrated in a landmark study by Hart and Risley (1995), who did frequency counts of words heard by children. They found that children who heard more words spoken by adults in their environment had better vocabularies and IQ scores. This research has been corroborated by more recent studies using electronic recording and analysis devices (Oller et al., 2010; Zimmerman et al., 2009) and was the basis for the development of the LENA technology (LENA Research Foundation, http://www.lenafoundation.org).

LENA stands for language environment analysis. The LENA system uses an automatic electronic recording device and computer analysis software to analyze the child’s listening language environment. The software package provides reports on frequency of adult talk, frequency of conversational turns, child vocalizations, and amount of background noise in the child’s language learning environment. It has been used in both home and school settings.

Because a child spends more time with the family than at intervention sessions, it is vital to encourage parents or caregivers to become knowledgeable and confident in how they talk, how much they talk, and what they talk about to their child. The LENA has become a clinical research tool that can provide information to parents about how much time they spend talking to their child, how many conversational turns the child takes, and their child’s vocalizations. It can also report the amount of background noise, such as television or radio sound. Recent studies using the LENA system with young children with hearing loss indicate that the technology holds great promise for guiding parents in these key areas, so that the quality and quantity of auditory language input to the child can be increased (Morrison & Lew, 2012; Yoshinaga-Itano et al., 2011).

Hearing Age: Tracking Auditory Learning

A concept of hearing age or listening age is useful when working with children with hearing loss (Cole & Flexer, 2015; Cole & Paterson, 1984; Estabrooks, MacIver-Lux & Rhoades, 2016; Pollack et al., 1997). Hearing age is calculated from the date the child begins to consistently wear appropriate
hearing technology. For example, if a child is 2 years old and began wearing hearing aids consistently at 3 months of age, then his or her functional hearing age would be 21 months. This child is not far behind and has a good chance of closing the gap between his or her hearing/listening age and his or her chronological age. A child of 3 years whose hearing loss was detected late and who did not start wearing hearing aids until 2 years old would have a hearing age of 1 year. At 2 years behind his or her chronological age, this child will have a more challenging time closing the gap between his or her hearing/listening age and chronological age. This calculation process can become complex if there are periods when the child does not have good auditory access to spoken language. This might be due to damaged or lost technology, poor earmolds, ear infections, deteriorating hearing thresholds, or reluctance of the child to wear the hearing technology (or the parent to put it on the child). In addition, if the child becomes a cochlear implant candidate, it is useful to calculate the amount of time of successful implant use with appropriately mapped implant(s), especially if the child did not have good access to the complete speech signal prior to receiving the implant.

The use of hearing age helps put into perspective the child's length of listening and how he or she is progressing. A child with normal hearing usually listens for about a year before first words emerge, so we need to give the child with hearing loss a sufficient amount of time to learn to listen. However, an older child (say 3 years old) with sufficient cognitive experience can accelerate learning once he or she knows how to listen and learning happens.

**Auditory Hierarchies, Checklists, and Developmental Scales**

In the past 20 years, universal newborn hearing screening with early detection of hearing loss, improved hearing technologies, the lowering of the age of cochlear implantation, and expectations of parents in choosing auditory–oral education options have all had an impact on the requisite knowledge and skills needed by professionals. Cochlear implants in particular have led to a surge in interest in using audition to develop spoken language. More and more professionals, cochlear implant and hearing aid manufacturers, and professional organizations have produced information related to auditory-based learning for children with hearing loss. Jointly written textbooks on auditory–verbal therapy (Estabrooks, 2012; Estabrooks, MacIver-Lux & Rhoades, 2016; Rhoades & Duncan, 2010), auditory models, hierarchies of auditory skills, checklists, and scales of development have appeared. Some focus purely on auditory skills, whereas others have information on additional areas of development. Although both types are helpful, it is essential for the professional who is providing intervention to be aware of the holistic development of each child and see how auditory skills are being acquired in relation to other areas of development. As we observe and document the progress of a child with hearing loss, it is important to view the whole child—not a set of ears in isolation (Boothroyd & Gatty, 2012).

A list of useful resources, including auditory hierarchies, checklists, and developmental scales, can be found in Appendix 15-C at the end of this chapter. It is by no means an exhaustive list, but will give the reader some resources. The Auditory Skills Checklist by Anderson (2004) is available online and also printed by permission in Appendix 15-B at the end of this chapter. Also available online is the Integrated Scales of Development by Cochlear Corporation (2009). In conjunction with other auditory measures, these can be useful when observing the child's listening behaviors to help guide both assessment and intervention.

**Functional Auditory Assessment**

The term *functional auditory assessment* has been used to describe a variety of parent- and teacher-reporting tools. Good summaries of these are
available in Cole and Flexer (2015), Tharpe and Flynn (2012), and on Anderson’s website (http://successforkidswithhearingloss.com/tests). For our purposes, we consider functional assessments of listening to encompass not only observational reports, but also diagnostic assessments of the child’s listening skills on a variety of tasks (Perigoe & Paterson, 2016).

Why do a functional listening assessment? Assessment is the basis for setting long- and short-term goals. It gives a baseline of performance and, when readministered, measures growth and the effectiveness of our intervention. It determines what we teach and, often, the order in which we teach it. An audiogram is limited in what it can tell us about how a child hears. It gives us information about the frequency and intensity of the child’s hearing thresholds (both unaided and aided), but does not tell us anything about durational cues or how sound is processed and interpreted. Two children with similar audiograms may differ greatly in their listening and speaking skills.

Many factors can impact listening and spoken language outcomes. Some of these are intrinsic to the child, such as cognitive ability, the presence of other disabilities, learning style, and ability of the brain to process speech and spoken language input. Extrinsic factors may include age at identification and intervention, appropriateness of hearing technology, consistent wearing of hearing technology, type and amount of intervention, and parental support. It is therefore often difficult to predict functional listening abilities from audiograms. We need to go beyond the audiogram to find out what the child can do in real-life situations outside of the audiology booth. Functional assessment of listening does not replace traditional audiological assessment, but can complement and help us determine the amount of carryover (Robbins, Svirsky, Osberger, & Pisoni, 1998). By evaluating how the child uses his or her hearing, we get a more complete picture of the child’s abilities.

As with any type of assessment, professionals need to have a basic understanding of what we are assessing and why we are assessing it. Are we using the results to set goals, measure the effectiveness of our intervention, or establish eligibility for services? We need to be able to assess clients of different ages and abilities. We need to adapt assessments as needed and to select goals, teach, and then reassess. We also need to be able to interpret our assessment results and explain them to the family.

Assessments may be formal or informal. Most formal tests are available commercially, but do not underestimate the value of teacher-made assessments. Tests may be normed or criterion referenced. Due to the lack of current normed data for children with hearing loss, we are primarily using criterion-referenced tests, which assess the child’s level of performance against his or her earlier scores. Tests may be subjective, such as parent reports, or objective, such as those based on observation or on having the child demonstrate specific tasks. It is usually instructive to have a variety of assessments and not base all information on one kind of assessment. For example, questionnaires are helpful, but we suggest that you confirm these impressions by observing what the child does and perhaps developing some informal diagnostic activities to assess his or her listening skills.

Rather than give an exhaustive list of tests, we will talk next about types of tests and suggest some assessments we have used with success. Then we will provide some guidelines for creating your own assessments.

**Questionnaires**

Several questionnaires are available that fall into two categories: those for parents and those for teachers. Although parent reports are subjective, they can be an excellent starting point when assessing infants and very young children. They can also be useful with hard-to-test children. Teacher reports can give good insight into how the child functions in the classroom. The professional should be familiar with a few of these tools and how they can be used.

Two parent interview tools that we have found helpful are the Meaningful Auditory Integration
and the Infant–Toddler Meaningful Auditory Integration Scale (IT-MAIS; Zimmerman-Phillips, Osberger, & Robbins, 1997). These scales consist of 10 probe items designed to assess the young child’s use of hearing, hearing technology, and early auditory skills. The MAIS was designed for children ages 3 and up and the IT-MAIS was later developed for children aged 0–3 years. The IT-MAIS is now available from Advanced Bionics online (http://c324175.r75.cf1.rackcdn.com/IT-MAS_20brochure_20_2.pdf). We have found that, because companies sometimes change where particular pages are located on their websites, it is often more efficient to find items by using a web search engine.

Another useful tool is LittlEARS: Auditory Questionnaire Manual: Parent Questionnaire to Assess Auditory Behavior in Young Children (Coninx, Weichbold, & Tsiakpini, 2003), which is available through Med-El.

A parent tool that guides the parent through observation of listening activities is the test of Early Listening Function (ELF; Anderson, 2002). This has the added advantage of assessing the young child’s ability to hear a variety of speech and environmental sounds at different distances. It also looks at listening in quiet versus listening in noise, thus sensitizing the parent to the importance of the auditory environment.

Two tools useful for classroom teachers are the Screening Instrument for Targeting Educational Risk (SIFTER; Anderson, 1989) and the Preschool SIFTER (Anderson & Matkin, 1996). These each have 15 items that help the teacher identify which children may be at risk for educational failure. These and other assessment tools by Anderson are available for free from her website (http://successforkidswithhearingloss.com/tests).

Closed-Set Auditory Assessments

A closed-set assessment has a fixed number of stimuli from which the child chooses the correct answer. For example, the child may have a set of four objects or picture cards from which to choose—a ball, a cookie, a hotdog, and a hamburger. The examiner presents the word through audition only, such as “cookie,” and the child must select the correct item. In our experience, it is highly advantageous to have the child repeat the word (or an approximation) before selecting the item. This helps the tester to determine whether the child is selecting what he or she actually heard or is just picking a favored item.

Two well-known assessments used in closed-set tasks are the Early Speech Perception (ESP) Test, which uses pictures, and the Low-Verbal ESP, which uses objects (Moog & Geers, 1990). These are both word-level tests, but phrase- and sentence-level assessments can be constructed for using written sentences (for students who are readers) or pictures.

Open-Set Auditory Assessments

An open-set assessment is a test for which there are no materials—the items on the test are unknown to the child. This is a more difficult assessment, because the child does not have a group of items from which to choose. The set can be limitless; however, it is important to remember that the items need to be within the child’s receptive language vocabulary. The Glendonald Auditory Screening Procedure (GASP) has a word-level test of 12 words and a sentence-level series of 10 questions (Erber, 1982). Both the GASP words and GASP sentences are straightforward and do not take very long to administer or score. They may need to be adapted for young children.

A useful assessment for older students is Auditory Rehabilitation: Memory, Language, Comprehension Test Probes (Stefanakos & Prater, 1982). Originally designed for hearing individuals, we find this a very good assessment for children ages 10 years and older who are placed in regular education classrooms. It begins with having the evaluator read one sentence and assessing the child’s ability to answer one fact-based question based on the information provided in the sentence. The probes increase in length and complexity until the examiner is reading a short paragraph and asking five fact-based and two inference questions. Many
of the passages contain new or unknown information/vocabulary, so it is a worthwhile assessment of whether the child can process (and remember) new information.

**Comprehensive Assessments**

A test that assesses a wide range of auditory abilities is the Auditory Perception Test for the Hearing-Impaired (APT/HI-R; Allen, 2016; Perigoe & Paterson, 2016). Designed for ages 3 years and older, the test begins at a basic level of sound detection and progresses through 16 skill areas of discrimination tasks, identification, comprehension with a picture prompt, and open-set auditory comprehension (similar to the GASP sentences). Skills are assessed in auditory plus visual versus auditory-only presentations, and results are reported on a student profile. This profile is a visual representation of the student’s auditory functioning on each of the auditory skills assessed. Comparison of the auditory plus visual and the auditory-only profiles over time are useful for documenting student progress (Rosa-Lugo & Allen, 2011).

**Practical Application: Developing Your Own Assessments**

Auditory learning is a dynamic process, and therefore assessment at various levels is needed. Children who are deaf or hard of hearing are a heterogeneous population; in other words, no two children are alike. It is necessary to gear your selection of assessments toward the individual child and his or her particular abilities. Once a professional understands the rationale behind the various assessments, it is possible to construct assessments that meet the needs of each child. This can be particularly useful when assessments need to be adapted or constructed for students with hearing loss and additional challenges or those with linguistic or cultural differences.

For example, if you were working with a 2.5-year-old child with limited vocabulary, you would need to select items that would be in the child’s listening vocabulary. Your instinct might be to use picture cards and have the child point, but it would be better to use three-dimensional objects or toys, because they will be more engaging and can be used in a more informal way. Table 15.6 provides an example of words that differ in number of syllables (pattern perception), two-syllable spondee words with equal stress, and three-syllable words that you might use in such an auditory task.

For a young child with very little vocabulary, you might use sound–object or sound–action associations, often called the “learning to listen” sounds (Estabrooks & Birkenshaw-Fleming, 2006; Rhoades, 2000). These usually include animal and vehicle sounds and emphasize different suprasegmental features of speech. They should be done with toys in an informal play situation to see what the child can select from a small set of choices. Table 15.7

### Table 15.6 A Closed-Set Auditory Task

<table>
<thead>
<tr>
<th>Pattern Perception</th>
<th>Spondees</th>
<th>Monosyllables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ball</td>
<td>Hotdog</td>
<td>Ball</td>
</tr>
<tr>
<td>Cookie</td>
<td>Airplane</td>
<td>Book</td>
</tr>
<tr>
<td>Hotdog</td>
<td>Toothbrush</td>
<td>Bird</td>
</tr>
<tr>
<td>Hamburger</td>
<td>Bathtub</td>
<td>Boat</td>
</tr>
</tbody>
</table>

Total Correct

Vary order of presentation within each column.

### Table 15.7 A Closed-Set Auditory Task Using Learning to Listen Sounds

<table>
<thead>
<tr>
<th>Pattern Perception</th>
<th>Two Syllables</th>
<th>Single, Extended Sounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>moo</td>
<td>quack-quack</td>
<td>mmm …</td>
</tr>
<tr>
<td>oink-oink</td>
<td>oink-oink</td>
<td>ah ….</td>
</tr>
<tr>
<td>hop-hop-hop</td>
<td>beep-beep</td>
<td>oo …</td>
</tr>
</tbody>
</table>

Total Correct

Vary order of presentation within each column.
Table 15.8  Open-Set Auditory Tasks for a Young Child with Hearing Loss

GASP WORDS
(vary order of presentation)

<table>
<thead>
<tr>
<th>One Syllable</th>
<th>Two-Syllable Trochees (Unequal Stress)</th>
<th>Two-Syllable Spondees (Equal Stress)</th>
<th>Three Syllables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoe</td>
<td>Water</td>
<td>Airplane</td>
<td>Butterfly</td>
</tr>
<tr>
<td>Fish</td>
<td>Table</td>
<td>Popcorn</td>
<td>Elephant</td>
</tr>
<tr>
<td>Ball</td>
<td>Pencil</td>
<td>Toothbrush</td>
<td>Santa Claus</td>
</tr>
</tbody>
</table>

Total Correct: _____________ /12

Sample Auditory Assessment for Open-Set Words

Child’s Name _______________ C.A. _______________ H.A. _______________ Date _______________

(vary order of presentation)

<table>
<thead>
<tr>
<th>One Syllable</th>
<th>Two-Syllable Trochees (Unequal Stress)</th>
<th>Two-Syllable Spondees (Equal Stress)</th>
<th>Three Syllables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoe</td>
<td>Cookie</td>
<td>Backpack</td>
<td>Hamburger</td>
</tr>
<tr>
<td>Fish</td>
<td>Baby</td>
<td>Hotdog</td>
<td>Elephant</td>
</tr>
<tr>
<td>Ball</td>
<td>Pencil</td>
<td>Bathtub</td>
<td>Santa Claus</td>
</tr>
</tbody>
</table>

Total Correct: _____________ /12

Blank Table for My Own Words

Child’s Name _______________ C.A. _______________ H.A. _______________ Date _______________

(vary order of presentation)

<table>
<thead>
<tr>
<th>One Syllable</th>
<th>Two-Syllable Trochees (Unequal Stress)</th>
<th>Two-Syllable Spondees (Equal Stress)</th>
<th>Three Syllables</th>
</tr>
</thead>
</table>

Total Correct: _____________ /12


provides an example of how these might be organized for an informal auditory-only assessment.

For an open-set word test, again, you should be guided by the child’s vocabulary. Table 15.8 lists some words you might use with a young preschool-aged child with hearing loss. First, we have presented Erber’s word list from the GASP (1982), then our own words (based on a fictitious child), and, finally, left a blank table for you to use for creating your own words. Remember to vary the order of presentation of the words (do not just read down or across the list) and to give the assessment through audition alone with no visual or context cues.

This has been only a sampling of functional listening assessments and how you might also develop your own auditory assessments. Ongoing diagnostic assessment and intervention is an integral part of listening and spoken language programs.
Speech pathologists and teachers of the deaf/hard of hearing play a critical role on the team with audiologists and other professionals. They need to be able to interpret results from the audiologist and be able to explain these results to parents. In addition, they should assess the functional listening skills of the child and see how these results fit with the child’s test results from the audiologist. An understanding of how auditory skills develop, how they are related to the development of spoken language, and how to observe and assess these skills is critical in order to lay the foundation for intervention. In conjunction with the parents, professionals should design an integrated program that incorporates acquisition of listening skills into the development of speech and spoken language.

Children with hearing loss who have been identified early, and who consistently use appropriate, current hearing technology from an early age, have the potential to process spoken language through hearing. However, intensive auditory stimulation in language-rich environment may be necessary for them to attain the listening and speaking skills commensurate with typically developing peers. Much depends on the ability of professionals and support personnel to monitor hearing technology, report any changes in hearing or suspected technology issues to the audiologist, optimize the child’s auditory access to the speech signal, and provide effective assessment and intervention that supports use and carryover of listening and spoken language skills to everyday, real-life communication.

As speech and hearing professionals, we are part of a collaborative team approach, seeking to develop the most effective interventions possible. The coordination of assessment and intervention among team members is critical to the child’s progress and the success of his or her educational program. Our goals for intervention need to be grounded in our understanding of how typical children develop and founded on our assessments and observations of individual child behaviors. Intervention must be based on the most current information available on the child’s performance—in other words, it is goal driven. In this process, we need to be asking the right questions.

Assessment and intervention that puts the emphasis on speech production, without addressing underlying auditory abilities, reduces our effectiveness as professionals and compromises the abilities of our students to succeed. An approach that answers these questions and puts appropriate emphasis on optimal auditory access for the development of listening and spoken language development makes our intervention evidence-based and yields the most likely path to success for the child. In addition, approaches that focus on the integration of listening, speech, and spoken language, rather than on isolated auditory training, will be more beneficial in the long-term.

In this chapter, we have given an overview of auditory development in typically developing children and discussed some important issues relative to the child who is deaf or hard of hearing. We have presented a framework for assessment and intervention and discussed various functional listening assessments. The next crucial step is how to plan and implement intervention for the child who is deaf or hard of hearing. The reader is encouraged to use more than just this resource when providing auditory interventions in a therapeutic setting. There are several tools and resources available, including curricula and free online materials.
designed for children with hearing loss, which are presented in the appendixes at the end of the chapter. We hope that these can guide you toward acquiring the knowledge and skills necessary to support children in developing listening and spoken language skills for meaningful communication.

**Discussion Questions**

1. Why is it important to understand how auditory skills develop in typically developing children with normal hearing?
2. What is the relationship between listening and spoken language?
3. What elements need to be in place for a child with hearing loss to learn language through audition?
4. What is the concept of “hearing/listening age,” and why is it important?
5. Discuss ways to ensure a beneficial auditory environment for learning through listening.
6. Discuss the four levels of auditory skill development proposed by Hirsh. How might they guide assessment and intervention?
7. What is the rationale for conducting a diagnostic, functional listening assessment with a child who is deaf or hard of hearing?

**References**


**Recommended Readings**

**APPENDIX 15-A**

**AUDITORY LEARNING GUIDE**

**Introduction**

The Auditory Learning Guide (ALG) is a **guide**: a hierarchical list of auditory behaviors, intended to provide professionals with:

- A **roadmap** through the development of a listening function
- A tool to help the child achieve an **optimal** rate of auditory learning
- A tool to help the child become a **confident** listener
- A tool that can help a child function with greater ease in a hearing environment

It is **not** an exhaustive list of skills a child must master, step-by-step, in order to develop a complete listening function. Some of the behaviors are self-explanatory and some require further information, typically obtained when the ALG is presented in a workshop.

The ALG is in “all in one” chart form, rather than in a series of lists, so the professional (and parents) can see each auditory behavior as part of the “big picture” in auditory learning rather than focus on each separate auditory skill. The color coding gives a “ball-park” idea about timelines for auditory learning. As professionals become more skilled, children are likely to move faster through timelines. Children with more hearing may move faster. Children who are implanted at later ages may move faster through some steps due to increased attention span.

The guide includes five areas, or **levels**, listed across the top of the page (Sound Awareness, Phoneme Level, Discourse Level, Sentence Level, and Word Level). Each level has one or more **steps**. Having all the levels on one chart rather than as separate lists, helps to communicate visually that several **areas of auditory development occur concurrently** for children who are deaf/hard of hearing, in the same way as they do for hearing children. The layout also reinforces the need to plan for auditory learning at several different levels, rather than to master one level before going onto the next.
# Auditory Learning Guide

<table>
<thead>
<tr>
<th>Step 1 - Detect* the presence of any speech syllable.</th>
<th>Step 1 - Imitate physical actions (before speech imitations).</th>
<th>Step 1a - Imitate motions of nursery rhymes/songs with accompanying vocalization.</th>
<th>Step 1 - Identify familiar stereotypic phrases or sentences.</th>
<th>Step 1a - Identify and imitate approximations of “Learning to Listen” sounds varying in suprasegmentals and vowel content, e.g., [a-a-a]/airplane, [u]-[u]/train, [oi]/pig in isolation, at the end, and then in the middle of a sentence.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
<tr>
<td>Step 2 - Detect* vowel variety, [u] [a] [l] and raspberries [b-r-r].</td>
<td>Step 2 - Imitate any phoneme that child produces spontaneously when given hand cue (or other cue).</td>
<td>Step 2 - Recall two critical elements in a message.</td>
<td>Step 1b - Identify nursery rhymes or songs.</td>
<td>Step 1b - Identify one, two, and three syllable words in isolation, e.g., cat vs. chicken vs. kangaroo.</td>
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<tr>
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</tr>
<tr>
<td>Step 3 - Detect* consonant variety, e.g., [m-m-m], [b^n] [b^n] [b^n] and [w^a] [w^a].</td>
<td>Step 3 - Imitate varying suprasegmental qualities in phonemes [v]ary intensity, duration, and pitch [eeeee] (long) vs. [ae ae] (pulsed); [ae-ae] loud/quiet/whispered; [ae] high/mid/low pitch.</td>
<td>Step 2 - Answer common questions with abundant contextual support, e.g., “What’s that?”, “Where’s mama?”, “What is ________ doing?”</td>
<td>Step 3 - Recall three critical elements in a message.</td>
<td>Step 2 - Identify words having the same number of syllables but different vowels/ diphthongs and consonants, e.g., horse vs. cow vs. sheep.</td>
</tr>
<tr>
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</tr>
<tr>
<td>Step 4 - Detect* the presence of environmental sounds at loud, medium, and soft levels at close range, at a distance of 6–12 ft., and at a distance of greater than 12 ft.</td>
<td>Step 4 - Imitate vowel and diphthong variety, e.g., [u], [ae], [au], [l], etc.</td>
<td>Step 3 - Identify a picture that corresponds to a story phrase in a three or four scene story.</td>
<td>Step 4 - Complete known linguistic messages from a closed set (ex: nursery rhymes, songs, familiar stories).</td>
<td>Step 3a - Identify words in which the initial consonants are the same but the vowels and final consonants are different, e.g., ball vs. bike.</td>
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</tr>
<tr>
<td>Step 5 - Detect* whispered [h^a] [h^a] and [p] [p] [p].</td>
<td>Step 5 - Imitate alternated vowels and diphthongs, e.g., [a-u] [e-l] [a-l].</td>
<td>Step 4 - Identify an object from several related descriptors (closed set).</td>
<td>Step 5 - Answer common questions about a disclosed and familiar topic: (a) without pictorial cues, (b) over the telephone, (c) on audio/videorecording.</td>
<td>Step 3b - Identify words in which the final consonants are the same but the vowels and initial consonants are different, e.g., food vs. card.</td>
</tr>
<tr>
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</tr>
<tr>
<td>Step 6 - Detect* the sounds of the Six Sound Test.</td>
<td>Step 6 - Imitate consonants varying in manner (fricatives, nasals, and plosives). Use phonemes previously produced, e.g., /h/ vs. /m-m-m/ vs. /p/.</td>
<td>Step 5 - Follow a conversation with the topic disclosed.</td>
<td>Step 6 - Recall four or more critical elements in a message to follow multiple element directions.</td>
<td>Step 4 - Identify words in which the initial and final consonants are identical but the vowels &amp; diphthongs are different, e.g., book vs. back.</td>
</tr>
<tr>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Step 7 - Detect* the sounds of the Six Sound Test at various distances.</td>
<td>Step 7 - Imitate consonants differing in voiced vs. unvoiced cues, e.g., [b^n] [b^n] [b^n] vs. [p] [p] and then with vowel variety, [pae-pae].</td>
<td>Step 6a - Answer questions about a story with the topic disclosed.</td>
<td>Step 7 - Complete known linguistic messages (open set).</td>
<td>Step 5a - Identify words in which the vowels &amp; final consonants are identical but the initial consonants differ by three features—manner, place of articulation, and voicing, e.g., mouse vs. house.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Step 8 - Locate the direction of sound if amplified binaurally.</td>
<td>Step 8 - Imitate consonants in place cues, first with varying vowels, e.g., /ma-ma/ /no-no/ /go-go/ /bi-bi/, etc.</td>
<td>Step 6b - Answer questions about a story with the topic disclosed; story is teacher recorded.</td>
<td>Step 8 - Follow open set directions and instructions (disclosed).</td>
<td>Step 5b - Identify words in which the vowels &amp; initial consonants are identical but the final consonants differ by three features—manner, place of articulation, and voicing, e.g., comb vs. coat.</td>
</tr>
</tbody>
</table>
### Table: Steps of Learning an Auditory-Based Approach

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1a</td>
<td>Identify one, two, and three syllable words in isolation, e.g., airplane, train, pig.</td>
</tr>
<tr>
<td>Step 2</td>
<td>Identify words having the same number of syllables but different vowels/diphthongs and consonants, e.g., cat vs. cow, vs. dog.</td>
</tr>
<tr>
<td>Step 3a</td>
<td>Identify words in which the consonants are the same but vowels/diphthongs differ, e.g., man vs. pan.</td>
</tr>
<tr>
<td>Step 3b</td>
<td>Identify a picture that corresponds to a story phrase in a three or four scene story.</td>
</tr>
<tr>
<td>Step 4</td>
<td>Identify words in which the initial and final consonants are identical but the vowels/diphthongs are different, e.g., mom vs. go.</td>
</tr>
<tr>
<td>Step 5a</td>
<td>Identify words in which the initial features—manner, place of articulation, and voicing, e.g., vs. go.</td>
</tr>
<tr>
<td>Step 5b</td>
<td>Detect whispered [hae] and [pa], [pa] vs. [p].</td>
</tr>
<tr>
<td>Step 6</td>
<td>Identify words in which the initial and final consonants are identical but the initial/final consonants differ by two features: (a) manner and place (voicing in common), coat vs. goat; (b) manner and voicing (place in common), man vs. pan; (c) place and voicing (manner in common), boat vs. coat.</td>
</tr>
<tr>
<td>Step 7a</td>
<td>Identify words in which the vowels and final consonants are identical but the initial consonants differ by only one feature—manner of articulation, e.g., ball vs. mall.</td>
</tr>
<tr>
<td>Step 7b</td>
<td>Identify words in which the vowels and initial consonants are identical but the final consonants differ by only one feature—manner of articulation, e.g., cloud vs. clown.</td>
</tr>
<tr>
<td>Step 8a</td>
<td>Identify words in which the vowels and final consonants are identical but the initial consonants differ by only one feature—voicing, e.g., coat vs. goat.</td>
</tr>
<tr>
<td>Step 8b</td>
<td>Identify words in which the vowels and initial consonants are identical but the final consonants differ by only one feature—place of articulation, e.g., bun vs. gun.</td>
</tr>
<tr>
<td>Step 9a</td>
<td>Identify words in which the vowels and initial consonants are identical but the final consonants differ by only one feature—place of articulation, e.g., sheep vs. sheet.</td>
</tr>
<tr>
<td>Step 9b</td>
<td>Identify words in which the vowels and initial consonants are identical but the final consonants differ by only one feature—manner of articulation, e.g., ball vs. mall.</td>
</tr>
<tr>
<td>Step 10</td>
<td>Repeat each word in a sentence exactly. (a) Predictable sentences “I’m going to the grocery store to buy cereal and milk.” (b) Less predictable sentences “A woman hit me so I told her to calm down.”</td>
</tr>
<tr>
<td>Step 11</td>
<td>Recall specific elements in a sentence by answering questions on an undisclosed topic.</td>
</tr>
<tr>
<td>Step 12</td>
<td>Retell a story about an undisclosed topic, recalling as many details as possible.</td>
</tr>
<tr>
<td>Step 13</td>
<td>Process information in noise and at various distances.</td>
</tr>
<tr>
<td>Step 14</td>
<td>Process group conversations.</td>
</tr>
</tbody>
</table>

---

This guide is intended to aid professionals in the beginning stages of learning an auditory-based approach. As professionals acquire more experience in auditory teaching, children should progress more rapidly.

The information on this chart was adapted from Judy Simser’s article in the *Volta Review* (1993) (** items); from the Auditory Skills Program, New South Wales Department of School Education; from the Foreworks Auditory Skills Curriculum (1976, North Hollywood, CA); and from teacher input.

**Notes:**

* A detection response could include turning head, pointing to ear, clapping, dropping a toy in a container, etc.

**Reference:**


## APPENDIX 15-B
### Auditory Skills Checklist

**Child’s Name:** _________________________  **Birth Date:** ______________  **Person Reviewing Skills:** ____________________________

**Dates Auditory Skills Reviewed:**

**Directions:** Skills should be checked off only if the child responds or has responded using auditory-only clues, without any visual information available. Although these skills are listed in a relatively typical order of development, it is common for children to increase in the depth of their development in previously acquired skills while learning skills at more advanced levels. Work on skills from one or two levels at a time. A child’s rate of progression can depend on cognitive ability, the ability to attend for periods of time, vocabulary size, ability to point, etc. Every time you monitor auditory skill development, check off changes in the child’s ability to respond or perform each skill that is being worked on. Estimates of percent of the time the child is seen to respond are approximations only based on the observation of the parents and others who regularly interact with the child. In subsequent reviews of the child's auditory skill development check off progress made (e.g., add check to E column if child is seen to begin to respond or demonstrate skill).

NOT PRESENT (0-10%) = EMERGING (11-35%) = INCONSISTENT (36-79%) = ACQUIRED (80-100%)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th>AUDITORY SKILL</th>
<th>EXAMPLE</th>
<th>APPROX DATE ACQUIRED</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>I</td>
<td>A</td>
<td><strong>LEVEL ONE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Child wears hearing aids or implant all waking hours.</td>
<td>Hearing aids worn at all times except for naps and bathing.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Awareness to sound: Child nonverbally or verbally indicates the presence or absence of sound.</td>
<td>Child’s eyes widen when she hears her mother’s voice.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Attention to sound: Child listens to what he/she hears for at least a few seconds or longer.</td>
<td>Child pauses to listen to father’s voice.</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Searching for the source of sound: Child looks around, but does not necessarily find sound source.</td>
<td>Child glances or moves in search of the sound.</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Auditory localization: Child turns to the source of sound.</td>
<td>Child turns to Mom when she calls her.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>LEVEL TWO</strong></td>
<td></td>
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<td></td>
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<td></td>
<td>Auditory feedback: Child uses what he/she hears of his/her own voice to modify his/her speech, so that it more closely matches a speech model.</td>
<td>Parent says ee-oh-ee and child imitates. Parent says woof-woof and child imitates.</td>
<td></td>
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<tr>
<td></td>
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<td></td>
<td>Auditory discrimination of nonlinguistic sounds and suprasegmental aspects of speech: Child perceives differences between sounds or sound qualities, such as loudness, long/short, pitch.</td>
<td>Child indicates which toys from two available made a loud sound.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Distance hearing: Child responds at increasing distances from the source of the sound.</td>
<td>Mother calls child from another room, and she hears her.</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Auditory association of environmental, animal, or vehicle sounds, and/or familiar person’s voices.</td>
<td>Child identifies dog barking, points to the dog. Child hears Dad’s car and smiles because she knows Dad is now home.</td>
<td></td>
</tr>
<tr>
<td>LEVEL THREE</td>
<td>AUDITORY SKILL</td>
<td>EXAMPLE</td>
<td></td>
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<tr>
<td>-------------</td>
<td>---------------</td>
<td>---------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>E</strong></td>
<td><strong>I</strong></td>
<td><strong>A</strong></td>
<td><strong>AUDITORY SKILL</strong></td>
<td><strong>EXAMPLE</strong></td>
<td></td>
</tr>
<tr>
<td><strong>E</strong></td>
<td><strong>I</strong></td>
<td><strong>A</strong></td>
<td><strong>LEVEL THREE</strong></td>
<td><strong>LEVEL THREE</strong></td>
<td></td>
</tr>
<tr>
<td><strong>E</strong></td>
<td><strong>I</strong></td>
<td><strong>A</strong></td>
<td>Auditory identification or association of different-sounding and familiar words and phrases – OBJECTS – closed set.</td>
<td>Child has three favorite toys on the floor and gives one to the parent when it is named.</td>
<td></td>
</tr>
<tr>
<td><strong>E</strong></td>
<td><strong>I</strong></td>
<td><strong>A</strong></td>
<td>Auditory identification or association of different-sounding and familiar words and phrases – OBJECTS – open set.</td>
<td>In the grocery store parent asks child to help find the apples.</td>
<td></td>
</tr>
<tr>
<td><strong>E</strong></td>
<td><strong>I</strong></td>
<td><strong>A</strong></td>
<td>Auditory identification or association of different-sounding and familiar words and phrases – COMMON PHRASES – closed set.</td>
<td>Child responds by clapping when parent says “Patty Cake” (no motions) or raises arms when parent says “So Big!”</td>
<td></td>
</tr>
<tr>
<td><strong>E</strong></td>
<td><strong>I</strong></td>
<td><strong>A</strong></td>
<td>Auditory identification or association of different-sounding and familiar words and phrases – SIMPLE DIRECTIONS – closed set.</td>
<td>Child is getting dressed with clothes laid out; parent asks child to give her the socks.</td>
<td></td>
</tr>
<tr>
<td><strong>LEVEL FOUR</strong></td>
<td><strong>LEVEL FOUR</strong></td>
<td><strong>LEVEL FOUR</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>I</strong></td>
<td><strong>A</strong></td>
<td><strong>AUDITORY SKILL</strong></td>
<td><strong>EXAMPLE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>I</strong></td>
<td><strong>A</strong></td>
<td><strong>LEVEL FOUR</strong></td>
<td><strong>LEVEL FOUR</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>I</strong></td>
<td><strong>A</strong></td>
<td>Auditory identification or association of different-sounding and familiar words and phrases – COMMON PHRASES OR SIMPLE DIRECTIONS – open set.</td>
<td>“Where’s Daddy?,” “Ow! My finger hurts!,” “Give mommy a kiss!” Upon entering the bedroom, parent asks child to get his socks.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>I</strong></td>
<td><strong>A</strong></td>
<td>Discrimination of words on the basis of segmental features: indicate words with different vowels but the same initial or final consonants.</td>
<td>Child can hear the difference between words like bat, bite, boat, bee.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>I</strong></td>
<td><strong>A</strong></td>
<td>Conditional response to sound (if 18 month or older): Child conditions to respond to the presence of sound.</td>
<td>Child claps when he perceives any or all of Ling’s sounds (oo, ah, ee, sh, s, m).</td>
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<tr>
<td><strong>I</strong></td>
<td><strong>A</strong></td>
<td>Discrimination of words on the basis of segmental features: indicate different manner of consonants but same vowels.</td>
<td>Child can tell difference between words like see, knee, bee.</td>
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<tr>
<td><strong>LEVEL FIVE</strong></td>
<td><strong>LEVEL FIVE</strong></td>
<td><strong>LEVEL FIVE</strong></td>
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<tr>
<td><strong>I</strong></td>
<td><strong>A</strong></td>
<td>Discrimination of words on the basis of segmental features: indicate same vowels, but consonants differ in voicing.</td>
<td>Child can tell difference between sue-zoo; cap-cab; curl-girl.</td>
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<tr>
<td><strong>I</strong></td>
<td><strong>A</strong></td>
<td>Discrimination of words on the basis of segmental features: indicate words with different manner and place of consonants but same vowel sound.</td>
<td>Child can tell difference between words like hill, still, pill.</td>
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<tr>
<td><strong>I</strong></td>
<td><strong>A</strong></td>
<td>Auditory recall: Child remembers groups of words that contain TWO CRITICAL ELEMENTS.</td>
<td>Child is “helping” to set the table and has big and little spoons and forks. Child can bring a big spoon to the parent.</td>
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<tr>
<td><strong>I</strong></td>
<td><strong>A</strong></td>
<td>Auditory recall: Child remembers groups of words that contain THREE CRITICAL ELEMENTS.</td>
<td>Big red ball, little blue car, big red car, little blue ball.</td>
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<td><strong>LEVEL SIX</strong></td>
<td><strong>LEVEL SIX</strong></td>
<td><strong>LEVEL SIX</strong></td>
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<tr>
<td><strong>I</strong></td>
<td><strong>A</strong></td>
<td>Discrimination of words on the basis of segmental features: indicate same manner of consonants but different place of consonants.</td>
<td>Child can tell difference between words like tea, pea, key.</td>
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<tr>
<td><strong>I</strong></td>
<td><strong>A</strong></td>
<td>Auditory recall: Child remembers groups of words that contain FOUR CRITICAL ELEMENTS.</td>
<td>Big dog with long black hair, little cat with short brown hair.</td>
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<td><strong>I</strong></td>
<td><strong>A</strong></td>
<td>Auditory sequencing digits: Child repeats several numbers or letters in correct order.</td>
<td>Child repeats the model “3-6-2-4.”</td>
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<tr>
<td><strong>I</strong></td>
<td><strong>A</strong></td>
<td>Auditory sequencing directions: Child carries out multipart directions.</td>
<td>Put the kitty under the chair, the mommy in the car, and the bike by the tree.</td>
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<td>LEVEL SEVEN</td>
<td>AUDITORY SKILL</td>
<td>EXAMPLE</td>
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<td>Figure-ground discrimination: Child identifies and comprehends primary speaker from a background of noise or competing voices.</td>
<td>Child hears and understands mom talking while music is playing.</td>
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<td>Auditory recall: Child remembers groups of words that contain &gt;FOUR CRITICAL ELEMENTS.</td>
<td>Parent describes items in kitchen utensil drawer and child picks correct one.</td>
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<td>Auditory sequencing a story: Child retells story in correct sequence.</td>
<td>Retell 3 Little Pigs or any other favorite story.</td>
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<td>Auditory blending: Child synthesizes isolated phonemes into words, or single words into sentences.</td>
<td>Child blends the sounds h-a-t to produce the word “hat.”</td>
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<td>LEVEL EIGHT</td>
<td>Auditory sequencing rhymes and songs: Child acts out and memorizes rhymes and songs.</td>
<td>I’m a Little Teapot; Itsy Bitsy Spider.</td>
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<td>Identification based on several related descriptions and contextual clues, including expansion of vocabulary.</td>
<td>Child participates in “description games” such as “I’m thinking of something that is red. It’s a fragrant flower which grows on a bush. Its stem has thorns on it. People give them for Valentine’s Day.”</td>
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<td>Auditory closure: Child understands and supplies the whole word or message when a part is missing.</td>
<td>Child completes the statement: “Triangle, square, and rectangle are all ______.” Or “Snow is white, grass is ______.”</td>
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<td>Processing questions: Child answers thinking process questions.</td>
<td>“What do you do when you’re hungry?”</td>
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<td>LEVEL NINE</td>
<td>Auditory analysis: Child processes phonemes, morphemes, and syntactic or semantic structures embedded in words and sentences.</td>
<td>Child related “-ed” to past tense in words. Child responds appropriately when an adult says, “Give me the shoe or the sock.”</td>
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<td>Auditory tracking: Child follows text as an adult reads aloud.</td>
<td>Child moves finger over the pictures in a storybook as an adult reads the book.</td>
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<td>Auditory comprehension: Listens and comprehends while engaged in another activity.</td>
<td>Child listens to and understands a story while brushing his/her hair.</td>
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<td>LEVEL TEN</td>
<td>Auditory comprehension: Child understands relationship between verbal language and children’s literature (story grammar).</td>
<td>Child relates to “Once upon a time,” “lived happily every after,” etc.</td>
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<td>Auditory comprehension: Child carries on a conversation using auditory-only cues.</td>
<td>Child carries on a conversation in the car or in the dark.</td>
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<td>Auditory comprehension: Child understands messages from electrical sound sources, such as tape recorders, videos/DVD, radio, etc.</td>
<td>Child understands the words to a song on a tape recorder. Child understands the message from a school loudspeaker.</td>
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<td>Auditory comprehension: Child understands conversations on the telephone.</td>
<td>Child talks to grandmother and is able to answer questions and discuss with her.</td>
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</table>

The following is a list of selected readings, auditory resources, CDs, videotapes/DVDs, and websites. This is not an exhaustive list, but it is a good starting place for parents and professionals interested in learning more about auditory development and about using listening to develop spoken language in children with hearing loss. It includes some older resources, so the reader may want to look at what has been incorporated into newer resources—especially those that are child and family centered. We have put an asterisk (*) next to those that are available for free on the Internet. Internet resources sometimes change their URL addresses, so it is a good practice to use a search engine to find the item.

**Recommended Readings**


**Resource Guides and Teaching Materials**

Estabrooks, W. *Hear & listen! Talk & sing!*  
Washington, DC: Alexander Graham Bell  
Association for the Deaf and Hard of Hearing.  
Book and music CD. Available from the AG  

Estabrooks, W. *Songs for listening, Songs for life.*  
Washington, DC: Alexander Graham Bell  
Association for the Deaf and Hard of Hearing.  
Book and music CD. Available from the AG  

level checklist for auditory-verbal families.*  
San Antonio, TX: Sunshine Cottage for Deaf  
products/our_products/comfort_level_ 
checklist/.

Pepper, J., & Weitzman, E. (2004). *It takes two to  
talk: A practical guide for parents of children  
with language delays* (3rd ed.). Toronto,  
Canada: The Hanen Centre. Available from  
http://www.hanen.org/Guidebooks—DVs  
/SLPs.aspx.

training guidebook.* London, Ontario, Canada:  
Wordplay.

London, Ontario, Canada: Wordplay.

who are newly identified as hard of hearing.*  
Available from Oticon Pediatrics, 580 Howard  
Avenue, Somerset, NJ 08873.

**Auditory Assessments/Assessment Information**

American Speech-Language Hearing Association  
(ASHA). *Directory of speech-language pathol- 
ogy assessment instruments.* Retrieved from  
http://www.asha.org/uploadedFiles/practice  
multicultural/EvalToolsforDiversePops.pdf.

*Anderson, K. L. *Supporting success for children  
with hearing loss.* Available from https://  
successforkidswithhearingloss.com/resources  
-for-professionals/early-intervention-for  

For assessments see http://successforkidswith  
hearingloss.com/tests.

Gallaudet University. *Suggested scales of develop- 
ment and assessment tools.* Available from  
http://www.gallaudet.edu/Clerc_Center  
/Information_and_Resources/Cochlear_  
Implant_Education_Center/Resources  
/Suggested_Scales_of_Development_and_  
Assessment_Tools.html.

**Auditory Checklists, Hierarchies, and  
Developmental Scales**

*Alexander Graham Bell Association for the Deaf  
and Hard of Hearing. *Listening and spoken lan-

guage knowledge center.* Available from http://  
www.listeningandspokenlanguage.org  
/Tertiary.aspx?id=1215.

scales of development. Listen, learn and talk.*  
Available from http://hope.cochlearamericas  
.com/reading-room/listen-learn-talk.

Estabrooks, W., & Marlowe, J. (2000). In *The  
baby is listening.* Washington, DC: Alexander  
Graham Bell Association for the Deaf and  
Hard of Hearing.

*Rhoades, E. *Auditory development scale: 0–6 years.*  
Available from http://www.auditoryverbal  
training.com/scale.htm.

*Simser, J. *Auditory-verbal techniques and hierar-

chies.* Available from http://auditory-verbal  
communicationcenter.blogspot.com/2011/06  
/auditory-verbal-techniques-and.html.

Sunshine Cottage School for Deaf Children.  
*Cottage acquisition scales for listening, lan-

guage & speech (CASLLS).* San Antonio, TX:  
Sunshine Cottage School for Deaf Children.  
Available from http://www.sunshinecottage  
.org/index.php/educational_products/our_  
products/caslls/.

**Auditory Curriculum Guides**


**Videotapes/DVDs**


*Listen, learn and talk. Sydney, Australia: Cochlear Corporation.*
Internet Resources (most are free)


Auditory-Verbal Center (Atlanta). http://www.avchears.org


Cochlear Corporation: HOPE online courses (free). http://hope.cochlearamericas.com/oncourse


John Tracy Clinic (including parent support and resources in Spanish). http://www.jtc.org


Ling Speech Cards. http://www.jtc.org/professional-materials/


Listening for Life (Joanna Stith). http://www.listeningforlife.com

Net Communications for Communication Disorders and Sciences (Judith Kuster). http://www.mnsu.edu/comdis/kuster2/welcome.html


National Center for Hearing Assessment and Management (NCHAM). http://www.infanthearing.org


Sound Foundation for Babies: 40 online weekly lessons, songs and rhymes. http://hope.cochlearamericas.com/node/2256


The Listening Room (Hearing Journey). http://thelisteningroom.com

Voice for Hearing Impaired Children (Canada). http://www.voicefordeafkids.com


Will Wonder and His Robot Ears (online comic). http://www.medel.com/data/willwonder/?PHPSESSID=v0u91v2cuijk7fvt9334vk8pq80
CHAPTER 16

ADDRESSING HEARING LOSS IN THE EARLY INTERVENTION YEARS

Nancy G. Schneider, MA, CCC-A, FAAA
Audiologist

OBJECTIVES

• Illustrate the deleterious effects that hearing loss of any type, degree, or configuration in one or both ears can have on the communicative, social/emotional, cognitive, and academic development of infants and toddlers.
• Explain recommended protocols for infants requiring audiologic follow-up as a result of all possible newborn hearing screening outcomes.
• Name risk indicators for possible late-onset hearing loss as defined by the current Joint Committee on Infant Hearing Position Statement and the importance of ongoing audiologic monitoring of children presenting with these conditions.
• Describe the purpose and benefit of utilizing functional auditory assessment tools for all children identified with hearing loss, particularly those under the age of 3 years.
• Explain the various roles that speech-language pathologists play in the Early Hearing Detection and Intervention process for children diagnosed with hearing loss as well as for those awaiting confirmation of their current auditory status.
• List and describe considerations used in developing an appropriate intervention plan for children ages 0 to 3 years identified with hearing loss.

KEY TERMS

Automated auditory brainstem response (AABR) screening
Early Hearing Detection and Intervention (EHDI)
Functional auditory assessment
Individualized Education Plan (IEP)
Individuals with Disabilities Education Act (IDEA)
Medical home
Natural environment
Otoacoustic emission (OAE) screening
Total communication
Universal newborn hearing screening (UNHS)
Introduction

The goal of Early Hearing Detection and Intervention (EHDI) is to maximize linguistic competence and literacy development for children who are Deaf or hard of hearing. Without appropriate opportunities to learn language, these children will fall behind their hearing peers in communication, cognition, reading, and social-emotional development (Joint Committee on Infant Hearing (JCIH), 2007, p. 898).

Over the span of the last 75 years, early identification of hearing loss in young children has evolved from the subjective observation of the auditory response behaviors of toddlers to bells and rattles to the current administration of objective electrophysiologic hearing screening measures performed on infants younger than 24 hours old. With the advent of user-friendly hearing screening technology, passage of national and state legislation supporting \textit{universal newborn hearing screening (UNHS)}, and the endorsement of professional organizations on the importance of early hearing loss detection in infants and toddlers, as of 2013, more than 97% of children born in the United States are receiving their very first hearing screening prior to nursery discharge, compared with less than 3% in 1989 (White, Forsman, Eichwald, & Munoz, 2012). The effectiveness of universal newborn hearing screening has also resulted in a significant decrease in the age at which children are diagnosed with hearing loss and, subsequently, when they receive medical intervention, connection to parent support services, initial hearing aid or bone-anchored hearing system fitting, cochlear implantation, and enrollment in early intervention. In addition, advancements in the development of evidence-based protocols for hearing screening, pediatric audiologic evaluation, and audiologic monitoring have resulted not only in earlier identification of bilateral peripheral hearing loss of varying types, degrees, and configurations, but also the early diagnosis of unilateral hearing loss and central forms of auditory pathology such as auditory neuropathy spectrum disorder (ANSD).

As shown in Figure 16.1, hearing loss is the most common congenital health condition screened for in the neonatal period (White, 2002). The incidence of hearing loss is estimated to range from 1 to 6 per 1,000 live births; however, these figures increase if transient conductive and late-onset hearing losses are also included (White & Behrens, 1993). Depending on the electrophysiologic method used, initial hearing screening can be effectively administered as early as 6–14 hours after birth, with rescreening (if necessary) often performed prior to an infant’s discharge from the nursery. Diagnostic audiologic evaluation, administered by audiologists who have expertise in working with infants and toddlers, can also be performed as early as prenursery discharge, though it is typically conducted on an outpatient
basis within the first 1–3 months of life. Even at such a young age, objective electrophysiologic testing can yield accurate information regarding the hearing status of each ear and, in the cases where hearing loss is present, provide comprehensive information on its type, degree, and configuration.

Current newborn hearing screening and pediatric audiologic assessment timelines are in sharp contrast to those referenced in the Commission on Education of the Deaf’s 1988 report, “Toward Equality: Education of the Deaf,” which revealed that the average age of identification of profound hearing loss in the United States was 2.5 years (Commission on Education of the Deaf, 1988), with mild or unilateral hearing losses not identified until a child’s entry into kindergarten. Delays in the identification of pediatric hearing loss in one or both ears not only adversely affects the developing auditory nervous system of a young child, but also can have deleterious consequences for social, emotional, cognitive, and academic development, and subsequently, for the vocational and economic potential of children as they age into adulthood (Northern & Downs, 2002; National Institutes of Health Consensus Statement, 1993). Research has shown that the earlier pediatric hearing loss is identified and treatment begun, the greater the likelihood of preventing or reducing the disabling effects that can result (Apuzo & Yoshinaga-Itano, 1995). Because the most critical period for speech and language acquisition is during the first 3 years of life, it has become a national goal to reduce the age of hearing loss identification to within the first few months of life (Joint Committee on Infant Hearing, 1994).

The successful coordination and administration of effective newborn hearing screening and follow-up services can only be accomplished through the collaborative efforts of all the stakeholders involved in the UNHS process, including, but not limited to, birthing facilities, parents, physicians, nurses, audiologists, speech-language pathologists (SLPs), healthcare providers, early interventionists, hearing aid dispensers, parent support organizations, community and state agencies that provide family-centered services, and state and federal legislators. Full participation of each stakeholder ensures that the goals of early hearing loss identification and the provision of appropriate habilitative services are being met in a timely manner for very young children and that these services include a seamless transition from screening to diagnosis to a habilitation plan leading from early intervention to preschool.

What Is EHDI?

Early Hearing Detection and Intervention, or, as it is better known, EHDI (pronounced “Eddie”), is a national public health initiative that has become the gold standard of pediatric hearing health care for children from birth to 3 years of age. Hospital-based newborn hearing screening programs have been in existence as far back as the 1960s; however, technological advancements in the field of audiology coupled with widespread acceptance of the need for early hearing loss identification in infants prompted the evolution of the current EHDI process.

Almost immediately after the Commission on Education of the Deaf published its 1988 report (noted previously), C. Everett Koop, the Surgeon General of the United States, issued the following statement: “By the year 2000, 90% of children with significant hearing loss be identified by 12 months of age” (Mauk & Behrens, 1993). The U.S. Department of Health and Human Services’ Healthy People 2000 national healthcare report included Dr. Koop’s recommended timeline as part of its public health goals (National Center for Health Statistics, 2001). As a result, the Newborn and Infant Hearing Screening and Intervention Act (also known as the Walsh Bill, named for New York Congressman James Walsh) was passed in 1999 (National Center for Hearing Assessment and Management [NCHAM], n.d.a.), leading to improved hearing healthcare services for infants, toddlers, and their families. As a result of this landmark legislation, funding was provided to all states from both the Centers for Disease Control and Prevention (CDC) and the Health Resources Services Administration (HRSA) to support the
development, planning, implementation, and monitoring of EHDI programs throughout the country.

All EHDI programs support the early identification of hearing loss through universal newborn hearing screening (UNHS), timely audioligic and medical evaluations and monitoring, enrollment in early intervention (EI), and ongoing connections to family support services. EHDI programs, established in all 50 states and the U.S. territories, strive to achieve the nationally recognized “1-3-6” Rule, which includes screening all infants for hearing loss prior to 1 month of age (preferably prior to nursery discharge); conducting a complete, ear-specific, pediatric audioligic evaluation on infants who do not pass their newborn hearing screening by no later than 3 months of age; and enrolling children who have been identified with hearing loss into an appropriate, family-centered, culturally competent early intervention program before 6 months of age. In addition to the 1-3-6 Rule, national EHDI goals include appropriate audioligic monitoring for children presenting with risk indicators for possible late-onset hearing loss, ensuring that all children with hearing loss are established with a medical home, creation of state-specific EHDI tracking and surveillance systems to minimize the possibility of children being lost to follow-up, and establishment of a system that monitors and evaluates a state’s progress toward meeting national EHDI goals and objectives.

The gold standard for each step of the EHDI process is outlined in a regularly published set of guidelines developed by the Joint Committee on Infant Hearing (JCIH). JCIH is represented by a variety of different professional organizations, all of whom share a common interest in the early identification of hearing loss in infants and toddlers. Organizations currently represented in JCIH include the American Speech-Language-Hearing Association, American Academy of Audiology, American Academy of Otolaryngology—Head and Neck Surgery, American Academy of Pediatrics, Directors of Speech and Hearing Programs in State Health and Welfare Agencies, and the Council on Education of the Deaf, including the American Society for Deaf Children, Alexander Graham Bell Association for the Deaf and Hard of Hearing, Conference of Educational Administrators of Schools and Programs for the Deaf, Convention of American Instructors of the Deaf, National Association of the Deaf, and Association of College Educators of the Deaf and Hard of Hearing. Since 1971, JCIH regularly publishes Position Statements that outline recent research and recommended practices for UNHS, diagnostic audioligic evaluation, audioligic monitoring, medical evaluation, and appropriate intervention for infants and toddlers at risk for, or diagnosed with, all degrees of hearing loss in one or both ears (JCIH, 2007).

Personnel involved in the hands-on provision of hearing screening services as well as those responsible for the administrative oversight of hospital-based UNHS programs often vary from state to state and even from hospital to hospital. Hearing screeners may be nurses, audiologists, physicians, SLPs, technicians, and, in some cases, trained volunteers. Administrative management of UNHS programs typically is performed by audiologists or physicians, who are responsible for providing training and supervision to screeners, ensuring that hearing screening equipment is functioning in accordance with manufacturers’ specifications and developing quality assurance policies and procedures to monitor the performance of their facility’s UNHS program.

The mission of EHDI programs is to meet all national EHDI goals; however, there can be great variability in the legislative requirements in place for each state and territory to ensure that these goals are being met. EHDI programs throughout the United States typically are funded with federal grants and are supported by evidence-based practice guidelines from professional organizations, recommendations by a variety of advocacy groups, and legislative directives on both federal and state levels. Although all 50 states have EHDI programs in place, as of December 2009, laws and/
or regulations related to UNHS have been passed in only 43 (National Early Childhood Technical Assistance Center [NEC-TAC], 2011). State-specific UNHS and follow-up legislation typically indicates the minimum expectations of state policy makers, but does not necessarily define all aspects of what state newborn hearing screening programs are actually doing to achieve compliance with national EHDI goals. An excellent resource for locating individual state/territory EHDI program guidelines and requirements, as well as legislative mandates, can be found at the National Center for Hearing Assessment and Management (NCHAM) website at http://www.infanthearing.com.

**EHDI Rule #1: Screening by 1 Month of Age**

Because behavioral observation of auditory responses in neonates does not provide accurate predictions of hearing ability, the possible presence of hearing loss in children this young can only be inferred through the use of electrophysiologic screening tools such as **automated auditory brainstem response (AABR) screening** and/or **evoked otoacoustic emission (OAE) screening**. An important caveat regarding these screening tools is that they are not, technically, direct measures of hearing; rather, they are measures of auditory nerve integrity and cochlea integrity, respectively. However, both technologies can serve as effective, noninvasive, and easy-to-perform hearing screening tools for newborns. Although the objective hearing screening tools of the past only focused on identification of infants with severe to profound degrees of hearing loss, current newborn screening methodologies for infants allow reliable detection of hearing loss of greater than 30 decibels hearing level (dB HL) in the frequency region important for speech recognition in one or both ears. The development of these portable, user-friendly, and affordable hearing screening technologies has allowed for cost-effective, mass hearing screening of newborns by a variety of healthcare personnel (including the SLP on occasion) in birthing facilities, pediatric practices, and health clinics throughout the world. As shown in [Figure 16.2](#), evoked OAE screening is performed by placing a small probe at the entrance to the infant’s ear canal while the infant is lying in a quiet state. The probe assembly generates a series of quiet clicks or tones that travel through the ear canal to the middle ear and through to the cochlea. In a normally functioning cochlea, a small echo is generated by the outer hair cells within the cochlear structure, which then travels back through the middle and outer ear to be picked up by a sensitive microphone within the OAE probe. The echo response (or OAE) is then analyzed by a computer, which generates a pass response if the OAE is present and a refer result if the OAE is absent or too small to measure. Although a pass result on an OAE screening does not definitively confirm the presence of normal hearing for all frequencies (e.g., children with slight to mild hearing losses may be able to pass a hearing screening), it does rule out the presence of a peripheral handicapping hearing loss. OAEs are absent in individuals who present with hearing loss greater than approximately

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**Figure 16.2** Objective hearing screening measures can be performed mere hours following birth.  
Courtesy of U.S. Air Force photo/Samuel King Jr.
30 dB HL (depending on type of OAE screening performed); however, an OAE refer result may also be the screening outcome when transmission of the OAE is compromised by the presence of middle or outer ear pathology or by high levels of myogenic or environmental noise during the screening procedure. Children who refer on OAE screening for one or both ears will require hearing rescreening or each ear no later than 1 month of age to determine if abnormal screening results persist in the weeks after birth when vernix is no longer present in the ear canal and amniotic fluid has been absorbed in the middle ear cavity.

To review, there are two types of evoked OAE technology available for use in newborn hearing screening programs: transient-evoked otoacoustic emission (TEOAE) screening and distortion-product otoacoustic emission (DPOAE) screening. Both OAE technologies are administered in a similar fashion, and can usually take less than 5 minutes to perform on a child in a quiet state; however, they differ in the types of auditory stimuli used to generate an echo response. TEOAE screening utilizes a click stimulus and DPOAE screening uses two simultaneous pure tones. Passing either a TEOAE or DPOAE screening does not provide any information about the auditory system beyond the level of the cochlea; it offers information only about peripheral auditory functioning (up to and including the cochlea in each ear). Use of evoked OAE technology is an appropriate screening tool for infants in the term nursery or those who have been in the neonatal intensive care nursery for fewer than 5 days. For children who have had longer than a 5-day NICU stay, the screening measure of choice is the automated auditory brainstem response (AABR) screener.

AABR screening is performed by introducing soft, high-pitched clicking sounds to the ear canal via a probe placed at the opening of the infant’s ear or through a small adhesive earphone coupled to the area surrounding the external ear. Figure 16.3 illustrates electrode placement used with AABR screening. Electrodes are placed on the infant's head that are designed to pick up the presence of ongoing electroencephalogram (EEG) activity as well as the changes in that activity as a result of the introduction of sound. The auditory stimulus generated by the AABR unit passes through the external, middle, and inner ear; however, unlike the evoked OAE screening tools, the AABR signal also makes its way to the auditory portion of the eighth cranial nerve (VIII) up to where the auditory nerve meets the brainstem. Like OAE screening, it is especially crucial that the infant is in a calm, settled state and in a quiet screening environment throughout the screening process as patient movement and/or vocalizations can adversely affect the administration and interpretation of the screening. A complex filtering system within the AABR unit digitally removes the random EEG signals and transmits the averaged auditory response to a computer that compares the infant’s response pattern to a template of a normal AABR response. If the responses match, the AABR will generate a pass result; if a match does not occur, a refer result is offered.

Like OAE screening, an AABR response will be absent in individuals presenting with hearing loss greater than 30 dB HL or in the ears of infants with outer and/or middle ear pathology; however
an AABR refer result may also be seen in infants in those infants who present with immature brainstem function or brainstem pathology, or those who may be diagnosed with ANSD. In keeping with the recommendations noted in the Year 2007 JCIH Position Statement, infants who do not pass AABR screening must be rescreened with AABR or referred for a diagnostic auditory brainstem response (ABR) evaluation and not solely rescreened with OAE technology. While OAE and AABR screening both offer information regarding the status of the peripheral auditory system, AABR also screens for retrocochlear issues affecting the eighth nerve and the brainstem auditory pathways. Therefore, a passing OAE screening outcome, following a refer result on an AABR, will not completely address possible retrocochlear concerns and should prompt referral for ABR testing to investigate issues originating from higher levels in the auditory system.

Some birthing hospitals will opt to utilize a two-tiered approach to newborn hearing screening, using both OAE and AABR technologies when screening for peripheral hearing loss for newborns that don't pass an initial OAE screening. Hearing screening refer rates tend to be somewhat higher with the isolated use of evoked OAE screening than for AABR screening. Use of a two-tiered approach to screening (i.e., rescreening infants who refer on OAE screening with AABR) yields the lowest refer rate of all. Another benefit to the utilization of both OAE and AABR is to also be able to screen for more central forms of hearing loss, specifically in identifying auditory neuropathy spectrum disorder (ANSD). Should the outcome of this screening yield a pass result on OAE screening and a refer result on AABR screening, the results are highly suggestive of ANSD and require immediate referral for a comprehensive diagnostic pediatric audiologic evaluation for further assessment.

Prior to the release of the Year 2007 JCIH Position Statement, the goal of UNHS was to screen for peripheral hearing loss, which only gave birthing facilities the option of utilizing either OAE or AABR screening technology. In 2007, JCIH expanded the focus of newborn hearing screening so that it was no longer the norm to screen only for unilateral or bilateral peripheral hearing loss (e.g., sensory hearing loss originating in the cochlea, permanent conductive hearing loss, and/or mixed hearing loss), but also to screen for neural hearing loss (particularly in children who are considered at risk for this condition, such as infants with a prolonged neonatal intensive care unit (NICU) stay of greater than 5 days).

The type of screening tool selected for use in a birthing facility is dictated in part by the administrator who oversees the UNHS program, but is more related to the type of nursery population to be screened. As such, JCIH now requires hospitals to screen infants with AABR if a child has had a greater than 5-day stay in the NICU. If these infants don't pass their screening for one or both ears, they are to be rescreened with AABR within 1 month of life or referred for a diagnostic ABR evaluation by an audiologist with expertise in working with a pediatric population. Some birthing hospitals without NICUs have opted to purchase and utilize AABR screening on all their newborns; however, the requirement for AABR rescreening or referral for diagnostic ABR testing remains the same, whether the infant has stayed in the NICU for more than 5 days or not.

Regardless of the screening tool used, a refer result prior to nursery discharge can prompt either a referral for an outpatient rescreening within the first month of life or a direct referral for a complete pediatric audiologic evaluation well before 3 months of age. Other Year 2007 JCIH Position Statement recommendations include rescreening both ears of children who present with a unilateral refer result on their initial hearing screening as opposed to rescreening only the affected ear. The rationale for bilateral rescreening is related to possible errors in the documentation of a nursery-based unilateral refer result. Results of inpatient hearing screening outcomes are often recorded in the child's electronic birth certificate and/or may be documented
in a written hospital nursery discharge summary. Although it is uncommon, the potential for documenting the wrong ear as the “refer” ear is a possibility; therefore, rescreening of both ears for each rescreening encounter will ensure that all children with unilateral refer results will receive accurate ear-specific screening outcomes.

If a child passes her or his hearing screening prior to nursery discharge but is readmitted to the hospital within 1 month of life due to presentation of a healthcare issue associated with potential hearing loss, JCIH recommends rescreening of each ear prior to hospital discharge.

Birthing hospitals must ensure that all screening results and recommendations (e.g., pass, refer, pass with the recommendation for audiologic monitoring due to the presence of risk indicators for possible late-onset hearing loss) be presented to parents and the medical home provider who has been identified in the birth record as the child’s future source of medical care. The “medical home” refers to a healthcare provider (pediatrician, nurse practitioner) who oversees coordination of comprehensive, family-centered, and accessible health care throughout a child’s lifetime. A comprehensive resource for the concept of a medical home can be found at the American Academy of Pediatrics (AAP) website: www.aap.org. In addition to sharing objective hearing screening results with the medical home, the results of a child’s hearing screening and follow-up recommendation need to be offered to parents in an understandable and culturally sensitive manner with regard to the implications of screening outcomes and recommendations, including information as to where the child can receive follow-up services for rescreening, diagnostic audiologic evaluation, or audiologic monitoring, if necessary.

**Barriers to Newborn Hearing Screening**

There are circumstances in which a hearing screening cannot be performed, either because the infant is considered medically fragile resulting in medical contraindications to screening administration, or because the child presents with microtia with external auditory canal atresia in one or both ears. For infants considered too medically fragile to undergo hearing screening in the nursery, the screener must obtain clearance from the child’s physician prior to attempting to conduct the screening. Infants born with external auditory canal (EAC) atresia cannot undergo hearing screening of their affected ear(s) because they do not possess an entrance to the external auditory canal. The appropriate course of action for infants with EAC atresia (also known as “aural” atresia) is a direct referral for diagnostic auditory brainstem response evaluation via both air and bone conduction no later than 3 months of age to determine cochlear function in the atretic ear(s), as well as, in the case of unilateral EACH atresia, to obtain a baseline measure of hearing sensitivity in the unaffected ear. Infants with microtia (with or without EAC atresia) or any other type of facial differences are best served by an immediate referral to a craniofacial center for multidisciplinary team assessment along with regular monitoring of audiologic, speech-language, medical, developmental, and psychosocial status, as well as for parent support services. A listing of craniofacial and cleft palate centers throughout the United States can be found at the website for the American Cleft Palate and Craniofacial Association’s Cleft Palate Foundation: http://www.cleftline.org/parents-individuals/team-care/.

Although JCIH encourages that newborn hearing screening results and recommendations, along with appropriate follow-up and resource information, be provided to families in an understandable and culturally sensitive manner, there may still be a variety of reasons why families of children requiring follow-up do not comply. Parents typically receive a wealth of information in their nursery discharge paperwork and may feel overwhelmed with the volume of documents received, all while trying to adjust to the changes in lifestyle that occur with the addition of a newborn to the family. Insurance impediments may also make locating a pediatric audiologist who participates in a family’s insurance plan challenging and lead to a child being lost
to follow-up. Terms and vocabulary used in the UNHS process may be unfamiliar to families and to hospital staff who provide general scheduling for outpatient appointments. As a result, a child may inadvertently be scheduled for an OAE screening, when in fact, he or she may actually be in need of an AABR screening. Similarly, an appointment for a 15-minute rescreening may be scheduled when the child should instead receive a 1.5-hour diagnostic ABR evaluation. This may result in the child being turned away from the appointment without the proper follow-up appointment being scheduled. In addition, families often rely on medical referral for outpatient rescreening or audiologic evaluation via the support of their pediatrician, who may have to provide necessary written or electronic referral in accordance with insurance provider guidelines. Without a referral and the appropriate coding information, a family may be asked to reschedule for a later date when an appropriate referral can be provided. Another potential delay in services may result if the family’s medical home provider is unfamiliar with national EHDI guidelines, or if they choose to advocate the antiquated and non-evidence-based “wait and see” approach regarding referral for audiologic evaluation, resulting in parents feeling uncomfortable pursuing recommended follow-up without their pediatrician’s support. JCIH, state-based EHDI programs, and the AAP have all developed a wealth of materials for the pediatric community to highlight the importance of early hearing loss detection as well as outline guidelines for timely referral for infants and toddlers regarding rescreening, diagnostic audiologic evaluation, and audiologic monitoring for late-onset hearing loss.

**EHDI Rule #2: Pediatric Audiologic Evaluation by 3 Months of Age**

JCIH’s second rule in the 1-3-6 trilogy involves prompt referral of infants who do not pass their hearing screening for one or both ears (or who are not able to be screened because of medical contraindications or the presence of EAC atresia) for comprehensive, ear-specific, pediatric audiologic evaluation no later than 3 months of age. The American Speech-Language-Hearing Association (ASHA, 2004) and JCIH (JCIH, 2007) both recommend an evidence-based pediatric audiologic evaluation that comprises specific test protocols for children between birth and 36 months of age. For children under the age of 6 months, pediatric audiologic evaluation should include comprehensive child and family case histories; frequency-specific, tone-burst diagnostic ABR studies by both air and bone conduction; click-evoked ABR testing using both condensation and rarefaction stimuli to rule out concerns regarding the possible presence of ANSD; OAE screening; high-frequency tympanometry (with a 1,000 Hz probe tone); and a review of the family’s observations of the infant’s responses to sound, including use of a functional auditory assessment tool. Because ABR studies require the child to be in a quiet state, the goal is for infants who are referred on their hearing screenings to receive their audiologic evaluations as soon as possible so that the evaluations can be performed under natural sleep conditions rather than with the use of sedation (see Appendix 16-B).

Children undergoing comprehensive audiologic evaluation from 6 to 36 months of age undergo many of the same tests noted in the previous birth to 6 months of age protocol for the hearing status of each ear to be determined. Unlike infants, toddlers are capable of offering reliable and repeatable behavioral responses to tonal and speech stimuli, and JCIH endorses the use of either visual reinforcement audiometry (VRA) or conditioned play audiometry (CPA) based on the child’s level of development, along with a comprehensive child and family case history, speech detection and recognition measures, replacement of the use of high-frequency tympanometry with standard probe tone frequency tympanometry studies, acoustic reflex testing, functional auditory assessment, and parental reports of both auditory and visual behaviors along with a review of communication milestones. If results of this diagnostic audiologic test battery reveal the presence of hearing loss in one or both
ears, or if test results are inconclusive, referral for diagnostic ABR studies is advised. Infants and toddlers diagnosed with unilateral or bilateral sensorineural, permanent conductive, mixed forms of hearing loss or ANSD should be referred for early intervention services within 2 days of the diagnosis. In addition, the child will need to undergo a series of medical evaluations including, but not limited to, examination by an otolaryngologist, pediatric ophthalmologist, and geneticist. Coordination of these evaluations, as well as any other referrals to other medical specialists, are the responsibility of the medical home, with all medical assessments preferably performed by physicians with experience and expertise in working with a pediatric population. As physicians with expertise in identifying medical conditions of the ears, nose, throat, and related head and neck structures, otolaryngologists will serve as the medical professionals charged with diagnosis, treatment, and otologic management of the child with hearing loss. In addition to obtaining a prenatal and perinatal history (to investigate the possible presence of risk indicators to hearing loss), otolaryngologists will also conduct an overall head and neck examination with special attention to the auditory structures (e.g., presence of stigmata, ear tags/pits, EAC atresia, or stenosis) as well as craniofacial disorders (e.g., cleft lip, cleft palate, facial asymmetry, craniosynostosis, micrognathia, etc.). Based on physical exam, case history information, and results of audiologic evaluation, the otolaryngologist may refer the child for imaging studies such as computed tomography (CT) scans or magnetic resonance imaging (MRI) of the temporal bones to obtain a clearer view of internal auditory structures and possible malformation. In addition, referral will be made for laboratory studies including, but not limited to, EEG, blood work, and urinalysis to aid in the diagnostic process of determining the etiology of the hearing loss. Results of these evaluations may prompt referral to other medical specialists for further evaluation and monitoring. In keeping with JCIH recommendations, any child diagnosed with hearing loss who is considered a candidate for amplification in one or both ears should be fit with appropriate hearing aid(s) within 1 month of diagnosis, for families who elect to pursue this option. The otolaryngologist is the physician who will provide otologic clearance for hearing aid fitting and will also continue to provide services to children with hearing loss for evaluation and treatment of middle ear pathology, candidacy for pressure equalization (PE) tubes, removal of impacted cerumen, and evaluation for cochlear implantation or surgically implanted bone-anchored hearing systems (if applicable).

A Word About Genetics

Approximately 40% of hearing loss diagnoses are thought to be due to infectious agents or environmental factors (for example, bacterial or viral infections, ototoxic drug exposure, and acoustic trauma), with the remaining 60% attributed to genetic causes. Thirty percent of genetic hearing loss is considered syndromic in nature, and 70% is deemed nonsyndromic (Pletcher, 2012). Genetic evaluation for children with hearing loss includes an investigation of hearing loss etiology as well as forming a determination regarding the probability of recurrence risk of hearing loss in the affected child’s siblings or their future children. A typical genetics evaluation for children identified with hearing loss would include a thorough three- to four-generation family history (with special attention to hearing status of family members) and a physical examination of the child, including otologic, ophthalmologic, endocrine, cardiac, nephrology, and craniofacial evaluations. Today, genetic evaluation and testing for children identified with hearing loss is an established step in the etiologic diagnosis of hearing loss (JCIH, 2007). Families and physicians gain valuable information from a genetics evaluation that can guide both medical management and intervention for babies with hearing loss. Parents and physicians need to be aware of the findings of genetic testing to understand whether the child’s hearing loss may be part of a syndrome in which other health conditions that require medical evaluation, treatment,
and monitoring may be present. An understanding of the etiology of the hearing loss may also help to guide families in making decisions regarding their child’s habilitation plan. Genetic counseling can be especially useful in relieving a parent’s sense of confusion as to the cause of an unexpected hearing loss diagnosis for the child. The information provided by the genetics team can assure parents that their child’s hearing loss was not a result of a non-related event during pregnancy, thereby allaying the possible guilt a parent may feel, and assist in their acceptance of their child’s needs so they may move forward in their habilitative process.

Ninety percent of children with hearing loss are born to hearing parents who may not have any experience with hearing health care or hearing loss. Culturally Deaf parents may react quite differently to the news that their child has been diagnosed with a hearing loss and embrace the diagnosis without the communication concerns expressed by parents who are unfamiliar with the richness and pride inherent in the Deaf Community. JCIH therefore advocates that discussions with all parents regarding their child’s hearing status and communication options be handled with sensitivity to cultural attitudes and beliefs and be presented in an unbiased manner.

**Functional Auditory Assessment Tools: Looking Beyond the Audiogram**

In addition to obtaining pediatric audiological evaluation information regarding the type, degree, configuration, and laterality of a child’s hearing loss, functional auditory assessment tools can offer useful information to parents regarding the impact hearing loss has on their child’s day-to-day communicative functioning; provide validation of hearing aid fitting, cochlear implantation, and use of assistive listening technology; assist in the process of determining a child’s eligibility for enrollment into EI; and serve as measurement tools for evaluating the efficacy of therapeutic intervention (Anderson, 2006). In addition, questioning parents and caregivers with regard to personal observations of their child’s auditory response behaviors in real-world settings through the administration of functional auditory assessments can provide information about how a child uses his or her hearing in a variety of real-world listening environments, both in quiet settings and when speech is presented in background noise. The Guidelines for the Audiologic Assessment of Children from Birth to 5 Years of Age (ASHA, 2004; p. 7) includes the following recommendation:

> ... in addition to the assessment of peripheral hearing status, it is essential for audiologists working with infants and young children to consider the functional implications of hearing loss. As it is feasible within the time constraints of clinical practice, assessments of speech perception ability and screening for communication skills, cognitive development and social-emotional status should be included as part of the pediatric test battery.

Speech-language pathologists have a variety of standardized tools available to assess both expressive and receptive speech-language development; however, use of functional auditory assessment tools with infants and toddlers with hearing loss will yield additional useful information in developing a habilitation plan that best meets a child’s needs, regardless of the severity of their hearing loss. The following functional auditory assessment tools are considered appropriate for use with children presenting with hearing loss and can evaluate a child’s listening skills in meaningful, real-world situations as well as encourage parent participation in the hearing loss discovery, monitoring, and intervention process:

**Developmental Index of Audition and Listening (DIAL):** The DIAL (Palmer & Mormer, 1999) is a functional auditory assessment tool that is based on the types of listening behaviors one would expect to observe in children at specific developmental ages. The DIAL was constructed on the basis of human development with a specific focus on auditory skill development for children from birth to 22 years of age.
Early Listening Function (ELF): The ELF (Anderson, 2002) is designed to assist parents in systematically observing and rating their child's auditory awareness skills in response to stimuli presented during a variety of listening environments, including variations in distance from the sound source relative to the child's location (e.g., 6 inches, 3 feet, 6 feet, 10 feet, and 151 feet) and with stimuli presented at different intensity levels (e.g., observing the child's responses to quiet, typical, and loud listening activities). The ELF not only assists families in the observation of their child's auditory behaviors, but also provides a mechanism to track improvement in auditory development over time. Families can use this tool with children from 5 months to 3 years of age to measure improvements in auditory skills under aided listening conditions; audiologists, in turn, can use the ELF as a validation measure for determining the functional benefit of amplification. Furthermore, the ELF is useful not only in providing feedback to parents, but also in helping them to understand the ramifications distance and noise effects have on their child's hearing.

Functional Auditory Performance Indicators (FAPI): The FAPI (Stredler Brown & Johnson, 2010) is designed to assess children's auditory skills by examining seven categories of auditory development (sound awareness, sound is meaningful, auditory feedback, localization, auditory discrimination, short-term memory, and linguistic auditory processing). The FAPI uses a hierarchical sequence of development, opposed to limiting observation to “detection only,” as in the ELF. The results of these assessments are combined to formulate a functional auditory skill profile that describes a child's use of auditory stimuli in natural settings and her or his ability to generalize these skills to different listening environments. There are no age limits on the use of this tool, and it allows for several different skills to be evaluated over time. There are also no age norms because the protocol is used to monitor progress of the development of auditory skills.

Auditory Behavior in Everyday Life (ABEL): Purdy and colleagues (2002) developed the ABEL questionnaire to assess parental perceptions of their children's auditory behavior. The original 49-item questionnaire was intended to assess auditory communication, environmental awareness, functional independence, and social/communication skills. The goal was to capture some of the changes in children's everyday auditory behavior in a reliable and easily quantifiable manner. The 24-item ABEL questionnaire has an excellent overall reliability of 0.95. The items fall within three factors: Aural–Oral, Auditory Awareness, and Social/Conversational Skills. Children's auditory behavior can be assessed using an overall rating, or separately for each of the three factors.

LittleEARS Auditory Questionnaire: The questionnaire portion of the LittleEARS battery (Kühn-Inacker, Weichboldt, Tsiakpini, Conninx, & D’Haese, 2003) is designed to assess the auditory behaviors of children with hearing loss up to the age of 24 months after cochlear implantation or hearing aid fitting. This parent questionnaire consists of 35 age-related questions that require a yes/no response from parents/caregivers and provides information on preverbal auditory development in the child's first 2 years of hearing in their natural environment. This tool has been validated in normally hearing children, and assesses auditory development and early speech production in a child's natural environment.

Parents' Evaluation of Aural/Oral Performance of Children (PEACH): The PEACH questionnaire (Ching & Hill, 2007) was designed to assess the effectiveness of amplification in real-world situations through systematic use of parent observations. The PEACH, which
can be used with children as young as 1 month old and up to 7 years old, includes 15 probe questions, administered by any professional trained to work with families of children with hearing loss, and is scored on the basis of how frequently relevant auditory behaviors occur. Subscale scores can also be calculated for elements such as “hearing aid usage, loudness discomfort, functional performance in quiet and noise, awareness of environmental sounds and use of the telephone.”

*Infant-Toddler Meaningful Auditory Integration Scale (IT MAIS):* Zimmerman-Phillips and colleagues (1998) modified the Meaningful Auditory Integration Scale (Robbins, Renshaw, & Berry, 1991) to be used with children from birth to 3 years of age. This functional auditory assessment tool was developed for children who have a profound hearing loss and have been fit with hearing aids or a cochlear implant. Like the PEACH, the IT MAIS is administered to parents by an audiologist. It examines three primary areas: vocalization behavior, alerting to sounds, and deriving meaning from sound. Scoring is based on the percentages of time that a child demonstrates specific auditory abilities. Detailed documentation of parent responses to structured interview questions is required, as are parental reports on specific areas of behaviors observed.

*FM Listening Evaluation:* The frequency-modulation (FM) Listening Evaluation (Johnson & Von Almen, 2004) evaluates the use and benefits for children of amplification and FM systems after initial fitting, and quarterly thereafter. This functional auditory assessment tool can be completed by a parent or professional working with the child. Not only does this tool provide outcome measures of benefit and is a suitable tool for comparing performance with various types of FM systems, but it also can be used to assess the counseling and technical support needs of parents.

For children under the age of 3 years, having access to the results of these assessments may offer critical information to the EI community in determining a child’s candidacy for enrollment in therapy services by providing information beyond what a typical audiogram might suggest.

**EHDI Rule #3: Enrollment in Early Intervention by 6 Months of Age**

Successfully identifying pediatric hearing loss as a result of newborn screening, but without effective follow-up services in place that include rescreening, diagnostic evaluation, and timely enrollment into appropriate early intervention services, defeats the very purpose of UNHS. Ideally, all children under the age of 3 years presenting with any degree of unilateral or bilateral hearing loss should be “referred” to EI within 2 days of diagnosis. JCIH (2007) indicates that all children with hearing loss should be enrolled in EI programs with providers who are knowledgeable about hearing loss as soon as possible after diagnosis, and no later than 6 months of age. The goal of timely enrollment in a culturally sensitive, community-based, collaborative, and developmentally appropriate EI program is to prevent the significant negative effects that even a minimal hearing loss can have on a child’s overall development. Studies reveal that children with hearing loss, without other disabilities, who receive EI before 6 months of age have language development similar to their normally hearing peers and, when compared with children who do not have early access to EI services, show significantly improved social-emotional development as well as communication outcomes in the areas of vocabulary development, receptive and expressive language, syntax, and speech production (Moeller, 2000; Yoshinaga-Itano, 2000).

JCIH (2007) describes the “Quality of Care” for infants and toddlers with hearing loss. These guidelines are designed to highlight components of early intervention that are unique to children who have confirmed hearing loss in one or both ears. EI services should:
• Be family centered.
• Provide families with unbiased information on all options regarding approaches to communication.
• Monitor development at 6-month intervals with norm-referenced instruments.
• Include family interaction with individuals who are Deaf or hard of hearing.
• Provide services in a natural environment.
• Offer high-quality service regardless of where the family lives.
• Obtain informed consent.
• Be sensitive to cultural and language differences and provide accommodations as needed.
• Conduct annual surveys of parent satisfaction.

Intervention for children with hearing loss requires a close-knit team that includes the family, individuals working within the child’s EI program, and professionals working outside the perimeters of the EI system of care, including but not limited to physicians, SLPs, teachers of the deaf, audiologists, child development specialists, and social workers. Complete medical and audiologic records as well as other diagnostic information are both essential and invaluable in understanding of the child’s unique needs. All of the individuals involved in a child’s care in the EI system need to work together to ensure that necessary data are collected and assimilated into the planning for the child. Families should have access to information about all intervention and treatment options and counseling regarding hearing loss (JCIH, 2007). The JCIH 2007 Position Statement also indicates that, “the child and family should have immediate access to high-quality technology including hearing aids, cochlear implant(s) and other assistive devices when appropriate.”

Part C of the Individuals with Disabilities Education Act (IDEA) (see Appendix 16-C) indicates that EI services should be provided in “… natural environments, including the home and community settings in which children without disabilities participate” (IDEA, 2004; p. 36). Although natural environments may include the home or child care venue, the key consideration is that it be a location that employs the mode of communication used by the child with hearing loss and that the child be exposed to peers and adults who are fluent in this communication methodology, thereby allowing them to serve as models to the child in how to communicate effectively. In keeping with the spirit of defining a natural environment for a child with hearing loss, EI services need to consider use of home-based and center-based intervention options that offer a language-rich environment. A language-rich environment needs to include EI personnel who are able to communicate with the child in whichever mode has been defined by the parents in conjunction with the EI team. Similarly, children with hearing loss need to be surrounded by children who share similar communication methodologies so that even activities of play will foster an environment where all children with hearing loss can communicate freely with their peers. This language-rich environment defines the context of least restrictive and natural environments for infants and toddlers who are Deaf or hard of hearing (DesGeorges, DeConde Johnson, & Stredler Brown, 2005).

As part of the EI process, in addition to assessing the child, the family’s concerns, available resources, and priorities for a comprehensive habilitation plan need to be explored. Information from assessment is then used to identify child and family outcomes, and the services and supports that will be needed to meet these outcomes are written into the Individualized Family Service Plan (IFSP). As new information regarding the child’s communication status is brought to the attention of the IFSP team, the IFSP plan is reviewed and revised on a regular basis, typically every 3 months. The progress of a child diagnosed with hearing loss should be reviewed at least every 3 months, particularly if the child recently has received a hearing aid(s); a bone-anchored hearing system, or a cochlear implant(s). Six-month intervals are appropriate after 2 years of implantation or device use, provided that the child has shown evidence of progress in his or her auditory skill levels. The child’s progress toward expected milestones
post-implant or post-amplification should be evaluated to determine if the child is meeting target listening and verbal skills. Communication abilities should be evaluated to determine if the child is developing in a manner commensurate with methodology and age expectations; however, if there is limited or no progress, or if the child’s unaided thresholds or aided performance has deteriorated, audiologic monitoring should occur at 1- to 3-month intervals to determine if any changes in hearing or middle ear status have occurred or if amplification or assistive technology needs to be modified to meet the child’s current listening needs. Recommendations for the IFSP should be based on evaluation recommendations and on a comprehensive assessment of the child and the family’s priorities, resources, and concerns. Families should be provided with unbiased and comprehensive information regarding all EI options in order to support families in selecting the programs, providers, settings, and services that best meet the needs of the child.

El Services for Children Who Are Deaf or Hard of Hearing: Programmatic Planning Considerations… in a Perfect World

Under Part C of the IDEA, the federal government awards grants to states, the District of Columbia, and some U.S. territories to assist them in developing coordinated, comprehensive, multidisciplinary, and interagency EI programs for children with disabilities, aged birth to 3 years, and their families (United States Department of Education [DOE], n.d.). IDEA mandates that EI services must be provided by qualified personnel, in natural environments, and at no cost to the family, except in states that provide for a system of payment such as a fee-for-service or sliding fee scale. A comprehensive listing of each of these EI programs, including their websites and contact information for their Part C Coordinators, can be found at The Early Childhood Technical Assistance Center at: http://ectacenter.org/contact/ptccoord.asp

Part C guidelines define “infants and toddlers with disabilities” as those children who are experiencing measurable developmental delays in one or more of the following five basic skill areas: cognitive, physical, communication, social/emotional, and self-help/adaptive development; or those who have been diagnosed with a physical or mental condition that has a high probability of resulting in developmental delay (DOE, n.d.). Because the majority of children diagnosed with hearing loss will, without treatment, present with delays related to communication and literacy skills, they are considered presumptively eligible for EI services. The JCIH Position Statement (2007) endorses the recommendation that all children from birth to age 3 years, with any degree of permanent hearing loss in one or both ears, be considered eligible for EI and that their families have the right to prompt access to quality intervention services. Factors to be taken into consideration for program planning of EI services for children with hearing loss include, but are not limited to:

- The current age of the child
- Age of hearing loss onset
- Age at which the hearing loss was actually diagnosed
- Age at which amplification or cochlear implantation was introduced
- Age at which therapy and intervention services were started
- Type of hearing loss
- Etiology of hearing loss
- Stability of hearing loss over time
- Presence of comorbid conditions
- Family desires and goals for the child

Although Part C services are required under federal law, each state has its own designated agency that oversees its EI system and, as such, has its own rules regarding a child’s eligibility for services. For example, some states may only consider EI eligibility as an option for children diagnosed
with moderate to profound degrees of bilateral hearing loss, while others will also extend candidacy for EI services to children presenting with minimal hearing loss (e.g., mild hearing loss, unilateral hearing loss, high-frequency hearing loss). JCIH (2007) recommends that individual states develop a single point of entry into EI specifically for children identified with hearing loss to ensure that all families, regardless of geographic location, receive information about a full range of options regarding communication, intervention, amplification, family support and technology, as well as appropriate counseling services. Speech-language pathologists working with a pediatric population need to be aware of their state’s Part C eligibility guidelines and facilitate the inclusion of infants and toddlers with hearing loss into early intervention as soon as possible after diagnosis (ASHA, n.d.a). A listing of each state’s criteria for IDEA Part C eligibility can be found at: http://www.nectac.org/~pdfs/topics/earlyid/partc_elig_table.pdf.

In 2013, JCIH developed a supplement to their 2007 Position Statement that included an overview of the optimal programmatic components of EI systems that are designed specifically to meet the needs of Deaf and hard-of-hearing children and their families. This supplement also offers quality assurance guidelines that all EI programs should utilize as a means to evaluate and promote positive outcomes in assessing their effectiveness for this population. Best practice guidelines listed in this document include the following 10 goals:

- All children who are Deaf/hard of hearing, and their families, have access to timely and coordinated entry into EI programs supported by a data management system capable of tracking families and children from confirmation of hearing loss to enrollment into EI services.

- All children who are Deaf/hard of hearing, and their families, experience timely access to service coordinators who have specialized knowledge and skills related to working with individuals who are Deaf/hard of hearing.

- All children who are Deaf/hard of hearing from birth to 3 years of age, and their families, have EI providers who have the professional qualifications and core knowledge and skills to optimize the child’s development and child/family well-being.

- All children who are Deaf/hard of hearing with additional disabilities, and their families, have access to specialists who have the professional qualifications and specialized knowledge and skill set support and promote optimal developmental outcomes.

- Children who are Deaf/hard of hearing, and their families, and from culturally diverse backgrounds and/or from non-English-speaking homes have access to culturally competent services with provision of the same quality and quantity of information given to families from the majority culture.

- All children who are Deaf/hard of hearing should have their progress monitored every 6 months from birth to 36 months of age, through a protocol that includes the use of standardized, norm-referenced developmental evaluations for language (spoken and/or signed); the modality of communication (auditory, visual, and/or augmentative); and social-emotional, cognitive, and fine and gross motor skills.

- All children who are identified with hearing loss of any degree, including those with unilateral or slight hearing loss, ANSD, and those with progressive or fluctuating hearing loss, receive appropriate monitoring and immediate follow-up intervention services where appropriate.

- Families will be active participants in the development and implementation of EHDI systems at the state/territory and local levels.

- All families will have access to other families who have children who are Deaf/hard of hearing and who are appropriately trained to provide culturally and linguistically sensitive support, mentorship, and guidance.
Individuals who are Deaf/hard of hearing will be active participants in the development and implementation of EHDI systems at the national, state/territory, and local levels; their participation will be an expected and integral component of the EHDI systems.

All children who are Deaf/hard of hearing, and their families, have access to support, mentorship, and guidance from individuals who are Deaf/hard of hearing.

As best practices are increasingly identified and implemented, all children who are Deaf/hard of hearing, and their families, will be ensured of fidelity in the implementation of the intervention they receive (JCIH, 2013).

The EI Journey: Referral to Transition Preschool

Referral

Each state has its own system point of entry that is responsible for ensuring that children from birth to age 3 years who present with either a suspected developmental delay or a diagnosed disability are identified and evaluated in a timely manner. This lead agency is also charged with conducting public awareness and Child Find activities throughout their state to let residents know that EI services are available to help infants and toddlers with disabilities. Children diagnosed with hearing loss must be referred to the state-designated Part C system of entry as the first step in the EI process. There are a variety of individuals who can initiate a referral to Part C, including, but not limited to, physicians, speech-language pathologists, audiologists, hospitals, child care programs, and public health facilities. In addition, lead agencies for Part C conduct Child Find activities within their own state that allow parents to contact EI to request that their infant or toddler be evaluated. Referrals to the state's Part C program should occur as soon as possible after hearing loss diagnosis. According to federal guidelines, a referral should be initiated to an EI program within 2 days of confirmation of hearing loss. Timely referral to Part C allows for a seamless link from the diagnostic audiologic evaluation and counseling process to the transition to early intervention services by offering families early, unbiased and accurate information regarding their child and their choices (CDC, n.d.).

Parental Consent

The early intervention system “should be family centered with infant and family rights and privacy guaranteed through informed choice, shared decision-making, and parental consent in accordance with state and federal guidelines” (JCIH, 2007; p. 901). Written parental consent must be obtained by the Part C program prior to a child being evaluated for EI. Consent affords the EI team the opportunity to obtain and share all information about a child that may impact development of EI goals and his or her progress as a result of therapeutic intervention. This information may include, but is not limited to, the results of independent professional evaluations, a description of the child's ability to function in group or child care situations, information about emerging or progressing medical conditions, and any other information that could affect the child's progress.

The Evaluation Process: Meeting the Team

The Service Coordinator: Each family that participates in the Part C program is assigned to a service coordinator, who is the liaison between the family and the EI program. For children referred to Part C by a healthcare provider, the service coordinator is responsible for reaching out to the parents to confirm their interest in following through with the EI referral, as well as to schedule a developmental evaluation for their child. Many parents of children with hearing loss have had no previous exposure to the unique needs of raising a Deaf or hard-of-hearing child, yet they must become the decision makers very early on and need to be educated and informed to make the best choices.
for their families. One of the many roles of their service coordinator is to assist parents in understanding the special needs of their child and preparing them for the next stages of the EI process. The initial intake interview for Part C services should be conducted by a service coordinator who has participated in specialized training that helps him or her to better understand the unique impact that hearing loss can have on all aspects of development. Having specialized knowledge related to pediatric hearing loss and its implications aids the service coordinator in selecting both the appropriate assessment tools and team members. Specific training recommendations required to fulfill the defined role of the service coordinator are outlined in the current JCIH (2007) Position Statement. Upon receipt of parental consent, the Service Coordinator will schedule a meeting with the parent to discuss the evaluation process, help the parent select an evaluation site, discuss the parent’s rights, and provide resources related to pediatric hearing loss.

The Evaluation Team: Effective EI services for children with hearing loss require a collaborative and close-knit team that includes the parents and professionals, both within and outside of the Part C Program. Professional members of the evaluation team may include, but are not limited to, the child’s service coordinator, a teacher of the deaf, an early childhood specialist, a SLP, an audiologist, a social worker, occupational and physical therapists, a nurse, a family advocate, and a special education teacher. JCIH (2007) indicates that EI services for this population should only be provided by professionals who have expertise in hearing loss. Service coordinators, service providers, medical personnel, and family members need to work together to insure that all necessary information is collected and assimilated into the planning an intervention program that will best match the unique strengths and needs of each child with hearing loss (CDC, n.d.). In addition to the standard basic skills required of all assessment team members in the EI system the following specific skills are recommended by JCIH (2007):

- Team members should be knowledgeable about the impact hearing loss can have on all areas of development, including social, emotional, speech, language, and cognition.
- Team members should have experience in differential diagnosis that will allow them to recognize and bring to light developmental concerns in addition to those directly attributable to hearing loss that require further investigation and intervention.
- Team members should have training and skill in the use of nonverbal assessment tools and techniques, including those developed for children with hearing loss.
- A licensed pediatric audiologist, who is knowledgeable about both the child’s specific audiologic status and the early intervention system, should be part of the team.
- For children with cochlear implants, there should be well-established linkages with members of the implant team for additional input regarding IFSP development as well as for ongoing updates regarding the child’s cochlear implant status.
- Evaluation team members should be knowledgeable about the various intervention methods for establishing receptive and expressive language and speech, including a bilingual-bicultural approach using American Sign Language, auditory-verbal, auditory-oral, cued speech, and total communication. They should be able to provide unbiased information about the various options for intervention and the results of research that guide the selection of a particular option for an individual family.

Assessment

Although hearing loss is one of the medical conditions that allow for presumptive eligibility for EI services, all children must still undergo a comprehensive initial developmental evaluation/assessment to plan for outcomes and services based
on the specific needs of the child and family. Each child should be assessed by a team of professionals with expertise in assessing children with hearing loss. The evaluations must include an assessment of the child’s abilities in each area of development (cognitive, communication, social/emotional, adaptive/self-help, and physical) plus a review of the child’s medical records (with parental consent). In addition to evaluating the child’s developmental status, an assessment of his or her family members is conducted to identify their concerns, priorities, and available resources related to the development of the child. The child’s developmental abilities and unique characteristics, along with the family’s perspective, must guide the decision-making process for subsequent action. The evaluator must provide a summary of the evaluations to the parent, and parents may request a copy of the full report from the evaluators. Based on the results of all of the evaluation procedures, the evaluation team will determine if the infant or toddler is eligible for EI services. If the child is not found to be eligible, the parents are informed in writing of that determination and their right to dispute it. If the child is found to be eligible, a meeting is scheduled between the parents and the team to develop a written IFSP to outline appropriate EI services to the child and his or her family.

Development of the IFSP

The IFSP is a document that addresses the areas of concern regarding a child’s specific needs and details the services that he or she will receive. It defines goals for the child’s development and establishes a plan for providing EI services to the child and his or her family. If the child is eligible for services, the EI team must schedule a meeting to develop the child’s IFSP within 45 days of the initial referral. The initial meeting to write an IFSP for an eligible child and family must also be held within those 45 days. At this meeting, which must be conducted in the family’s native language, the team will select the services it deems most needed by the child; however, the parent must agree to each service or it will not be provided. If the EI team does not agree to provide a service that the child or family needs, the parent may request mediation or an impartial hearing. In addition, a family has the right to accept or reject any of the services offered by EI and has the option to later accept services that they rejected. Any disputes that may arise at any point in the EI process can be addressed either informally or through mediation, a due process hearing, or through a formal administrative complaint to the Part C Office of Procedural Safeguards. The IFSP includes an assessment of child’s present level of development, a statement of the goals and the support services that will be put in place in achieve those goals, and the date services will begin.

IFSP Review

In general, the IFSP team must evaluate and revise IFSP services on a regular basis, occurring typically every 6 months, though families may request an additional review at any time. IFSP review intervals may be shorter for children who present with progressive hearing loss, ANSD, or unilateral hearing loss, or if they have been fitted with amplification or a cochlear implant. Frequent, ongoing reviews of the IFSP and service delivery method are crucial to ensure progress and the appropriateness of services for all children. Evaluation of communication abilities should be conducted to determine if the child is developing in a manner commensurate with methodology and age expectation. Consistent progress toward defined outcomes indicates to the team that the current services are effective. If the child is not meeting outcomes, a modification of services may be needed. There may be a need to obtain additional evaluations to identify factors that may be interfering with progress or a reconsideration of the instructional method.

Service Delivery

The decision regarding the specific number of hours for direct services should be determined after consideration of the following:

- The outcomes identified by the IFSP team
- The child’s age
The child’s overall developmental status and presence of other disabilities
Time of hearing loss identification
Type and degree of hearing loss identified in one or both ears
Type of amplification, cochlear implant(s), bone-anchored hearing system or other assistive technology
The family’s availability and ability to participate in activities that foster auditory, language, and speech development

All of the services outlined in the IFSP must be made available to the child and his or her family as soon as possible after the parents have provided consent for each particular service.

Writing Outcomes
IFSP teams must develop meaningful, functional, and measurable outcomes that can be accomplished within 3- to 6-month timeframes. The outcomes should be specific, provide guideposts for progress, and take into consideration research regarding reasonable progress. For the child with a hearing loss, these outcomes are specific to audition, language, speech, and communication and any other developmental areas that have been identified. In addition to these outcomes, there are less-obvious specific considerations for a child with a unilateral loss. These relate to parental understanding of potential problems so that they can make appropriate accommodations.

Transition from EI to Preschool
Once children are 3 years of age, they transition from Part C to Part B services. The transition plan should begin when the child is about 2.5 years of age. Early intervention plays an important role in assisting families with the transition to school-based services. Providers and service coordinators should be aware that this transitional period can be stressful for families as they prepare for a change in service delivery and personnel, and issues surrounding choice of communication methodology or type of school program that best suits the child will resurface. Professionals with whom they have been acquainted up to this point in the child’s life will transition out of their roles as the child moves to a center-based preschool program. The transition team should collaborate with the receiving school child study team to ensure understanding of the child’s hearing loss and individual needs. Procedures for transition apply to all children receiving early intervention services. The initial Individualized Education Plan (IEP) Team meeting for a child who is transitioning from EI to preschool should, with parental permission, include attendance by the Part C service coordinator. The service coordinator is the professional who facilitates the development of a transition plan to preschool services if deemed appropriate. The transition meeting itself includes a discussion of the transition services that need to occur as the child and their family move from Part C to either Part B of IDEA, Early Head Start, private therapy services, or another appropriate child care program. The goals and services needed to provide a seamless transition from a child’s EI experience to the next program must be included in the child’s IFSP, with parental consent required before the transition plan can be put in place. If the child is considered eligible for Part B services through their local educational agency, the Part C program must notify both the state and local educational agencies 90 days before the child’s third birthday. From there, the child’s school district must then provide the family with procedural safeguards information as it relates to Part B services and also set up a child study team evaluation to determine eligibility. Once the child is found to be eligible for Part B services, the Child Study Team will develop an IEP. If the family leaves EI with an understanding of the special education system and with confidence in their ability to support their child within that system, then an important goal has been met (ASHA, 2008).

EI Benchmarks
In order to measure successful outcomes for EI programs, JCIH (2007) offered the following
A Word About Telepractice

The use of the “telepractice” model of delivering EI services to children with hearing loss and their families recently has emerged as a viable and effective alternative to “hands-on” therapy services. ASHA (n.d.b) defines telepractice as “the application of telecommunications technology to delivery of professional services at a distance by linking clinician to client or clinician to clinician for assessment, intervention and/or consultation.” The standard of care for administration of telepractice services must be equal to those provided by SLPs and early interventionists for children receiving EI services that are seen in-person.

Successful administration of telepractice services requires the use of regularly maintained, high-speed interactive video and remote computing applications accessible at both the SLP’s clinical setting and the child and her or his family’s Part C setting. EI programs considering the use of this method of service delivery need to develop policies and procedures that will ensure that secure and confidential technology systems are in place for both early interventionists and their clients. The unique characteristics of every child with hearing loss and his or her family will determine whether or not she or he will benefit from EI services provided via telepractice, and this must be assessed prior to initiation of EI services through this mode of delivery. As per ASHA (n.d.b), factors to consider in determining candidacy include the child’s physical and sensory characteristics (e.g., hearing ability, visual ability, manual dexterity, physical endurance); cognitive, behavioral, and/or motivational characteristics (e.g., level of cognitive functioning, ability to maintain attention, ability to sit in front of a camera with minimal extraneous movements as to not compromise image resolution, willingness by family to receive services via telepractice); communication characteristics (e.g., auditory comprehension, literacy, speech intelligibility, cultural/linguistic values, availability of interpreting services); and support resources (e.g., availability of technology, access to telecommunications network, appropriate environment for telepractice, the ability of the family and/or facilitator to follow directions to operate and troubleshoot telepractice technology).

Telepractice not only serves as a mechanism for providing speech-language therapy to children in rural or remote areas where qualified Part C service providers are not readily available, but can afford the family members of children with hearing loss who may be offsite during a therapy session to actively participate in their child’s therapy program through remote access from their personal computer laptop or tablet. Utilization of telepractice can also overcome challenges with personnel shortages, access to professional interpreters, and delivery of EI services in the event of inclement weather that may impede the SLP’s ability to travel to the child’s home. Telepractice can also help to facilitate transition
meetings among the family, their Part C coordinators, and their Part B coordinators. Furthermore, given that the JCIH 2007 recommendation of ensuring that qualified personnel are involved in service delivery to Deaf and hard-of-hearing children, use of telepractice can provide remote access to qualified personnel with experts that may not be readily available in a family’s local geographic area.

Although telepractice is considered an appropriate model of service delivery for SLPs, it is of paramount importance that EI programs must investigate state-specific licensing requirements for the provision of both intrastate and interstate telepractice services prior to initiating practice. In addition, Part C programs must develop billing practices that would allow for sources of reimbursement to cover the provision of EI through this type of service delivery model. The National Center for Hearing Assessment and Management (NCHAM, n.d.b.) provides an excellent overview of considerations for the implementation of a telepractice component to Part C Programs entitled, “The Tele-Intervention Resource Guide,” which is available at their website: http://www.infanthearing.org.

Risk Indicator Monitoring

Up until this point in this chapter, discussion has focused on children who were ultimately diagnosed with hearing loss. It is important to consider that passing a newborn hearing screening prior to 1 month of age does not necessarily mean that a family’s journey through the EHDI/EI process has come to an end. Audiologic reevaluation of infants and toddlers may extend throughout early childhood, particularly for those infants who require ongoing audiologic monitoring due to the presence of a risk indicator for late-onset hearing loss.

As previously stated, implementation of UNHS ensures that all infants have equal access to early hearing loss identification, as opposed to earlier risk-based approaches to hearing screening in which only those children who were identified as having one or more risk indicators to hearing loss were targeted for screening. Even with the advent of UNHS, infants presenting with risk indicators to possible late-onset or progressive hearing loss continue to hold a special place in the UNHS process since currently accepted national guidelines extend the need for rescreening and pediatric audiologic monitoring throughout early childhood to detect hearing loss that may occur post-nursery discharge. With each publication of the JCIH Position Statement, updates are made to the list of risk indicator conditions that warrant ongoing audiologic monitoring as well as the recommended time frames for follow-up. The current list of risk indicators included in the Year 2007 Position Statement (JCIH, 2007) is as follows:

- **Caregiver concern** regarding hearing, speech, language, or developmental delay
- **Family history** of permanent childhood hearing loss: all infants with or without risk factors requiring a NICU stay for more than 5 days, including any of the following: extra-corporeal membrane oxygenation (ECMO), assisted ventilation, exposure to ototoxic medications (gentamycin and tobramycin) or loop diuretics (furosemide/lasix). In addition, regardless of length of stay: hyperbilirubinemia requiring exchange transfusion
- **Intrauterine TORCH infections**, particularly cytomegalovirus (CMV), herpes, rubella, syphilis, and toxoplasmosis
- **Craniofacial anomalies**, especially those involving the temporal bone, the pinna, the ear canal, ear tags, or preauricular pits
- **Physical findings** associated with a syndrome known to include hearing loss
- **Syndromes associated with progressive hearing loss**
- **Neurodegenerative disorders**
- **Culture-positive postnatal infections associated with sensorineural hearing loss**
- **Head trauma**, especially **basal skull/temporal bone fractures** requiring hospitalization
- **Chemotherapy**

**NOTE**: Risk indicators that are listed in italics are of greater concern for delayed-onset hearing loss necessitating early and more frequent assessments.
Previous JCIH Position Statements made recommendations for uniform audiologic monitoring of children presenting with risk indicators every 6 months until the age of 3 years (JCIH, 2000). Although the general 6-month audiologic reevaluation timeline recommendation was a straightforward, easy-to-remember guideline for birthing hospitals and physicians, it proved to be an unrealistic healthcare goal given the large volume of children presenting with risk indicators for late-onset hearing loss who would require, at a minimum, six separate pediatric audiologic evaluations from birth to the age of 3 years. Families of newborns presenting with risk indicators struggled to locate the limited number of qualified pediatric audiologists available in their geographic region who could provide audiologic assessments on infants and toddlers. Available pediatric audiology facilities were overwhelmed with the number of referrals for risk factor monitoring evaluations, and appointment wait times increased exponentially. Many health insurance companies rejected bills for audiologic monitoring services, particularly in circumstances where challenges in obtaining ear-specific test results due to patient fatigue or higher than acceptable levels of activity resulted in more than one clinical encounter for a 6-month recall appointment. It became an impossible undertaking for EHDI programs to effectively track the timeliness and outcomes of audiologic monitoring, unless 6-month recall appointments were strictly adhered to and a complete assessment was obtained for each visit. Most challenging of all became the increasing difficulty in advocating for a globally used 6-month recall schedule in children who either required far more frequent monitoring (e.g., children diagnosed with meningitis or CMV, or those treated with chemotherapy) or who may not have required as much monitoring over as long a period of time (e.g., children who were referred for audiologic evaluation due to caregiver concern, but who were found to present with normal hearing bilaterally with no evidence of retrocochlear pathology, or children referred for audiologic evaluation as a result of sustaining head trauma, in the absence of a skull fracture, who were already found to have normal hearing following their hospitalization). These challenges resulted in a difficult justification for audiologic monitoring recall every 6 months until the age of 3 years. The conservative global recommendation of 6-month regularly scheduled audiologic reevaluation in the Year 2000 JCIH Position Statement was therefore modified to a more specific set of recommendations in the Year 2007 Statement, which stated that children with risk indicators should continue to receive periodic audiologic monitoring; however, the time frames were to be determined based on the specific risk indicator and the individual child's needs. At a minimum, all children with risk indicators to late-onset hearing loss must undergo a complete audiologic evaluation by 24 and 30 months of age, with certain risk indicators requiring more frequent assessments throughout the birth to age 3 years time frame.

According to the National Institutes of Health Consensus Conference on Early Identification of Hearing Impairment (1993), as many as 70% of infants and children with hearing loss are identified because of parental concerns about their child's hearing. Therefore, it is important to educate parents about signs of a potential hearing loss and familiarize them with normal developmental milestones for expressive and receptive speech and language development. Ongoing parental counseling is advised for those babies who present with risk indicators for late-onset hearing loss, but who passed their initial hearing screening.

The Year 2007 JCIH Position Statement incorporated a special safety net to ensure that all children receive ongoing surveillance of developmental milestones and communication skills, as well as inclusion of ongoing pediatric inquiries to parents regarding their own concerns on these issues during well baby visits to the medical home. The American Academy of Pediatrics developed the Pediatric Periodicity Schedule, which stipulates that all children, regardless of whether they present with any risk indicators to hearing loss, receive global developmental screening with validated measurement tools at specific ages (9, 18, and 24–30 months
of age), or at any time if concerns are raised by parents, caregivers, or healthcare professionals regarding the child’s communication ability. If the child does not pass the communicative screening measures conducted in the medical home, or if any concerns regarding hearing or speech-language development are raised by the family to the medical home provider, they are to be immediately referred to a speech-language pathologist and audiologist for comprehensive assessments. In addition, pediatricians are advised to assess middle ear status at all well-child visits and refer for otologic evaluation if persistent middle ear effusion lasts for beyond 3 months. In addition to adhering to the JCIH 1-3-6 Rules, the AAP supports referring for audiologic evaluation the siblings of the pediatric family member who sustains a hearing loss.

A Word About Children with Multiple Disabilities

It is estimated that 30–40% of children with permanent childhood hearing loss will present with at least one additional disability (Gallaudet Research Institute 2003; Laurent Clerc Deaf Education Center, n.d.), including but not limited to developmental delays; cleft palate; vision loss; transient middle ear disorders resulting in fluctuating conductive overlay to the permanent hearing loss; cerebral palsy; balance difficulties; seizure disorders; cardiac, renal, or orthopedic problems; craniofacial anomalies; autism spectrum disorder; and an array of syndromes that include hearing loss. Approximately 70% of children with vision loss have an additional disability (Chen, 2000), and up to 80% of children with a dual sensory loss (vision loss and hearing loss) also present with other disabilities (Minnesota Deaf-Blind Technical Assistance Project, n.d.). These data emphasize the importance of ongoing assessment of sensory status through audiologic and ophthalmologic evaluations for infants with developmental delays or disabilities, and highlights the need for an interdisciplinary approach to EI assessment and services. Although many of these disabilities accompanying hearing loss may be apparent at birth, the extent and nature of others may not be recognized until considerably later, making comprehensive follow-up a necessity. Members of the EI team who work with infants and toddlers with hearing loss must be aware of the significant number of additional healthcare issues and learning problems that potentially coexist in these children. It is vital for all EI professionals to provide sensitive, well-coordinated care for these families because caring for these children’s diverse and frequent needs is demanding for both families and providers of EI services. Medical and habilitative care professionals should be mindful of changes in hearing and vision status and ensure that audiologic and ophthalmologic statuses are monitored regularly. Early intervention services must be carefully designed to take into account the unique learning needs of a child with multiple disabilities, with thoughtful consideration about how to make information accessible to the child and how to establish language and communication.

The SKI-HI Institute (www.skihi.org) is an organization based at Utah State University whose goal is to enhance the lives of young children with special needs, their families, and caregivers to ensure that children with special needs become able participants in society. SKI-HI provides technical assistance and ongoing support to the states implementing Institute programs through the use of newsletters, additional onsite visits, phone calls, and regional conferences. Founded in 1972, its training and services focus on early intervention and early childhood programming for infants and young children, ages birth to 5 years, with hearing loss and additional disabilities.

The Speech-Language Pathologist’s Role in the EHDI Process

In addition to offering the expected evaluation and treatment therapy for children, age birth to 3 years, who exhibit speech-language delays as a consequence
of pediatric hearing loss, SLPs play a vital role throughout the EHDI process, from administration of newborn hearing screening in the nursery to their full participation in the child’s EI experience. To be effective in this role, SLPs must be aware of the historical trends in universal newborn hearing screening and how these programs are being implemented around the country (Houston, 2009). In addition, as per ASHA’s document entitled *Roles and Responsibilities of Speech-Language Pathologists in Early Intervention: Guidelines* (ASHA, 2008), appropriate roles for SLPs serving infants and toddlers include, but are not limited to, awareness of “federal, state, agency, and professional policies and procedures pertaining to screening (including hearing), evaluating, and assessing infants and toddlers with, or at risk for, disabilities; standardized measures for screening, evaluation, and assessment and their psychometric properties that are available and appropriate for infants and toddlers.” SLPs who work in a birthing hospital setting may be called upon to provide hearing screening services to infants in the nursery. In addition, the expertise of a SLP will also play a role in collaboration with other health professionals by identifying neonates at risk for hearing loss.

SLPs are in the ideal position to explain to parents the variety of effects that an unidentified pediatric hearing loss can have on their child’s speech and language development. As such, the SLP can reinforce the need for audiologic evaluation for families of children who did not pass their newborn hearing screening and who have not complied with this recommendation for audiologic follow-up or for those children for whom a potential late-onset hearing loss is of concern. The SLP’s ongoing review of communication and developmental milestones paired with discussion on how pediatric hearing loss of any degree in one or both ears can impede a child’s ability to achieve these milestones can empower families to recognize potential gaps in their child’s communicative skills. Even children presenting with minimal hearing loss (e.g., slight to mild degrees of bilateral hearing loss or unilateral hearing loss of any degree) may exhibit communication difficulties that may not be obvious in the neonatal period, but, through the watchful eyes of both their SLP and parents, will become obvious during the early years of life. Studies have demonstrated that children with minimal hearing loss can exhibit a myriad of communication difficulties, including phonological, vocabulary, and language delays; present with difficulty understanding speech presented in background noise; experience difficulty localizing the source of a sound; encounter problems with reading comprehension and additional educational difficulties resulting in grade retention and resource room assistance; and experience social-emotional dysfunction, including low self-esteem, low energy, high stress, and short-term memory deficits (Bess, Dodd-Murphy, & Parker, 1998; Bess & Tharpe, 1984; Oyler & Matkin, 1988; Oyler, Oyler, & Matkin, 1987). Because there is no clear way to predict which children with minimal hearing loss will experience difficulties, and consequently which children will benefit from early intervention and early amplification, the SLP and audiologist caring for a child with this diagnosis should both be responsible for regular reevaluation of hearing status, monitoring of communication development, and educating families and early interventionists on how to help give these children the best chance for success (McKay, Gravel, & Tharpe, 2008).

Given the collaboration evident between the speech-language pathology and audiology communities, sharing a comprehensive list of local diagnostic audiology facilities that provide services to pediatric patients would help expedite referral for audiologic evaluation if questions arise regarding the current state of a child’s hearing or middle ear status. Reinforcement of the purpose of hearing screening, diagnostic audiologic testing, and ongoing monitoring, as well as reviewing the rationale behind audiologic recommendations for follow-up services, can help empower families to be able to advocate for the hearing healthcare needs of their children. Families should be provided with written materials and pertinent websites to use as reference materials between appointments and throughout the habilitation process (see Appendix 16-A).
Although audiologists and otolaryngologists are the primary professionals involved in diagnosing hearing loss in children, SLPs play a significant role in supporting parents through the adjustment process. Parents of a child with hearing loss may encounter a SLP at any stage of their hearing loss discovery process (e.g., shock, denial, anger, grief, and acceptance). Until more information is known about where the family is in this process, it is especially helpful for parents to take the lead in expressing their needs at any given time, and to do so with professionals who are keenly aware of the impact hearing loss can have on a child. Allowing parents to ask questions and express their concerns and feelings about their child’s diagnosis in an accepting and empathetic environment will allow them to move toward making informed decisions regarding their child’s habilitation plan.

With each appointment, the SLP can continue to engage parents in a series of conversations that will allow them time to digest information regarding test results/recommendations, communication options (if applicable), and short- and long-term habilitation plans so that they can more fully participate in the decision-making process that best suits the unique needs of their child. Parents should be encouraged to bring additional family members to audiology and/or speech therapy appointments for support and have the option of contacting the clinician (telephone, email, and so on) in between appointments should questions or concerns arise.

Reinforcing the Option of Speaking with a Trained Support Parent

Trained support parents have experienced firsthand the emotions and challenges related to having a child with special needs and are able to support other parents in similar situations. In addition, they have participated in specific and ongoing skill building and training sessions in preparation for their role of offering emotional and informational support to families who would like to talk to another parent who has had similar experiences. They have gone through a parent-to-parent support orientation to familiarize themselves with communication skills, listening skills, and peer-support skills. Trained support parents do not provide audiologic or medical counseling but offer encouragement, emotional support, and information on an informal and personal basis. In addition trained support parents do not give direct advice, but rather offer suggestions or outline options that leave the decision making to the parent.

In addition to the importance of referring parents to trained support parents who have “walked in their shoes,” families should also be provided with the valuable opportunity of meeting with Deaf and hard-of-hearing mentors. Meeting regularly with a Deaf or hard-of-hearing mentor can provide the entire family with the chance to learn firsthand of the experiences of “growing up” with a hearing loss.

Mentors are in the unique position to increase the family’s awareness of strategies that will help them foster welcoming and accessible environments for their child. A Deaf or hard-of-hearing mentor is in the unique position of being able to share firsthand insights on the successes and challenges of living with a hearing loss, serve as a language role model, and ultimately be a positive role model throughout the family’s journey of raising a child with hearing loss.
**Summary**

The EHDI process is a multidisciplinary team approach to the hearing health care of infants and toddlers, from birth to age 3 years. It is a public health initiative with strong support from medical professionals, parents, JCIH members, advocacy agencies for children with hearing loss, and federal and state government policy makers. Although the ultimate goals of early hearing detection and intervention are simple and straightforward, the success of this process is dependent on the awareness and action of all the stakeholders involved. EHDI has been and continues to be a work in progress on both national and state levels as new, evidence-based practices become available in the screening, diagnostic, and habilitative process and as greater numbers of healthcare providers and parents become advocates for ensuring that EHDI/IDEA Part C goals are being met. Although challenges in funding, insurance impediments to care, and availability of qualified healthcare providers with expertise in working with very young children with hearing loss still exist, EHDI/IDEA Part C programs throughout the United States continue to work toward finding solutions that will allow the achievement of all goals in a timely and seamless manner.

Speech-language pathologists will always play a vital role in both the EHDI and EI processes. SLP services can be found through:

- Provision of hearing screening services
- Identification of children presenting with risk indicators for late-onset hearing loss
- Making timely referrals for audiologic evaluation and monitoring
- Assisting families in navigating their child’s hearing loss journey from hearing loss diagnosis to entry into early intervention
- Offering support to children with hearing loss and their families as the child transitions from early intervention to pre-K
- Connecting families to resources and agencies that serve as a bridge to meeting other deaf and hard-of-hearing children, as well as adult role models who present with hearing loss
- Providing speech-language therapeutic services to children identified with all types and degrees of hearing loss in one or both ears

In the early intervention process, it is the ultimate goal of the speech-language pathologist to ensure that each child has the best access to early communication skill development as a foundation for optimal social, academic, and vocational outcomes.

**Discussion Questions**

1. You recently received a referral requesting a speech-language evaluation for a 20-month-old male who presents with delays in both cognitive skills and speech-language development. Case history information reveals that he passed his newborn hearing screening prior to nursery discharge. Medical history since that time has been unremarkable with the exception of a brief stay in the hospital at 15 months of age, following a fall from a high chair that resulted in a skull fracture. Should additional pediatric audiologic assessment have been performed? If so, why? What further recommendations should you
consider regarding this child’s hearing health care?

2. In reviewing medical records of a premature 10-month-old female (31 weeks gestational age) in your care, you learn that she referred bilaterally on two automated auditory brainstem response (AABR) screenings prior to discharge from the NICU, where she was a patient for 3 weeks. Her parents present documentation that shows she has since passed a transient-evoked otoacoustic emission (TEOAE) screening of each ear during a well-baby visit with her pediatrician at 3 months of age. Has this child received appropriate follow-up related to her abnormal hospital hearing screening result? If not, why not? Is additional testing warranted? If so, what type of testing?

3. Describe each of the goals of the nationally recognized 1-3-6 Rule in regards to early hearing detection and intervention, and discuss the adverse consequences on a child’s development of not adhering to these timelines.

4. Discuss the newborn hearing screening protocols for infants in the term (or well-baby) nursery as compared to those children who have had a NICU stay of greater than 5 days. What is the rationale behind these differences, and what is the appropriate follow-up for children in either nursery who do not pass their hearing screening prior to nursery discharge?

5. Describe which medical specialists need to be consulted for children who have been diagnosed with permanent hearing loss of any degree/configuration in one or both ears and what the rationale is for referral to each of these professionals.

6. Discuss the role that functional auditory assessments have on developing a full understanding of the impact a unilateral or bilateral hearing loss of any degree, type, or configuration can have on a child’s day-to-day communication.

7. What are the benefits of ensuring that children who are diagnosed with hearing loss are enrolled in early intervention prior to 6 months of age? Describe how provision of a natural environment for early intervention services (Part C of the Individuals with Disabilities Education Act) takes on a different meaning for children with hearing loss than for children with normal hearing who receive early intervention services.

8. Describe the various roles speech-language pathologists play in the early hearing detection and intervention process. In what ways can a SLP empower families of children from birth to age 3 to ensure their optimal hearing health care?

9. After several years of working as a SLP in your state’s early intervention (EI) system, you have decided to relocate to a bordering state to take a similar EI position. Should you assume that the regulatory requirements for each state regarding universal newborn hearing screening are identical in meeting national EHDI goals? If not, what resources should you review to address your new state’s EHDI program requirements?


questionnaire (LEAQ): Parent questions to assess auditory behavior. Innsbruck, Austria: MED-EL.


APPENDIX 16-A
WEBSITES: PEDIATRIC HEARING HEALTHCARE AND RELATED RESOURCE INFORMATION FOR FAMILIES OF CHILDREN WITH HEARING LOSS

Beginnings: For Parents of Children Who Are Deaf or Hard of Hearing, Inc.*
http://www.ncbegin.org

My Baby’s Hearing*
http://www.babyhearing.org

Raising Deaf Kids*
http://www.raisingdeafkids.org/about.php

Hands and Voices*
http://www.handsandvoices.org

Centers for Disease Control and Prevention: Hearing Loss in Children*
http://www.cdc.gov/ncbddd/hearingloss/index.html

Listen Up
http://www.listen-up.org

National Institute on Deafness and Other Communication Disorders: Health Information*
http://www.nidcd.nih.gov/health/

National Center for Hearing Assessment and Management
http://www.infanthearing.org

Laurent Clerc National Deaf Education Center: Info to Go
http://www.gallaudet.edu/clerc-center/info-to-go.html

U.S. Department of Education, Office of Special Education and Rehabilitation Services: Opening Doors: Technology and Communication Options for Children with Hearing Loss*
http://www2.ed.gov/about/offices/list/osers/products/opening_doors/index.html

American Academy of Audiology
http://www.howsyourhearing.org

American Speech-Language-Hearing Association*
http://www.asha.org/public
American Academy of Otolaryngology—Head and Neck Surgery: Pediatric*
http://www.entnet.org/healthinformation/Pediatric.cfm
Cleft Palate Foundation*
http://www.cleffline.org
American Society for Deaf Children
http://www.deafchildren.org
Alexander Graham Bell Association for the Deaf and Hard of Hearing*
http://www.agbell.org
National Cued Speech Association
http://www.cuedspeech.org
John Tracy Clinic*
http://www.jtc.org
National Association of the Deaf*
http://www.nad.org
Parent2Parent USA
http://www.p2pusa.org

* = Website also available in Spanish.
The following set of questions may be helpful in obtaining a comprehensive hearing healthcare history on children in your caseload ranging in age from birth to 3 years. The questions will serve as guidelines to pertinent aspects within the entire Early Hearing Detection and Intervention (EHDI) continuum of care, though some questions may not be applicable for children of all ages. Regardless of the answers provided by parents and/or caregivers, it is especially important to obtain written parental consent through a signed and dated Release of Information form to allow you access to formal documentation of a particular child’s newborn hearing screening, rescreening results, audiologic evaluations, hearing aid verification or cochlear implant mapping information, pertinent medical reports, early intervention information, and other tests that may have been performed (if applicable). Of particular interest will be verifying that a clear picture emerges regarding the hearing (and, if applicable, hearing aid or cochlear implant) status of each child for whom you provide speech-language pathology services. If hearing status is unknown, the SLP will play a truly vital role in encouraging family compliance in securing pediatric audiologic assessment to determine comprehensive information regarding this child’s auditory functioning.

**Newborn Hearing Screening Inquiries**

- Did the child undergo a newborn hearing screening? □ Yes □ No □ Unknown
- If so, how old was the child when the screening was performed? __________
- Where was the screening performed? ______
- What type of screening was conducted? □ OAE □ AABR □ Both
- What was the result of the screening?
  - OAE: Right ear: □ Pass □ Refer □ Did Not Test
  - OAE: Left ear: □ Pass □ Refer □ Did Not Test
  - AABR: Right ear: □ Pass □ Refer □ Did Not Test
  - AABR: Left ear: □ Pass □ Refer □ Did Not Test
- What follow-up recommendations were given as a result of the screening? __________
- Does the family have any questions regarding the results of their child’s hearing screening? □ Yes □ No
Children Who Passed Their Newborn Hearing Screening, but Who Present with Risk Indicators to Possible Late-Onset Hearing Loss Inquiries

- Do you or your family have any concerns regarding this child’s hearing or any possible speech, language, or developmental delays? □ Yes □ No
  If yes: __________________________

- Is there a history of permanent childhood hearing loss in this family (including parents, siblings, grandparents, great-grandparents, cousins, aunts, or uncles)? □ Yes □ No
  o If so, do you know the etiology of the hearing loss? □ Yes □ No
  o Specify their relationship to the child and, if known, the etiology of the loss

- Did this child spend more than 5 days in the neonatal intensive care unit (NICU) prior to nursery discharge? □ Yes □ No
- While in the NICU for over 5 days, did this child receive (check all that apply):
  □ Extracorporeal membrane oxygenation (ECMO) □ Assisted ventilation □ Ototoxic medications (gentamycin and tobramycin) or loop diuretics (furosemide/lasix)?
- Has this child ever undergone an exchange transfusion to treat hyperbilirubinemia? □ Yes □ No
- Has this child been diagnosed with intra-uterine infections or TORCH infections (check all that apply): □ CMV □ Herpes
Rubella  Syphilis  Toxoplasmosis  None
• Does this child present with any craniofacial anomalies such as, but not limited to (check all that apply):  Malformation of the external ear (microtia)  External auditory canal atresia  Pre-auricular pits  Malformation of the temporal bone  Other not listed here (please specify:)  None

If the observed facial difference is related to the ear, which ear(s) is affected?  Right ear  Left ear  Both ears
• Does this child receive services from a craniofacial or cleft palate team?  Yes  No
• If so, where is the team located?

When was the last visit with the team?

When does this child return to the team?

What recommendations were made at the most recent team meeting?

• Does this child present with any physical findings that may be associated with a syndrome known to include a sensorineural or conductive hearing loss?  Yes  No

• Has this child been identified with a neurodegenerative disorder?  Yes  No

If yes, specify findings:

• Has this child been diagnosed with a culture-positive postnatal infection associated with sensorineural hearing loss, including, but not limited to, bacterial and viral meningitis?  Yes  No

If yes, specify findings:

• Has this child ever sustained a head trauma?  Yes  No

If so, when did the incident occur?

If so, what were the circumstances of the trauma and when did it occur?

• Were they diagnosed with either a basal skull or temporal bone fracture that required hospitalization?  Yes  No

• Has this child ever received chemotherapy?  Yes  No

If so, how old was he/she when chemotherapy was administered?

• Is he/she still receiving treatment?  Yes  No

• What type of cancer is he/she (or was he/she) being treated for?

*NOTE: although all the risk indicators listed require periodic audiologic monitoring, those in bold italics are of greater concern for delayed-onset hearing loss and require more frequent assessment.
Pediatric Audiologic Evaluation Inquiries

- Did this child undergo a pediatric audiologic evaluation?  □ Yes  □ No
  - If so, how old was the child when the audiologic evaluation was performed?  
  - Where was the pediatric audiologic evaluation performed?  

- Was a diagnostic ABR evaluation performed as part of this child's pediatric audiologic evaluation?  □ Yes  □ No
- What were the results of the pediatric audiologic evaluation?
  **Right Ear:**  □ Normal hearing  □ Sensorineural hearing loss  □ Permanent conductive hearing loss  □ Transient conductive hearing loss  □ Mixed hearing loss with permanent conductive pathology  □ Mixed hearing loss with transient conductive pathology  □ Auditory neuropathy spectrum disorder (ANSD)  □ Results were inconclusive  □ Results unknown
  **Left Ear:**  □ Normal hearing  □ Sensorineural hearing loss  □ Permanent conductive hearing loss  □ Transient conductive hearing loss  □ Mixed hearing loss with permanent conductive pathology  □ Mixed hearing loss with transient conductive pathology  □ Auditory neuropathy spectrum disorder (ANSD)  □ Results were inconclusive  □ Results unknown
  - What follow-up recommendations were given as a result of the pediatric audiologic evaluation?  

- Where was the last audiologic evaluation performed?  

- Have there been any changes in this child's hearing since their initial audiologic evaluation?  □ Yes  □ No
  - If yes, please specify the nature of the reported change in hearing:  

- When are they scheduled for their next audiologic evaluation?  

- Where will they be receiving their next audiologic evaluation?  

- Has this child's siblings undergone audiologic evaluation?  □ Yes  □ No
  - If yes, have any been diagnosed with hearing loss?  □ Yes  □ No

Amplification Inquiries

- Has this child ever used hearing aids?  □ Yes  □ No  Age at time of fitting: 

- Has the child had more than one set of hearing aids?  □ Yes  □ No
- Describe the hearing aid fitting by circling any of the following:
  - Ear: Right ear aided  Left ear aided  Binaurally aided
  - Style:
    - Behind the ear hearing aid(s)  □ Right  □ Left  □ Binaural
    - Bone-anchored hearing system: nonsurgical  □ Right  □ Left  □ Binaural
    - Bone-anchored hearing system: surgically implanted (for children over 5 years)  □ Right  □ Left  □ Binaural
    - Conventional bone conduction hearing aid:  □ Yes  □ No
- Make/model/serial # of hearing aid (right ear):
  
- Make/model/serial # of hearing aid (left ear):
  
- Dispensing location: ________________
  
- Are hearing aids used through all waking hours daily? □ Yes □ No
  ○ If not, how many hours daily?
  
- What reasons can the family provide as to why this child is not a full-time hearing aid user? ________________
  
- How long ago did this child receive their current earmolds?
  
- When was the last aided testing conducted with this child?
  
- What was the outcome of the most recent aided testing? ________________
  
### FM System Inquiries

- Does this child use an FM system? Circle: Personal School
  
- Make/model: ________________
  
- Does this child utilize an FM system in conjunction with their hearing aids? □ Yes □ No
  
- Has this child undergone an FM system evaluation? □ Yes □ No
  
### Cochlear Implant Information

- Does this child have a cochlear implant? □ Yes □ No
  
- Age of initial stimulation: ________________
  
- Manufacturer: ________________
  
- Name of surgeon: ________________
  
- Name/location of the CI center: ________________
  
- When was this child’s last mapping appointment?
  
- What was the outcome of the last CI evaluation?
  
- When is this child scheduled for their next CI appointment?
  
### Habilitation Inquiries

- Is this child currently enrolled in an early intervention program? □ Yes □ No
  
- Is the program home based? □ Yes □ No
  
- Is the program center based? □ Yes □ No
  
- Indicate which of the following services this child receives as part of their EI program:
  - Speech therapy
  - Physical therapy
  - Occupational therapy
  - Sign language instruction
  - Teacher of the Deaf services
  
- Does this child participate in therapy for one of the following communication modes?
  - Auditory verbal
  - Auditory oral
  - Cued speech
  - Total communication
  - ASL
  - Augmentative communication
  - Bilingual/bicultural
  
- List the names of specialists providing EI services:
  
- If this child is not receiving EI services, why not?
  
Otolaryngology Inquiries

- Has this child been evaluated by an otolaryngologist? □ Yes □ No
  - If so, what is the name/address of the otolaryngologist? ____________________________
  - When did the examination take place? ____________________________
  - What were the findings for the evaluation? ____________________________
- Was otolaryngology follow-up recommended? □ Yes □ No
- Is there a history of ear infections? □ Yes □ No
  - When was the last ear infection: ____________
    □ Right ear □ Left ear □ Both ears
- Has this child undergone surgery for placement of PE tubes? □ Yes □ No
  - If so, when: ____________
  - Where did surgery take place? ____________
  - If so, which ear(s): □ Right ear □ Left ear □ Both ears
- Does this child have seasonal allergies? □ Yes □ No
- Has this child ever experienced dizziness? □ Yes □ No
  - If yes, provide details:
    ____________________________
    ____________________________
- If yes, provide details:
  ____________________________
  ____________________________

Genetics Inquiries

- Has this child been referred for a genetic counseling evaluation? □ Yes □ No
  - If so, when did the genetic counseling evaluation take place? ____________
  - Where did the genetic counseling take place? ____________
- Did this child undergo genetic testing? □ Yes □ No
- Has this child been diagnosed with a syndrome? □ Yes □ No
  - If yes, provide details:
    ____________________________
    ____________________________
  - Does this child present with any other health conditions other than hearing loss? □ Yes □ No
  - If yes, specify condition(s): ____________________________
  - What were the findings of the genetics evaluation? ____________________________
  - What recommendations were made as a result of the genetics evaluation? ____________________________
  - Has this child had to return to the geneticist since their initial evaluation? □ Yes □ No
    - If so, when? ____________________________
    - What was the outcome of the follow-up visit? ____________________________

Ophthalmological Inquiries

- Has this child had their vision assessed by an ophthalmologist? □ Yes □ No
  - If so, when was this assessment performed? ____________________________
  - Where was this assessment performed? ____________________________
  - What was the outcome of this assessment? ____________________________
- Does this child wear glasses? □ Yes □ No
- At what age did he/she begin wearing glasses? ____________________________
○ Has this child had a follow-up examination?  □ Yes  □ No
  - If so, when was this reassessment performed?

○ Were any changes noted in this child’s vision?  □ Yes  □ No

• What recommendations were made at the follow-up evaluation?

• When is this child’s next eye examination?

---

**Medication Inquiries**

• Does this child currently take any medications?  □ Yes  □ No
  - If so, which medications does this child take, and for what purpose?

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**Parent Support Service Inquiries**

• Has this family been referred for parent support services?  □ Yes  □ No
  - If so, when?

• What is the name of the parent support agency?

• When was the last contact this family had with a parent support agency?

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**Counseling Services Inquiries**

• Has this family been referred for counseling?  □ Yes  □ No
  - If so, when?

• What is the name of the counseling agency?

• Is this an agency with specific experience in working with children with hearing loss and their families?  □ Yes  □ No

• When was the last contact this family had with their counselor?

---

**Additional Medical Referral Inquiries**

• Has this child been evaluated by any other medical specialists?  □ Yes  □ No
  - If so, list name, specialty, and details below:

Be certain to obtain signed release of information in order to obtain pertinent records as well as to have the parent’s permission to speak with the professionals who have provided services to this child.
As a practicing speech-language pathologist, you will come to realize that state and federal regulations regarding service provision for children under the age of 3 years who are Deaf or hard of hearing are “living” documents that are in a constant state of review and revision. A recent document, *Part C Eligibility Considerations for Infants and Toddlers Who Are Deaf or Hard of Hearing* (2011), is available from the National Center for Hearing Assessment and Management (NCHAM) and the Individual with Disabilities Education Act (IDEA) Infant and Toddler Coordinators Association (ITCA). The purpose of this document is to provide information that will assist all people responsible for state Part C systems in:

- Making informed evidence-based decisions as they develop or review eligibility criteria related to infants and toddlers who are deaf or hard of hearing
- Determining the appropriate personnel to participate in eligibility determination and the development of an individualized family service plan (IFSP) to address service needs of the child with hearing loss and their family
- Providing resource information to families of children with hearing loss who do not meet the eligibility criteria established by the state’s Part C program

Audiology Services in the School System

Cheryl DeConde Johnson, EdD, FAAA, Board Certified in Audiology

Key Terms

Americans with Disabilities Act (ADA)
American Sign Language (ASL)
Auditory habilitation
Child Find
Classroom acoustics
Classroom listening assessment
Cued speech

Deafness
Hard of hearing
Hearing impairment
Hearing status
Highest qualified provider
Identification
Individualized Education Plan (IEP)
Individual Family Service Plan (IFSP)

Listening and spoken language (LSL)
Manual communication
Manually coded English (MCE)
Multitiered systems of support (MTSS)
Response to intervention (RTI)
Reverberation time
Section 504 (504 Plan)
Signal-to-noise ratio (SNR)

Objectives

• Explain the different ways in which a student can potentially receive services through the public education system.
• Illustrate the various components of IDEA as it applies to children who are deaf and hard of hearing.
• Understand the basic acoustical characteristics of a classroom and the deleterious effects they have on children with auditory impairments.
• Determine the school district’s responsibility for the selection, purchase, management, and maintenance of assistive technology.
• Understand and discuss models of habilitation for children and the influence of self-determination on motivation and self-regulation for learning, self-advocacy abilities, and general well-being.
• Describe communication approaches and discuss the role of the speech-language pathologist in guiding parents through decisions about approaches for their child.
Introduction

This chapter is intended to assist the speech-language pathologist (SLP) in understanding and supporting appropriate school-based audiology services. Audiology services in an educational setting are different from those in a clinical setting. In hospitals and other medical facilities, a medical model of service provision is utilized for the continuity of patient care. In education, service provision is driven by local, state, and federal administrative codes. To effectively support students with auditory impairments, the SLP should expect school audiology services to align with the Individuals with Disabilities Education Act (IDEA), the Americans with Disabilities Act (ADA), and state and federal accountability reporting requirements. It is important that the SLP be provided with the information and tools necessary to align services in the classroom for deaf and hard-of-hearing students, as well as for students with auditory processing deficits, with special education and accessibility laws.

Whether educational audiology services are provided in-house or contracted through a local audiologist or other entity, they must address the individual’s listening skills, language learning abilities, and communication access preferences as well as the various parameters of the classroom and educational environment that impact communication. The primary goal of school-based audiology services is to level the playing field by minimizing the impact of auditory impairments on communication and learning so that children who are deaf or hard of hearing, or have other auditory deficits, have the same learning opportunities as their hearing peers.

To do so, these services must adhere to the following:

- Identify and assess children/youth with hearing and listening problems.
- Provide appropriate habilitation, including communication and listening skill development training, hearing and other assistive technologies, and other relevant accommodations that ensure full access to communication and the educational environment.
- Provide counseling so that children/youth develop positive self-concepts; understand the impact their hearing status has on communication, communication options, relevant accommodations, and rights; and are able to take responsibility for self-managing their needs.
- Create and administer programs for the prevention of hearing loss.
- Train teachers and staff and monitor the learning environment to ensure that it is structured to support students with auditory impairments.

In this chapter, we will dissect the federal laws pertaining to the definition of audiology services [34 CFR 300.34(c)(1)], educational service provision [34 CFR 300.113], and assistive technology for students with hearing loss in public schools from ages 3 through 21 [34 CFR 300.5]. The regulations for implementing these laws are summarized in Appendix 17-A.

34 CFR 300.34(c)(1) Definition of Audiology

Audiology includes—

(i) Identification of children with hearing loss;
(ii) Determination of the range, nature, and degree of hearing loss, including referral for medical or other professional attention for the habilitation of hearing;
(iii) Provision of habilitation activities, such as language habilitation, auditory training, speech reading (lip-reading), hearing evaluation, and speech conservation;
(iv) Creation and administration of programs for prevention of hearing loss;
(v) Counseling and guidance of children, parents, and teachers regarding hearing loss; and
(vi) Determination of children's needs for group and individual amplification, selecting and fitting an appropriate aid, and evaluating the effectiveness of amplification.

The provision of audiology services in a public school is a related educational service under IDEA, along with other services such as speech-language pathology, occupational therapy, physical therapy, psychological services, counseling, interpreting, parent counseling and training, and transportation. Educational audiology practices that are considered “related services” in the Individual Education Plan (IEP) may include, but are not limited to, audiological evaluation including a classroom listening assessment and classroom acoustics measurements, assistive technology devices and services, listening skill training, self-advocacy development, and teacher support for the general management of children with hearing impairment in the classroom. In the absence of a school system employing an educational audiologist, these responsibilities may be contracted. Some practices may also be assigned to the speech-language pathologist Within IDEA, specific terminology is used to refer to the highest qualified provider within a local education agency (LEA). When it comes to providing audiology services in the school setting, the SLP may be considered as the qualified service provider. However, delegation of audiology responsibilities to a SLP is not appropriate for all areas. Decisions regarding services for hearing screening, counseling, habilitation, and hearing loss prevention should be determined by the multidisciplinary team, which includes an audiologist and a teacher of the deaf, based on their qualifications, and the experience of the SLP to address the needs of each individual child. It is in the best interest of the SLP to refer to professional standards of practice to address these issues with a supervisor specific to the municipality or state in which they are employed.

**IDEA, ADA, & 504**

As we refer back to the laws of IDEA, ADA, and Section 504 of the Rehabilitation Act of 1973, which is where Section 504 (504 Plan) originated, there are slightly different interpretations of what makes one eligible to receive services for a child with a physical disability (in this case, hearing impairment). Under IDEA, eligibility for services requires an “educational manifestation” of the disability (i.e., evidence that the disability adversely affects a child’s educational performance). Title II of ADA and Section 504 apply to all public school students, regardless of IDEA eligibility, who meet the definition of disability as a condition that “substantially limits one or more major life activity.” Title II nondiscrimination requirements of ADA include accommodations to ensure communication is as effective as for nondisabled peers and is based upon the communication preferences of the individual when determining appropriate auxiliary aids and services. In some cases, these accommodations may exceed those required under IDEA.

Imagine, for example, a middle-school student with a cochlear implant who is achieving mostly A’s without specialized instruction, but with the support of a frequency-modulation (FM) system and real-time captioning. Under IDEA, this student might only receive the FM system if the student is making “reasonable” progress evidenced by passing grades. Whether the student is eligible for IDEA or not, ADA supports the addition of captioning if requested by the student to seek accommodations that provide “equal” access. Accommodations for participation as a result of ADA are included in the IEP for IDEA-eligible students and are delineated in a 504 Plan for non-IEP students.

It is the educational audiologist or, in many cases, the speech-language pathologist who must make the case for eligibility and service provision during the child study team evaluation process. Throughout your career, you will more than likely encounter individuals who are under the misconception that hearing aids correct hearing impairment equivalent to eyeglasses correcting a vision problem. Especially in the educational realm, this statement could not be further from the truth. Unfortunately, this mindset must be overcome so that these students are serviced appropriately within their educational programs.
Identification

The identification of children with hearing impairment features several roles for the audiologist or speech-language pathologist. Identification does not explicitly mean screening of all children, but rather screening as a step in the process toward identification of hearing impairment. Resources and regulations generally dictate the level of involvement of the audiologist or SLP at this stage, and may vary from state to state. At this point, let us clarify for a moment some processes and programs you will encounter when working in the school setting.

Hearing screening of all children in schools generally is the responsibility of a health and/or education agency that guides the screening processes and procedures. Therefore, basic hearing screening is considered a population-based activity, not a program under IDEA. Hence, nurses, health aides, volunteers, or other individuals designated by the responsible agency provide the services.

Population-based screening should not be confused with Child Find, which is the special education program under IDEA that requires schools to seek out and identify children from birth to 21 years of age with disabilities. Child Find programs primarily target at-risk early childhood groups by providing developmental screenings that also include vision and hearing. Procedures for screening hearing within the Child Find program should be designed and managed by the educational audiologist. Depending on local procedures, resources, and expertise, the SLP may also conduct or participate in the screening and assist in securing follow-up appointments for children who require additional assessment.

Screening procedures should include measures to target specific populations of students. For example, tympanometry may be part of a screening protocol for young children to identify middle ear problems; the addition of 6000 and/or 8000 Hz to a pure tone protocol for middle school- and high school-age students might identify potential noise-induced hearing loss (NIHL).

Children who are very young or unable to respond with traditional pure tone screening methods may require special behavioral screening techniques and technologies that require the expertise of an audiologist. Automated otoacoustic emissions (OAE) screeners have enabled widespread screening of young children by nonaudiologists. However, misuse is a concern; OAEs are not a substitute for pure tone measures and should not be used as a sole screening tool (American Academy of Audiology [AAA], 2011a). It is critical that you consult with an audiologist to manage screening programs, guide the development of the screening procedures, and provide training and supervision, if necessary. The speech-language pathologist may find himself or herself in charge of managing required screenings (preschool and school age) and Child Find screening following state policies and procedures. As part of this process, the SLP may also be responsible for conducting follow-up activities to ensure that those referred have received the prescribed service, facilitate transition between early intervention and educational programs and services, and provide nonbiased information regarding communication options, service options, and community resources.

Putting Education in the Audiological Assessment: The Classroom Listening Assessment (CLA)

Audiological assessment for children with identified auditory disorders should include a combination of standard clinical measures and functional classroom-based measures to yield a comprehensive profile of auditory and communication abilities. Although you may find yourself with a diagnostic evaluation report from a clinical audiologist, the information may be lacking as to how the hearing impairment may or may not impact the child’s education.
Many measures are available for evaluating the function of a student with hearing impairment and determining how that impairment may or, in rare cases, may not manifest itself in the classroom environment. These measures include objective and subjective assessments from the perspectives of the student, his or her teachers, and, if desired, parent(s). In addition to the student, the classroom environment is also assessed to determine how well it supports communication access and learning. This comprehensive assessment leads the practitioner to the evidence for accommodations, including such assistance as hearing instrument technology, assistive listening devices, or other accommodations within the classroom. It may also lead the practitioner to information regarding the appropriateness of program placement decisions, particularly the components falling under the special factors reflected in the IDEA (see textbox: Development, Review, and Revision of the IEP, Consideration of Special Factors) for further discussion related to the development of the IEP.

Table 17.1 summarizes the protocols used in the CLA. A detailed discussion of each assessment area follows. Ideally a CLA is performed as part of the IEP assessment on all students with hearing impairment who have auditory potential. However, the time required to conduct the CLA generally limits its use to students who require the information for programming decisions or specific protocols within the assessment. The speech-language pathologist should work in collaboration with an educational

<table>
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<tr>
<th>Type</th>
<th>Tool</th>
<th>Author</th>
<th>Where to Get It</th>
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<tbody>
<tr>
<td>Observation</td>
<td>Placement Checklist from Placement and Readiness Checklists (PARC) for Children Who Are Deaf and Hard of Hearing</td>
<td>Johnson, 2011b</td>
<td><a href="http://www.ADEvantage.com">http://www.ADEvantage.com</a></td>
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audiologist (or the child's private audiologist if there is not a school-based audiologist) and teacher of the deaf and hard of hearing to determine when the CLA is needed, identify the areas assessed, and determine who will complete each of them. The components of the CLA are not restricted in scope of practice to audiologists because they are classroom-based assessments that provide functional information regarding how communication and learning are impacted by hearing impairment. Therefore, the SLP in the educational setting may, in fact, be the responsible member of the child study team to complete these assessments.

Classroom Observation

A classroom observation provides a snapshot about the physical parameters of the classroom and the flow of communication. Information about the classroom design, seating arrangements, classroom acoustics, how a teacher manages instruction, expectations for student participation, and management of student behavior are useful when determining the classroom listening needs for a student. For example, a classroom that seems excessively noisy requires acoustic measurements before a recommendation can be made for the most appropriate type of hearing assistance technology (HAT). A predominantly lecture style format requires different accommodation strategies than a teacher who facilitates small group learning. A classroom seating arrangement in a U-shape or circle might provide good visual access but still not meet the acoustical needs of a student. Classroom participation expectations might not include sufficient “wait time” for a student with hearing impairment to hear and process information before being ready to respond.

Information about the student is equally important. What are the student's hearing impairment and functional listening abilities? How does noise influence the student's ability to respond? Was speech-in-noise testing part of the audiological assessment? Are language and academic performances at grade level, or is the student behind? Are there attention or hyperactivity concerns, or other learning or physical problems, impacting communication and learning? What hearing instruments are currently being used? Are there concerns about self-esteem and personal acceptance of hearing impairment? What is the student's level of self-determination? Is the student motivated to work hard? Can the student self-advocate for his or her own communication access?

Observation tools should include consideration of these physical and instructional properties of classrooms as well as student characteristics. Some components of these areas can be determined through checklists completed by teachers about their classrooms and about the student; however, actual observation of the classroom environment provides an invaluable perspective when determining instructional style, accommodations, and amplification that might be necessary for a student. It also creates the context for training and coaching for the teacher. Tools from Table 17.1 should be chosen that are best suited to the student's developmental abilities as well as the intended purpose of the assessment (e.g., SIFTER for general learning, L.I.F.E. for HAT efficacy, CHAPS for auditory skill development). These tools may also be used as pre-/post-validation and monitoring measures for use and implementation of accommodations including HAT.

Classroom Acoustics Appraisal

A traditional classroom, as with any other room, possesses its own acoustic characteristics; each classroom, even within the same school building, will vary. Classrooms are like snowflakes—no two are exactly the same. Let us, for a moment, examine the variability of traditional classrooms. There are (at least) four walls. Of what are the walls fabricated? Is there a full wall of windows? Do the windows open? (Not all windows do, and some only open an inch or two.) Are the walls covered with bulletin boards, interactive whiteboards, chalkboards, or student work? Is there a full wall of coat closets? Each classroom should have a door. Is it the school policy that the doors remain open or closed during the school day? Is the door solid or does it have a window? Is there an air vent above the door that remains open
to the hallway even if the door is closed? What covers the classroom floor? Is the floor hardwood, rubber tile, or carpeted? Are there area rugs? Of what is the ceiling made? Is it acoustic tile, a drop ceiling? How high is the ceiling? In the case of older schools, is the school plumbing exposed on the ceiling? While we are looking up, of what are the floors in the classroom above this one made? Can student activity be heard through the ceiling? Is there a heating/ventilation/air conditioning (HVAC) system in the classroom? Does it run continuously throughout the day? What type of lighting is used in the classroom? Do the lights emit a sound when they are on or when they are overheated? Are they bright enough for the students to clearly see the main area of instruction in the room? What other electronics are routinely used in the classroom? Is there a class pet? Aquarium filters and hamster wheels make a lot of noise. What type of student seating is used in the room, and what is the configuration of that seating? Individual desks and chairs within a classroom pose an interesting problem. Normal movement within the classroom requires desks and chairs to move on the floor. Are the legs of the desks and chairs covered to reduce this noise? Where does the child with hearing impairment (or auditory processing deficits [APD]) sit in respect to where the teacher spends most of his or her time instructing? Is the child in question sitting next to one of the major noise sources in the classroom? How many other students are in the classroom? Is the student enrollment a mix of general education and special education students, or is it a resource room special education environment? Are there special education students in the classroom who require external ventilation or other medical equipment? How many adults are in the classroom—teacher, inclusion teacher, personal aide, teacher's assistant, school nurse aide, and the like? What are their roles within the classroom? How have their instructional roles been defined? When you put all of these factors in motion at the same time, you can see the many variables that impact classroom acoustics and why evaluation of each classroom environment is necessary.

When assessing classroom acoustics, three aspects of sound must be evaluated. (1) The direct sound or primary signal is basically the information that should be the student's focus. Whether this is the teacher's voice, a teacher's aide providing supplemental instruction, or some type of recorded material, it is our goal for that signal to be clear and intelligible to the student. (2) Reverberation is the reflection of sound that varies according to the surfaces off of which it is reflected; softer surfaces generally have more absorption ability and therefore less sound reflection. Conversely, hard surfaces will generally have less absorption ability and therefore more sound reflection. Sound that is reflected off of a surface or multiple surfaces takes longer to reach the listener's ears than direct sound. This time delay to a normal auditory system, known as reverberation time, is usually inaudible but has a significant effect on speech intelligibility in an impaired auditory system. Speech intelligibility is further decreased as a result of the interaction of multiple reflections in highly reverberant classrooms. For children using personal hearing instruments alone in the classroom, reverberation time creates an amplified, distracting "echo," further decreasing the intelligibility of the primary signal. (3) Background noise is perhaps the greatest classroom offender when it comes to children with hearing impairment or APD. Outside of the primary signal, any unwanted sound generated by either internal or external sources is considered background noise. Within the classroom, a measurement is made of the intensity (loudness) of background noise compared to the intensity of the direct sound; this is referred to as the signal-to-noise-ratio (SNR). In this terminology, "signal" refers to the direct sound or speech, while "noise" refers to the background noise.

In a classroom, background noise levels (also referred to as ambient noise levels) and reverberation times should comply with American National Standards Institute (ANSI) s12.60-2010 (Acoustical Society of America, 2010); however, at present, this standard is voluntary unless there are state or local regulations that make it mandatory. The only mandatory
compliance with this standard is for new school construction. However, with appropriate assessment of the student’s listening requirements for communication and instructional access and the classroom acoustical environment, evidence can be acquired that substantiates a student’s need for instruction in a classroom that meets the ANSI standards.

**Determining Signal-to-Noise Ratio**

**What You Need to Know**

An educational audiologist typically performs classroom noise-level measurements using a sound level meter. Sound-level meter applications for handheld devices, such as Audio Tools by Studio Six Digital (www.studiosixdigital.com), are now available that make noise-level measurements simple to perform. Readings are taken using a decibel scale that is acoustically modified for speech communication; it is known as the dBA weighted scale. Taking measurements from a variety of points in the classroom may also help in determining the appropriate seating of the student with hearing impairment or APD.

**Technically Speaking**

The Classroom Acoustics Survey Worksheet (AAA, 2011b; see Appendix 17-B) contains observation considerations as well as a guide for making classroom acoustical measurements to identify whether classrooms meet ANSI noise and reverberation time standards (e.g., 35 dBA and 0.6 seconds for classrooms less than 10,000 cubic feet, which may be reduced to 0.3 seconds for children with special listening needs). Noise measurements should be made from several room locations with and without the HVAC system on, and with and without students in the room. Measurements should be repeated while the teacher reads a standard passage to establish SNRs for the same room locations. If a classroom audio distribution system (CADS) is used, measurements should be repeated to demonstrate the improvement in SNR. Children with auditory impairments generally require a +15 dB SNR, which means that the talker’s voice is 15 dB greater than the background noise at the student’s ear. Speech-in-noise assessments conducted as part of the audiological assessment, such as the BKB-SIN (Ety-motic Research, 2005), identify specific individual SNR requirements and, thus, are an important part of the audiological assessment battery for children with auditory impairments. More technical measurements using a conventional type 2 sound-level meter (a weighted scale, slow response, and a minimum lower limit of 35 dBA) should be performed when acoustical alterations are necessary, such as modifications to ventilation systems or installation of acoustical panels.

**Determining Reverberation Time**

**What You Need to Know**

Reverberation time can also be measured with an app or special reverberation time measurement equipment. Remember, for a student with hearing impairment, reverberation results from sound reflections that create a hollow, echo-like sound. Depending on the classroom design, the echo and the time this echo takes to reach the ear (reverberation time) cause distortions of the speech signal and therefore may result in degraded speech perception and significant auditory fatigue for the student. Hearing aids, cochlear implants, and other personal hearing instruments may exacerbate the listening problems created by excessive reverberation times. Constantly seeking out a clear primary signal in the classroom through this myriad reverberation becomes an arduous task for a child with hearing impairment or APD.

**Technically Speaking**

Reverberation time can also be measured using conventional reverberation time meters or applications for handheld devices (similar to those used for noise measurement), or it can be extrapolated
by calculating known absorption coefficients of common wall, floor, and ceiling surfaces. Critical distance marks the maximum point at which the listener receives the speech signal from the talker directly, i.e., direct sound, without additional sound reflections from room surfaces. Therefore, optimal speech understanding requires that the listener is located within the estimated critical distance from the talker. Critical distance is determined by room size and reverberation.

**Functional Assessment**

Now that we have discussed the classroom environment, we must now look at the student's ability to function in the classroom. The assessment of a child with hearing impairment or APD in his or her classroom environment provides objective performance data that reflect functional listening capabilities. The goal of this step in the CLA is to address how listening ability is affected by the acoustics of the classroom (e.g., noise and reverberation) and the communication characteristics (distance from the teacher and other talkers, audibility of the teacher/talker's and student's voices, visual access) encountered by children as these classroom dynamics change. For children who use hearing assistance technology (HAT), the assessment should be repeated with the HAT to document the benefit provided by the assistive technology.

Scoring of the CLA is based on the student's repetition of the stimuli (i.e., words or phrases) in the various listening conditions. Conducting the assessment live in a child's classroom is challenging. The mere presence of a new adult in the room with special test equipment requires explanation and acclimatization until the novelty diminishes. Assessing a child in the presence of his or her peers to capture the typical auditory and visual atmosphere is even more difficult. Therefore, it may be necessary to compromise some components of the real-world assessment by using tools that build in or simulate those situations.

The Ling Six-Sound Test is a simple functional listening procedure to determine the audibility of six sounds that represent the speech frequency spectrum of 1000–4000 Hz. The test can be used to determine detection, discrimination, and identification skills with and without amplification, and is an effective, quick, validation tool, especially for young children. Procedures and materials for the administration of the Ling Test are available from the Cochlear Americas website, as indicated in Table 17.1.

**Self-Assessment**

Children and youth should always have a role in the evaluation of their classroom listening performance as part of their annual assessment. Investing in self-perception increases knowledge of one's skills and needed accommodations as well as one's self-determination and self-advocacy development. Review of self-assessment results reveals issues that often open the door for further discussion and counseling about communication and/or listening problems and the development of strategies for addressing problem situations.

As with other parts of the CLA, self-assessment should be chosen based on the developmental considerations of the child/youth and the information desired from the assessment. For children who are unable to read the questions or statements, self-assessments can be read to the student and explanations of terminology or concepts provided. However, the evaluator should never try to influence the response choice of the student. The Listening Inventory for Education (L.I.F.E.) and the Classroom Participation Questionnaire (CPQ) are generally appropriate for children beginning in elementary grades; the Self-Assessment of Communication for Adolescents (SAC-A) is designed for older children. Often, comparison of self-perceptions to those of an observer is helpful. The Significant Other Assessment of Communication-Adolescents (SOAC-A) is designed as a companion tool to the SAC-A to gain this added perspective. This additional information is particularly instrumental in the counseling process.

Each of these tools is also useful for pre/post efficacy for accommodations, including HAT, and
to monitor their implementation. The CPQ (see Appendix 17-C) is particularly useful to gain information about communication access and ease of communication in the classroom and to initiate discussion of accommodations and self-advocacy during individual therapy sessions.

Hearing Assistance Technology (HAT)

Now that we have examined the classroom acoustics, we will return to IDEA to review its content in terms of the school system’s responsibility for HAT. One of the primary roles of an educational audiologist in the school setting is providing services related to amplification; however, in the absence of a school-based or consulting audiologist, the speech-language pathologist or the teacher of the deaf and hard of hearing is often asked to take on responsibility for amplification. Again, it is imperative that the SLP working with a child with hearing impairment or APD provides services that are only within his or her scope of practice. A good rule of thumb in this area is that any device that comes into school as the personal property of the child be serviced only if specified in the IEP that it is assistive technology to be used at school for the services described. However, as will be discussed further, schools are responsible for monitoring the functioning of personal devices to ensure that they are working properly, and when there is a problem or malfunction, the parents (or guardian) must be notified so that the child’s personal audiologist can perform the necessary repairs or modification.

Amplification

The use of hearing instruments in the classroom in conjunction with HAT, or in some cases HAT alone, can be an integral part of service provision for a student with a hearing impairment or auditory processing disorder. Although it is outside of the SLP’s scope of practice to apply 34 CFR 300.6 to “selecting, designing, fitting, customizing, adapting” to personal hearing instruments and HAT, maintaining/repairing (e.g., listening checks, changing the batteries) does fall within the interventions that support personal hearing instrument and HAT use. In the absence of an educational audiologist, SLPs may find themselves in situations in which a wide variety of school personnel have been or are currently in charge of HAT. The school-based SLP should work with the student’s audiologist (private), the teacher of the deaf and hard of hearing, and his/her supervisor to determine how the management of HAT can best be accomplished within the requirements of IDEA and professional scopes of practice. Selection of appropriate HAT devices, fitting, and management of HAT is a primary responsibility of audiologists; as such schools may need to contract with audiologists to perform these duties.

34 CFR 300.6 Assistive Technology Service

Assistive technology service means any service that directly assists a child with a disability in the selection, acquisition, or use of an assistive technology device. The term includes—

(a) The evaluation of the needs of a child with a disability, including a functional evaluation of the child in the child’s customary environment;
(b) Purchasing, leasing, or otherwise providing for the acquisition of assistive technology devices by children with disabilities;
(c) Selecting, designing, fitting, customizing, adapting, applying, maintaining, repairing, or replacing assistive technology devices;
(d) Coordinating and using other therapies, interventions, or services with assistive technology devices, such as those associated with existing education and rehabilitation plans and programs;
(e) Training or technical assistance for a child with a disability or, if appropriate, that child’s family; and
(f) Training or technical assistance for professionals (including individuals providing education or rehabilitation services), employers, or other individuals who provide services to, employ, or are otherwise substantially involved in the major life functions of children with disabilities.
Monitoring Cochlear Implants and Personal Hearing Instrument Function

The speech-language pathologist must be acutely aware of the legal responsibility of the school system for maintaining personal hearing instruments, including cochlear implants, and what is in and what is outside of his/her scope of practice. IDEA 2004 (34 CFR 300.113) requires schools to monitor performance of personal hearing instruments, including the external components of cochlear implants and other implanted hearing devices. As a result, schools should always include a monitoring plan that specifies who monitors the personal hearing instrument, when it is conducted, the procedures used, and what will happen if a problem is identified. It is recommended that this plan be included in the IEP. A sample amplification monitoring plan is located in Appendix 17-D.

34 CFR 300.113 Routine Checking of Hearing Aids and External Components of Surgically Implanted Medical Devices

Hearing aids. Each public agency must ensure that hearing aids worn in school by children with hearing impairments, including deafness, are functioning properly.

External components of surgically implanted medical devices.

1. Subject to paragraph (b)(2) of this section, each public agency must ensure that the external components of surgically implanted medical devices are functioning properly.

2. For a child with a surgically implanted medical device who is receiving special education and related services under this part, a public agency is not responsible for the post-surgical maintenance, programming, or replacement of the medical device that has been surgically implanted (or of an external component of the surgically implanted medical device).

Parent Counseling and Training

Parent counseling and training is a specific related service in IDEA. The law specifies that there are to be goals related to parent services as a component of the IEP when parents need assistance and information as well as acquiring skills to help their children accomplish their IEP goals in order to receive a free and appropriate public education (FAPE). Parents can choose whether they desire the support, but it must be made available by the LEA. Unfortunately, this service is underutilized and can be difficult to implement due to confusion about how to include the service in the IEP, how to provide the service, and how to promote and monitor parent compliance.

34 CFR 300.34(c)(8) Parent Counseling and Training

(i) Parent counseling and training means assisting parents in understanding the special needs of their child;

(ii) Providing parents with information about their child’s development; and

(iii) Helping parents to acquire the necessary skills that will allow them to support the implementation of their child’s IEP or IFSP.

(iv) This includes determination of children’s needs for group and individual amplification, selecting and fitting an appropriate aid, and evaluating the effectiveness of amplification.

Hearing Loss Prevention

As we further review the definition of audiology services within the school system, the portion of the IDEA that is most often overlooked, but is becoming increasingly important within the educational setting, is the prevention of hearing loss. Concern in this area is growing based on some of the following issues:

- Schools, as government entities, are exempt from the U.S. Occupational Safety and Health Administration’s (OSHA’s) standards unless there are state OSHA-like requirements; however, shop class noise levels have been reported to range from 85 dB to 115 dB (Langford & West, 1993).

- Noise regulations that do exist in schools apply primarily to classified staff (e.g., grounds, facility, print shop, cooking staff).
• Insurance companies for schools have limited knowledge of noise exposure hazards.
• School hearing screening is not mandated in all states; thus, a mechanism to identify children with potential NIHL is not consistently available. When screening programs do exist, they generally are not designed to identify students with NIHL.

Based on the results of the Third National Health and Nutrition Examination Survey (NHANES III), Niskar and colleagues (2001) estimated that 12.5% of children 6 to 19 years of age demonstrate hearing loss that can be directly attributed to high levels of noise exposure. In recognition of the evidence, the U.S. Department of Health and Human Services (2010) in its Healthy People 2020 goals includes the following objectives related to hearing loss prevention in adolescents:

• Objective ENT-VSL 6.2: Increase the proportion of adolescents 12–19 years who have ever used hearing protection devices (earplug, earmuffs) when exposed to loud sounds or noise.
• Objective ENT-VSL 7: Reduce the proportion of adolescents who have elevated hearing thresholds, or audiometric notches, in high frequencies (3, 4, or 6 kHz) in both ears, signifying noise-induced hearing loss.

Although there are many resources available that provide hearing loss prevention education (e.g., Dangerous Decibels, http://www.dangerousdecibels.org; Crank It Down, http://www.hearingconservation.org; Wise Ears!, http://www.nidcd.nih.gov/health/wise/), the difficulty lies in coordinating efforts for implementing a systematic hearing loss prevention education program within the curriculum.

Because of the effort necessary to address this area for all students, it is imperative that this service be part of a larger agenda shared by health and general education services. Hearing loss prevention education needs a national focus as a preventable health condition. Educational audiologists and SLPs should support such an effort by promoting the following activities (Johnson & Meinke, 2008):

• Noise education activities that are embedded within school health and science curriculums at multiple grade levels
• Identification of “at-risk” and “dangerous” noise sources
• Mandatory noise safety instruction for classes with potentially hazardous noise exposure, including strategies to minimize noise exposure in those settings
• Mandatory use of hearing protection for all individuals who work in noise hazard areas
• Mandatory monitoring of hearing levels of classified employees and teachers who work in noise hazard areas
• Training for school employees in hearing loss prevention, proper use of ear protection, noise control strategies, and interpretation of hearing test results
• School policies to limit decibel levels and exposure time at school-sanctioned events
• Required hearing screening of students that includes protocols targeted to identification of NIHL

Recent Reports
Recent reports (Hendershot, Pakulski, Dowling, & Price, 2011; Sekhar et al., 2011) suggest that the most effective method for identifying teens with NIHL is a combination of a high-risk screening questionnaire for noise exposure, followed by hearing screening of those who report noise exposure that includes pure tone threshold measurements at 1–8 kHz.

Habilitation in the Schools for Students Who Are Deaf and Hard of Hearing
Speech-language pathologists are part of a skilled group of professionals that provides a range of habilitation services to school-aged children with
hearing impairment. Depending on the school setting and degree of hearing impairment, these individuals may include, but certainly are not limited to, a teacher of the deaf and hard of hearing, a general education teacher, an educational interpreter, a teacher’s assistant or paraprofessional, a school social worker, a school psychologist, a learning disabilities teacher-consultant (LDT-C), and, hopefully, an educational audiologist.

**Auditory Habilitation**

Graduate preparation in habilitation for children who are deaf and hard of hearing varies according to the program and its clinical opportunities. Even when audiologists have had more training in pediatric auditory habilitation than their speech-language pathology and deaf education team members, they are often the least likely to provide these services because of time and resource restrictions. Regardless of who delivers the services, you should be involving the educational audiologist and teacher of the deaf/hard of hearing in the development of habilitation activities so that everyone is on-board and supporting and reinforcing the same goals. Both the SLP and the audiologist must attend all annual and review IEP meetings with the teacher of the deaf/hard of hearing to support and advocate for appropriate intervention services across the students’ various academic and extracurricular settings. The following list comprises specific areas that should be considered based on individual goals for each student:

- Auditory skill development and listening skill training
- Language development (expressive and receptive): oral, signed, cued, and/or written language, including pragmatics
- Speech production training, including phonology, voice, and rhythm
- Visual communication systems and strategies, including speech-reading, manual communication, and cued speech
- Selection and use of appropriate instructional materials and media
- Use of assistive technologies, such as those necessary to access media, phones, pagers, and alerting devices
- Case management and care coordination with family/parent/guardian, school, and medical and community services
- Compensatory skill training to reduce academic deficits as related to, but not limited to, reading and writing
- The transition between and among levels, schools, programs, and agencies.
- Support for a variety of education options for children/students with hearing impairment and/or APD
- Along with the incorporation of some or all of the service recommendations in Table 17.2, it is also important that IEP goals are aligned with the state’s common core content standards. Standards addressing speaking and listening skills generally match well with hearing, listening, and speaking objectives for children with hearing impairment.

**Counseling**

The psychosocial implications of hearing impairment can be easily overlooked, especially in mainstream classroom settings. SLPs working in a program for students with hearing impairment, or providing services privately outside of the school setting, must understand the connection between hearing impairment and the resulting communication challenges that often isolate children from their hearing peers. It is important to probe students, as part of the assessment process, to uncover feelings and issues about self-awareness, self-esteem, and social skills that need to be addressed through counseling.

Instruments such as the Classroom Participation Questionnaire (CPQ), Self-Assessment of Communication for Adolescents (SAC-A), and Significant Other Assessment of Communication for
Adolescents (SOAC-A) often translate into counseling opportunities. The SLP must be prepared to address issues that are identified by the student during the assessment or interview process. Sufficient time should be scheduled during the assessment period or shortly thereafter to give students the opportunity to briefly talk about their communication challenges and for the SLP to begin to skillfully guide them through a problem-solving process. Anytime a student divulges sensitive information, it deserves acknowledgement and a response, even if brief. Scheduling of more in-depth counseling by the appropriately trained school personnel (i.e., social worker or school psychologist) can be scheduled once the “door has opened” (English, 2002).

### Self-Determination and Self-Advocacy

Self-determination is based on the belief that all individuals have the right to direct their own lives (Bremer, Kachgal, & Schoeller, 2003) and that a self-determined person is able to make use of knowledge and understanding of themselves (i.e., their characteristics, strengths, and limitations) to make decisions about one’s life (Wehmeyer, Kelchner, & Richards, 1996). Self-determination skills are therefore essential for achieving successful habilitation outcomes, particularly self-advocacy and personal responsibility for managing one’s hearing impairment, accommodations, and associated supports. Self-advocacy is a growing area of focus for deaf and hard-of-hearing students that builds upon self-determination skills. Students need to be able to effectively describe their hearing status and the necessary accommodations they require for various learning and communication situations as part of the process of becoming responsible for their hearing and communication needs. Independence with hearing aids, cochlear implants, HAT, classroom amplification, and implementing accommodations should occur as early as possible, with expectations for basic self-advocacy beginning in kindergarten or sooner.

Let’s consider an example of how self-determined learning translates to practice.

- **Our goal** is for our students to understand the impact of their hearing status on academic

### Table 17.2  Suggested Audiology IEP Services

<table>
<thead>
<tr>
<th>Service</th>
<th>Where to Include in the IEP</th>
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<tbody>
<tr>
<td>Training for students regarding use of their hearing aids, cochlear implants, and hearing assistance technology; self-advocacy development</td>
<td>IEP Goals and Objectives: Audiology-Related Services: Habilitation Assistive Technology Services</td>
</tr>
<tr>
<td>Counseling and training for students regarding their hearing loss and associated implications for communication and learning</td>
<td>IEP Goals and Objectives: Audiology-Related Services: Counseling</td>
</tr>
<tr>
<td>Recommending acoustic modifications based on classroom acoustic evaluations that structure or modify the learning environment</td>
<td>Accommodations</td>
</tr>
<tr>
<td>Educating and training teachers, other school personnel, and parents, when necessary, about the student’s hearing impairment, communication access needs, amplification, and classroom and instructional accommodations and modifications</td>
<td>Assistive Technology Services</td>
</tr>
<tr>
<td></td>
<td>Access Skills</td>
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<td></td>
<td>Audiology-Related Services: Parent Counseling and Training Related Services</td>
</tr>
<tr>
<td>Monitoring the functioning of hearing aids, cochlear implants, and hearing assistance technology (by who, how often, where, procedures used to monitor, and what will occur when a problem is identified)</td>
<td>Routine Checking of Hearing Aids and External Components of Surgically Implanted Medical Devices</td>
</tr>
<tr>
<td></td>
<td>Monitoring Plan Addendum to IEP</td>
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</tbody>
</table>
learning, relationships, participation in community activities, and employment.

- **Our tool** is Guide to Access Planning (GAP), an online learning resource available on the Phonak website (https://www.phonakpro.com/us/en/resources/counseling-tools/pediatric/gap.html) that promotes self-advocacy and personal responsibility. The curriculum includes tools for self-assessment of knowledge and materials regarding hearing impairment, use of hearing and other assistance technologies, disability and access laws, accommodations, and other skills necessary for independence after high school. There are also student-focused resources for problem solving difficult communication situations. The GAP complements high school transition activities with materials designed specifically for teens and young adults who are deaf and hard of hearing.

- **Our challenge** is for our students to be motivated and engaged in learning this information because they find it relevant, fun, and interesting; able to facilitate their own learning by setting goals, seeing options, solving problems, and evaluating outcomes; and experience success from their learning. Furthermore, it is critical that the students decide what is important to them to learn and that they have a supportive environment that promotes personal empowerment.

**Educating Children Who Are Deaf and Hard of Hearing: A Historical Perspective**

The first recorded schools for the deaf were created and administered by Pedro Ponce de Leon in Spain in the 1500s. Schools in France and Germany were opened in the 1700s, and it was Abbé de L'Épée in France who first utilized finger spelling and sign language (manual communication). Laurent Clerc was a student at this school for deaf children in Paris. Following his formal education, he became a teacher there. In 1815, he traveled to England for a public speaking engagement and it was there that he met a young Thomas Hopkins Gallaudet. Clerc invited Gallaudet back to France and became his teacher. Together, Clerc and Gallaudet traveled to the United States and, in 1817, started the first American school for the deaf in Connecticut. Its first classes were instructed in a room of an old hotel. This school remains today as the American School for the Deaf in Hartford, Connecticut.

It was at that time that a discussion originated between Alexander Graham Bell and Edward Miner Gallaudet (son of Thomas Gallaudet) over whether to use manual communication and/or a speech-reading/oral communication approach to maximize an individual’s residual hearing. The inception of amplification in the early 1900s brought into play the idea that deaf individuals, once thought to be both deaf and “dumb” (e.g., cognitively impaired), could, in fact, be “assimilated into the hearing world” by the use of amplification and lip-reading. This premise led schools in the early 1900s to adopt an aural (ear and hearing)/oral (speech only) approach to deaf education. The controversy over the “best method” for educating deaf and hard-of-hearing students—in essence, “to sign or not to sign”—still permeates the Deaf community today (Schow & Nerbonne, 2007). Although one may associate deaf education and audiology as working hand in hand, the field of audiology is actually much younger than that of deaf education. Today, the Common Ground project, on behalf of Option Schools (representing private or charter oral schools) and the Conference of Educational Administrators of Schools for the Deaf (CEASD), representing traditionally American Sign Language (ASL) schools, is bringing together both sides focused on the many areas of deaf education in which members of these groups have agreement.
Considerations for Educational Service Provision

Several important areas must be addressed when considering educational services for children with hearing impairment. Eligibility, 504 plans, multi-tiered systems of support (MTSS) and response to intervention (RTI), referral for evaluation for special education, special considerations for communication needs in the IEP, and placement options each have specific implications. A 2014 policy guidance issued jointly by the U.S. Departments of Justice and Education, *Frequently Asked Questions on Effective Communication for Students with Hearing, Vision, or Speech Disabilities in Public Elementary and Secondary School*, describes eligibility and accommodations under Title II of the ADA. This policy clarifies two critical points: (1) it affirms that IEP students are also eligible for services under ADA and (2) additional accommodations may be required to ensure communication is as effective as for nondisabled peers. Therefore, the ADA standard for effective communication is higher than the IDEA requirements of “reasonable” accommodations. The communication preferences of the individual are paramount when determining appropriate auxiliary aids and services. In the absence of an educational audiologist, the SLP may have a greater role in advocating for the student along with the teacher of the deaf and hard of hearing, to make sure that the IEP team (the child study team, school personnel, and parents) understands the implications of the student’s hearing impairment, especially language and communication issues, that may limit his or her access to the educational curriculum.

504 Service Provision

When an IEP team determines that a child’s hearing impairment does not adversely affect his or her educational performance, the child is not eligible for special education services. The student should then be considered for accommodations under ADA using a 504 accommodation plan. Although ADA and Section 504 of the Rehabilitation Act do not include the individual entitlements that are part of special education, they do provide protection through the Office of Civil Rights (OCR) under the U.S. Department of Education. A 504 plan is generally developed by a school-based team under regular education. This team is frequently composed of a school administrator and/or school counselor, and/or lead teacher, and/or the school nurse. Depending on local procedures, a representative from special education may also be involved. For an effective 504 plan, it is critical that the educational audiologist, SLP, or other specialist experienced with hearing impairment in children, as well as the student, be involved in the development of the accommodations plan. Each student’s 504 plan should be monitored annually and adjusted accordingly, even though there are no specific federal procedures that dictate the development of the plan, and how it is implemented or monitored. However, some states or local municipalities may have additional imposed timelines. It is imperative that the SLP be familiar with the local policies regarding 504 accommodation plans.

Students with hearing impairment who have a 504 plan, as well as those not receiving any support services, should have their hearing and school performance monitored at least annually to determine if they are exhibiting educational problems that require a future referral for special education. Students with hearing impairment who are not receiving special education services are the most vulnerable for falling through the cracks and eventually falling behind in school. The SLP should be aware of state and local procedures for special education eligibility and 504 plans so they can properly advocate for the hearing and learning needs of all of these students and prevent unnecessary failure.
Multitiered Systems of Support and Response to Intervention Initiatives

MTSS is similar to RTI, but is a broader approach to intervention that includes RTI as one component. MTSS is considered more comprehensive because it provides more supports to educators, including behavioral instruction and intervention, professional development, technology tools, and school-community collaboration. Both initiatives include methods for monitoring school performance and ensuring that the recommended accommodations are implemented correctly and are meeting the needs of children for academic success in the general education setting. MTSS/RTI initiatives have added additional dimensions to services within the general education classroom. These models are essentially prevention programs to reduce special education referrals and are based on applying a succession of increasingly more intensive interventions based on the individual needs of children as part of the general education delivery system. The hallmarks of RTI are that the programs must be school wide (i.e., apply to all children), must provide high-quality instruction matched to individual student needs, must include frequent monitoring of student progress to inform of changes in instruction, and must utilize child response data to make educational decisions (National Association of State Directors of Special Education [NASDSE], 2005). The multitiered RTI model should integrate the resources of general education, special education, and gifted education as well as any other school student support programs.

The implications of RTI include greater emphasis on research-based interventions that benefit students within the multiple tiers of the model (NASDSE, 2005). For children with hearing impairment and APD, these interventions include appropriate classroom acoustics and use of classroom audio distribution systems (CADS), both well-documented accommodations for all children (Crandell & Smaldino, 2000; Iglehart, 2008) that can be implemented at the Tier-1 universal level. Tier-2 interventions are individualized and might include special flexible seating or use of a personal FM system—again, accommodations that are known to be effective for children with special listening needs (Anderson & Goldstein, 2004; Boothroyd, 1992, Schafer & Thibodeau, 2003). To support children and youth with hearing and listening problems, audiologists and SLPs should be involved with school multidisciplinary teams through MTSS to ensure that appropriate interventions and accommodations are instituted.

While school-wide MTSS/RTI models are widely used, more will be learned about how general education and special education supports are integrated throughout the tiers of intervention to support students with hearing impairment in special education as well as those who may be on 504 plans because they do not meet special education eligibility. It is important to remember that MTSS/RTI is not special education. An important distinction of MTSS/RTI is its focus on prevention as compared to failure for special education services. Therefore, MTSS/RTI opens the door for SLPs and audiologists to support the classroom listening needs of all students who might benefit from listening-based services, not just those who have IEPs. Although this support is important, SLPs are reminded that schools cannot use MTSS/RTI strategies to delay or deny a timely referral and evaluation for children suspected of having a disability (DOE, 2011). Therefore, the SLP may need to advocate for a child with hearing impairment, making a direct referral to the child study team in order to address the specialized instruction needs of the student.

Eligibility for Special Education and Related Services

Part B of IDEA requires that a disability must have an adverse impact on learning for a student to be eligible for special education. Therefore, audiological assessment must include the procedures required by individual states for eligibility determination.
Some states use the federal definitions for **hearing impairment** and **deafness**, whereas other states have specific decibel and performance criteria. A child age 3 to 22 years with a hearing impairment that manifests itself within the educational setting is eligible for special education and related services under the disability condition of deafness or hearing impairment [34 CFR 300.8 (b)]:

1. **Deafness** means a hearing impairment that is so severe that the child is impaired in processing linguistic information through hearing, with or without amplification, that adversely affects a child’s educational performance.

2. **Hearing impairment** means an impairment in hearing, whether permanent or fluctuating, that adversely affects a child’s educational performance but that is not included under the definition of deafness in this section.

After reviewing these general definitions, one can see that interpretation can and does vary from state to state, or even from municipality to municipality. Typically, APD is not considered an auditory impairment under either of these definitions. APD may be addressed as an aspect of a specific learning disability or communication impairments under most state administrative codes for education. This variability has led some states to add additional “technical” information to their state education code to define hearing impairment as well as criteria for adverse effect.

Audiological assessments are required for initial eligibility and review evaluations. Because audiological assessments for children and youth are typically completed annually in order to monitor hearing thresholds, use and performance of hearing technologies, and functional performance, the child study team should include annual hearing evaluations in the child’s IEP.

Services under IDEA Part C, early intervention for infants and toddlers, are non-categorical and based on evidence of a physical or mental condition that has a high probability of resulting in developmental delay. An important issue is the increasing number of children who are not found eligible at transition to Part B. SLPs must work with their multidisciplinary teams to ensure that assessments are sufficiently comprehensive to uncover any present or potential language, listening, communication, or other developmental deficits that may impact progress in the highly critical preschool years as we prepare these children for kindergarten readiness.

### Special Considerations

The IDEA regulation 34 CFR 300.324(a)(2), Consideration of Special Factors, is the heart of the IEP for students who are deaf or hard of hearing. IEP teams must consider various aspects of language and communication access for every student as part of each annual meeting. The review should consider each element of the regulation, allowing for discussion regarding the current status and recommendations that should be addressed in the IEP. For example, if a student is the only one at the school with a hearing impairment, a discussion about opportunities for direct communication with peers in that child’s language and communication mode might result in bringing students in similar settings together a few times a year to provide peer social and learning opportunities. Ideally, the special factors discussion occurs early in the IEP meeting so that the IEP goals and services reflect the issues discussed. Some states have documents or forms within the IEP that guide the discussion for this regulation. Other states have passed Deaf Child Bill of Rights legislation that has essentially the same purpose (i.e., ensuring communication access in the child’s language and communication mode), but contains additional considerations and requirements. School-based SLPs must thoroughly understand this regulation and any comparable state regulations to ensure they are applied appropriately in the IEP process, while advocating for language and communication access. There are a wide variety of services appropriate for a SLPs to include in an IEP for a student with hearing impairment.
impairment. Refer to Table 17.2 for an overview of suggested goals.

34 CFR 300.324(a)(2). Development, Review, and Revision of the IEP Consideration of Special Factors

The IEP team must—

(iv) Consider the communication needs of the child, and in the case of a child who is deaf or hard of hearing, consider the child’s language and communication needs, opportunities for direct communication with peers and professional personnel in the child’s language and communication mode, academic level, and full range of needs, including opportunities for direct instruction in the child’s language and communication mode;

(v) Consider whether the child needs assistive technology devices and assistive technology services.

Communication Approaches for Children Who Are Deaf and Hard of Hearing

A number of communication approaches are available for children who are deaf or hard of hearing to learn speech and language. Both traditional and contemporary approaches are described in Table 17.3. Although there are no data that clearly illustrate that one communication approach leads to better educational outcomes than another, the speech-language pathologist may still find him- or herself in the midst of a longstanding controversy about different educational philosophies for deaf and hard-of-hearing students. According to Gravel and O’Gara (2003; p. 244), “both spoken and visual language approaches over the years have had strong proponents, which have led to the development of separate programs for the training of deaf educators and separate schools/classrooms wherein one philosophy or method of training/educating children who are hard of hearing or Deaf has been practiced.”

At this point in the text, the SLP should have a clear understanding that, if not adequately addressed, the effects of a hearing impairment on receptive and expressive language skill acquisition can be debilitating, causing “restricted academic performance (literacy skills) and soon after, hinder an individual’s opportunities for vocational choice and advancement” (Gravel & O’Gara, 2003; p. 243). When parents of a child with hearing impairment are faced with the reality that their child will potentially have a lifetime of communication challenges, it is the SLP’s role to step in, work with the concerns of the parents, and, if need be, refer the family to the appropriate professionals for more in-depth counseling services.

The SLP may find him- or herself working in early intervention (IDEA Part C) as part of a team creating an Individual Family Service Plan (IFSP). The United States Early Hearing Detection and Intervention program’s (EDHI’s) 1-3-6-month timeline of screening, evaluation, and enrollment in early intervention can leave a parent of a child newly identified with a hearing impairment reeling. Parents may not have had time to work through the grieving process to accept the presence of the hearing impairment in their child before being pressed to make important decisions regarding amplification, communication modalities, and programming for their child. The SLP will play an important role in assisting the parent through this process, reassuring the family that this is a process that can be adjusted as needed based on the abilities of the child as she or he develops over time.

When discussing what is in the best interests and needs of the child, SLPs must put aside their own opinions and consider all factors that will influence this child’s communication abilities. Some of these factors include type and degree of hearing impairment, mode of communication at home (spoken or American Sign Language [ASL]), age of child when identified with hearing
Table 17.3  Communication Approaches Used by Children Who Are Deaf and Hard of Hearing

<table>
<thead>
<tr>
<th>Approach Modalities</th>
<th>Descriptions of Traditional Approaches</th>
<th>Descriptions of Contemporary Approaches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primarily Auditory</td>
<td><strong>Auditory–Verbal (AV)</strong></td>
<td><strong>Listening and Spoken Language (LSL)</strong></td>
</tr>
<tr>
<td></td>
<td>The AV approach uses listening and speaking to facilitate communication. There is no access to Deaf culture or to sign language. The AV approach maximizes residual hearing through the use of amplification. During the therapy sessions clinicians often cover their mouths requiring the child to listen through his/her hearing aids/cochlear implants to hear the speech sounds to increase auditory access to the surrounding world and to successfully communicate with others in all environments.</td>
<td>LSL is the current term used to describe the auditory–verbal approach. LSL and AVT certification have become increasingly popular in the field of speech-language pathology for professionals to gain a greater understanding of auditory–verbal communication. Certifications for “LSLS Cert.AVT” (auditory verbal therapist) and “LSLS Cert.AVEd” (auditory verbal educator) are available through the Alexander Graham Bell Academy for Listening and Spoken Language. For further information readers are directed to the website: <a href="http://www.Listeningandspokenlanguage.org">http://www.Listeningandspokenlanguage.org</a>.</td>
</tr>
<tr>
<td>Auditory with Visual Support</td>
<td><strong>Auditory–Oral</strong></td>
<td></td>
</tr>
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<td></td>
<td>The auditory–oral approach is similar to AV or LSL incorporating the use of amplification (hearing aids/cochlear implants/HAT) utilizing the child’s residual hearing to develop his/her speech/language skills. While this approach does not use sign language or finger spelling it does encourage visual communication strategies such as facial expression, lip-reading, gestures, and reading body language. Children learn to use a natural auditory approach in their homes as well as in their schools and communities.</td>
<td></td>
</tr>
<tr>
<td>Auditory-Visual</td>
<td><strong>Cued Speech</strong></td>
<td><strong>Bilingual-Bimodal</strong></td>
</tr>
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<td>Cued speech is a spoken English/visual cue strategy that utilizes eight hand shapes in four different positions around the speaker’s face (see Figure 17.1) providing a phonetic representation of English syllables. The visual cues are incorporated because many of the different-sounding vowels and consonants can appear the same when lip-reading. The visual cues (hand pattern and location, mouth positioning) help the child to identify each sound. The use of amplification is encouraged (hearing aids/cochlear implants/HAT), and families are trained in the use of the speech cues. Cued speech can be considered a gateway for ASL users to learn English (Gravel &amp; O’Gara, 2003).</td>
<td>The bilingual-bimodal approach incorporates ASL (or other native sign language) and spoken English (or other spoken language) yielding communication through two languages and two modalities. Both languages have equal value and representation. This approach is increasingly common as more children utilize both approaches for communication access based upon communication situations and partners.</td>
</tr>
<tr>
<td>Visual with Auditory Support</td>
<td><strong>Total Communication (TC)</strong></td>
<td><strong>Simultaneous Communication</strong></td>
</tr>
<tr>
<td></td>
<td>The TC approach is philosophy that incorporates multiple modalities (e.g., ASL, manually coded English, or a derivative such as signing exact English (SEE), finger-spelling, lip-reading, nonverbal cues, amplification) to communicate. The speaker generally uses spoken English simultaneously with manual/visual methods to successfully communicate (Hawkins &amp; Brawner, 1997). As with the other modalities, amplification to maximize on the child’s residual hearing is encouraged.</td>
<td>The TC philosophy is generally represented practically in a dual approach of speaking and signing known as simultaneous communication. In this approach the signs (derived from ASL or other signed English system) are in English word order to match the spoken English words. Communication is also supported by other visual strategies such as facial expression and lip-reading.</td>
</tr>
</tbody>
</table>
impairment and age of amplification, how family members will communicate with the child, preferences and motivation of parents and family members, and type of amplification used (hearing aids/cochlear implants). Before decisions are made, all variables must be considered and discussed with the family as part of the IFSP process and the IEP process for children 3 years and older. Parents should never feel that they are locked into a decision or made to feel guilty for a decision they have made. The Centers for Disease Control (CDC) document, *Making a Plan for Your Child: IFSP Considerations for Your Child Who Is Deaf or Hard of Hearing*, is an effective tool to guide parents and ensure that their family’s preferences and child’s communication needs are addressed (http://www.cdc.gov/ncbddd/hearingloss/freematerials/planforyourchild.pdf). The Joint Committee on Infant Hearing (JCIH) Supplement to the 2007 JCIH Position Statement, *Principles and Guidelines for Early Intervention After Confirmation that a Child Is Deaf or Hard of Hearing* (March 25, 2013) contains critical guidance for all professionals, including SLPs, serving these children and their families (AAP, 2013).

Do not ever let anyone tell you that this is easy. The prevailing wisdom espoused by the parent organization, Hands & Voices, is “what works for your child is what makes the choice right” (Applegate, 2014). When considering what is working for a child, clinicians need to use the child’s developmental progress and trajectory data to guide parents with regard to communication and early intervention services.

### Table 17.3 Communication Approaches Used by Children Who Are Deaf and Hard of Hearing (Continued)

<table>
<thead>
<tr>
<th>Approach Modalities</th>
<th>Descriptions of Traditional Approaches</th>
<th>Descriptions of Contemporary Approaches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primarily Visual</td>
<td><strong>Manually Coded English (MCE)</strong></td>
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<tr>
<td></td>
<td>The MCE approach is made up of signs that are a visual code for spoken English. MCE incorporates finger-spelling and signing and follows the rules of English syntax (grammar/sentence structure). Spoken language may or may not accompany MCE to fully convey a message. Finger-spelling is used to transmit morphemes that do not translate with sign. Amplification is not always used with MCE. MCE can be advantageous in environments with high amounts of background noise when attempting to communicate orally, because the visual input takes the place of the missed spoken word, making it easier for the child to understand the message. Signing exact English (SEE2), seeing essential English (SEE1) and conceptually accurate signed English (CASE) are variations of MCE.</td>
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<td></td>
<td><strong>American Sign Language (ASL)</strong></td>
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<tr>
<td></td>
<td>ASL is a complete language with grammatical structures presented in a visual form. There is no written or spoken version of ASL. It is the language of the Deaf community in the U.S.</td>
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<tr>
<td></td>
<td><strong>Bilingualism</strong></td>
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<tr>
<td></td>
<td>Bilingualism refers to two languages and in this context refers to ASL as the language of visual communication and English as the written language for reading and writing. Bilingualism is common in schools and special programs for the Deaf where ASL is the language of communication and instruction and English is learned through reading and writing.</td>
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</tr>
</tbody>
</table>

### Student Service and Placement Considerations

Many factors influence decisions about the services provided to students who are deaf or hard of hearing and the location of those services. Services may be consultative, itinerant, or more direct instruction. The service options typically include the
general education classroom, a resource classroom, a special day program such as a regional program for students who are deaf and hard of hearing, or a school for the deaf. While IDEA requires a continuum of options, federal law also specifies “free and appropriate public education” (FAPE). Not always do these two mandates marry. Often, the options are limited by resources and the number of students with “like disability” in that area. If our goal is to set students up for a productive school experience, then we owe them a thorough evaluation to assess their ability to be successful in the recommended classroom environment. Even if the most appropriate instructional situation is not available, knowing the student’s limitations helps identify key supports that are needed to support their learning. The Readiness Checklists component of the Placement and Readiness Checklists (PARC) protocol (available at http://www.ADEvantage.com) covers the areas of inclusion, use of sign language interpreting, use of captioning, and competency for instruction in listening and spoken language (LSL), sign language, or both. The functional assessments within the CLA also provide information that should be used when determining services and placement. Data sources such as these keep the IEP team focused on the student’s abilities and performance rather than assumptions about learning. The audiologist, SLP, and teacher of the deaf must be strong advocates to guide these decisions. Another useful tool when assessing the educational needs of a deaf or hard-of-hearing student is the Colorado Individual Performance Profile (CIPP). This tool allows the evaluator to collect a wide range of functional and standardized assessment data on an individual student. Based on the data collected, a profile for educational service provision is derived. Using a tool that allows the professional to collect data from a wide variety of sources, gaining a comprehensive profile of the student’s strengths and weaknesses, will aid in establishing an appropriate educational program that may minimize bias about that student from school personnel.

Schools for the Deaf and other special schools and programs for students who are deaf or hard of hearing have unique responsibilities for the speech-language pathologist. In most instances, these schools and programs employ educational audiologists. In these environments, the educational audiologist and the SLP work in collaboration to support the communication system(s) utilized by the student or that are the philosophy of the school. This collaboration should ensure auditory communication access for those students who utilize hearing and listening whether a primary means of communication or to supplement or accompany visual systems (e.g., American Sign Language, signed English, manually coded English, or cued speech (see Figure 17.1)), while being sensitive to the preferences of the child, his or her family, and the culture of the school.

Help! I Need an Educational Audiologist

There are two primary methods that schools may utilize to deliver audiology services: (1) employment directly by the local education agency (LEA) responsible for providing special education and related services, or (2) a contract with an individual, organization, or agency for specified audiology services. Many school districts that do not employ a full-time educational audiologist will consider many services provided within the school setting the responsibility of the SLP and the teacher of the deaf/hard of hearing who service that specific setting. Again, emphasis is placed on the determination of what is and is not within the scope of practice for the SLP. At the very least, the district should be providing the SLP with the resources to consult with an educational audiologist under these conditions. The Educational Audiology Association’s document, Supporting Students Who Are Deaf and Hard of Hearing: Recommended Roles of Educational Audiologists, Teachers of the Deaf/Hard of Hearing and
### Consonants

1. /d, p, 3/ 
   - deep azure
2. /ð, k, v, z/ 
   - the caves
3. /r, h, s/ 
   - rehearse
4. /b, m, n/ 
   - by when
5. /m, f, t/ 
   - miffed
6. /w, l, j/ 
   - Welsh
7. /θ, g, dʒ/ 
   - thug Joe
8. /j, ŋ, tj/ 
   - young church

### Vowels

- **Mouth**
  - /i, ɪ, ə/ 
    - fir tree

- **Side**
  - /ʌ, ɔ, o, ɔ/ 
    - Aloha

- **Chin**
  - /u, ʊ, ɛ/ 
    - too tall

- **Throat**
  - /ʊ, ə, ɪ/ 
    - Look at it

### Diphthongs

- **Side-throat**
  - /æ, au/ 
    - time out

- **Chin-throat**
  - /ɔi, ei/ 
    - Oy vay!

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**Figure 17.1**  Cued speech chart.
Speech-Language Pathologists, is a valuable planning resource for insuring your team is addressing the necessary areas that support students who are deaf or hard of hearing.

Another avenue that may be available to the local educational agency is a consortium established by the state that provides special education services for a group of school districts. These consortiums are usually referred to as boards of cooperative educational services (BOCES), intermediate units (IU), or area education agencies (AEA), and they are structured under the respective state department of education to provide special education services. In the absence of the services of an educational audiologist, the speech-language pathologist may need to advocate for the local school district to establish such services to meet the needs of the children and ensure FAPE. For more information about contracting audiology services, see the Educational Audiology Association’s Guidelines for Developing Contracts for School-Based Audiology Services at http://www.edaud.org.

Resources Through the Educational Audiology Association

In addition to the recommended roles and contract guidelines documents mentioned previously, the Educational Audiology Association (EAA) has developed several resources to assist with the development and implementation of school-based audiology services. The School-Based Audiology Advocacy Series contains brief statements in the topics indicted below regarding typical audiology services in the schools:

- School-Based Audiology Services Overview
- Assessment
- Auditory Processing Deficits
- Auditory (Re)habilitation
- Audiology Services Under 504
- Classroom Acoustics
- Classroom Audio Distribution Systems
- Counseling
- Educational Audiology Services Under IDEA: Pertinent Regulations
- Hearing Assistance Technology
- Hearing Screening
- Noise and Hearing Loss Prevention
- References and Resource Materials
- Response to Intervention
- The Educational and Clinical Audiology Partnership
- The Educational Audiologist’s Role in EHDI and Ongoing Hearing Loss Surveillance in Young Children

These documents are particularly useful when discussing educational audiology with general educators, administrators, school boards, or other groups. A PowerPoint presentation based on this series provides an illustrated version of these statements. These resources are available at the EAA website, http://www.edaud.org.

Summary

Effective support and services are critical to all children and youth with hearing impairment in the schools. Educational audiologists have distinctive roles and responsibilities to ensure that these students are identified, properly assessed, and managed so that they have the same opportunity to access their educational program as all students. Speech-language pathologists are instrumental in
facilitating services and working collaboratively with the educational audiologist for the success of students with hearing impairments or APD. Students who are deaf or hard of hearing can be served within the educational setting through a number of federal and state laws. Services available to the student should be based on the severity of their disability and its impact on access to information within the classroom. Hard-of-hearing students face an extra communication challenge due to their hearing status; it is the job of the speech-language pathologist to work closely with not only the educational audiologist, but all school personnel to support deaf and hard-of-hearing students to minimize the impact of that impairment. Whether through a 504 plan or an IEP, these students can easily meet with academic success when appropriate services and supports are in place.

**DISCUSSION QUESTIONS**

1. Name two specific areas of service provision within 34 CFR 300 that are not within your scope of practice. Name three areas in which you may serve a child who is deaf or hard of hearing.

2. A child with a cochlear implant enters your program. For what portion(s) of the implant is the LEA responsible?

3. What are the major differences between a 504 accommodation plan and an Individualized Education Plan (IEP)?

4. List three ways you may access an educational audiologist. Choose one, and provide specific references and contact information for your geographic area.

5. Name the various communication approaches used by students who are deaf or hard of hearing. Choose one approach to describe and discuss.

**REFERENCES**


Part B: Related Services, 34 CFR 300.34(b)

Exception: services that apply to children with surgically implanted devices, including cochlear implants.

(1) Related services do not include a medical device that is surgically implanted, the optimization of that device's functioning (e.g., mapping), maintenance of that device, or the replacement of that device.

(2) Nothing in paragraph (b)(1) of this section—
   (i) Limits the right of a child with a surgically implanted device (e.g., cochlear implant) to receive related services (as listed in paragraph (a) of this section) that are determined by the IEP team to be necessary for the child to receive FAPE.
   (ii) Limits the responsibility of a public agency to appropriately monitor and maintain medical devices that are needed to maintain the health and safety of the child, including breathing, nutrition, or operation of other bodily functions, while the child is transported to and from school or is at school; or
   (iii) Prevents the routine checking of an external component of a surgically implanted device to make sure it is functioning properly, as required in Sec. 300.113(b).

Part B: Definition of Audiology, 34 CFR 300.34(c)(1)

Audiology includes—
   (i) Identification of children with hearing loss;
   (ii) Determination of the range, nature, and degree of hearing loss, including referral for medical or other professional attention for the habilitation of hearing;
   (iii) Provision of habilitation activities, such as language habilitation, auditory training, speech-reading (lip-reading), hearing evaluation, and speech conservation;
   (iv) Creation and administration of programs for prevention of hearing loss;
   (v) Counseling and guidance of children, parents, and teachers regarding hearing loss; and
   (vi) Determination of children’s needs for group and individual amplification, selecting and fitting an appropriate aid, and evaluating the effectiveness of amplification.
Part C: Definition of Audiology, 34 CFR 303.13(d)(2)
Audiology includes—

(i) Identification of children with impairments, using at-risk criteria and appropriate audiological screening techniques;
(ii) Determination of the range, nature, and degree of hearing loss and communication functions, by use of audiologic evaluation procedures;
(iii) Referral for medical and other services necessary for the habilitation or rehabilitation of children with auditory impairment;
(iv) Provision of auditory training, aural rehabilitation, speech-reading and listening device orientation and training, and other services;
(v) Provision of services for the prevention of hearing loss; and
(vi) Determination of the child’s need for individual amplification, including selecting, fitting, and dispensing of appropriate listening and vibrotactile devices, and evaluating the effectiveness of those devices.

Part B: Interpreting Services, 34 CFR 300.34(c)(4)
Interpreting services includes—

(i) The following, when used with respect to children who are deaf or hard of hearing: oral transliteration services, cued language transliteration services, sign language transliteration and interpreting services, and transcription services, such as communication access real-time translation (CART), C-Print, and TypeWell; and
(ii) Special interpreting services for children who are deaf-blind.

Part B: Assistive Technology, 34 CFR 300.105(b)
On a case-by-case basis, the use of school-purchased assistive technology devices in a child’s home or in other settings is required if the child’s IEP team determines that the child needs access to those devices in order to receive FAPE.

Part B: Routine Checking of Hearing Aids and External Components of Surgically Implanted Medical Devices, 34 CFR 300.113
(a) Hearing aids. Each public agency must ensure that hearing aids worn in school by children with hearing impairments, including deafness, are functioning properly.
(b) External components of surgically implanted medical devices.

(1) Subject to paragraph (b)(2) of this section, each public agency must ensure that the external components of surgically implanted medical devices are functioning properly.

(2) For a child with a surgically implanted medical device who is receiving special education and related services under this part, a public agency is not responsible for the post-surgical maintenance, programming, or replacement of the medical device that has been surgically implanted (or of an external component of the surgically implanted medical device).
Part B: Development, Review, and Revision of IEP, 34 CFR 300.324

(2) Consideration of special factors. The IEP team must—

(iv) Consider the communication needs of the child, and in the case of a child who is deaf or hard of hearing, consider the child's language and communication needs, opportunities for direct communications with peers and professional personnel in the child's language and communication mode, academic level, and full range of needs, including opportunities for direct instruction in the child's language and communication mode.

Part B: Assistive Technology Device, 34 CFR 300.5

Assistive technology device means any item, piece of equipment, or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve the functional capabilities of children with disabilities. The term does not include a medical device that is surgically implanted, or the replacement of such device.

Part B: Assistive Technology Service, 34 CFR 300.6

Assistive technology service means any service that directly assists a child with a disability in the selection, acquisition, or use of an assistive technology device. The term includes—

(a) The evaluation of the needs of a child with a disability, including a functional evaluation of the child in the child's customary environment;

(b) Purchasing, leasing, or otherwise providing for the acquisition of assistive technology devices by children with disabilities;

(c) Selecting, designing, fitting, customizing, adapting, applying, maintaining, repairing, or replacing assistive technology devices;

(d) Coordinating and using other therapies, interventions, or services with assistive technology devices, such as those associated with existing education and rehabilitation plans and programs;

(e) Training or technical assistance for a child with a disability or, if appropriate, that child's family; and

(f) Training or technical assistance for professionals (including individuals providing education or rehabilitation services), employers, or other individuals who provide services to, employ, or are otherwise substantially involved in the major life functions of that child.

Part B: Definitions, 34 CFR 300.8(b)

(2) Deaf-blindness means concomitant hearing and visual impairments, the combination of which causes such severe communication and other developmental and educational needs that they cannot be accommodated in special education programs solely for children with deafness or children with blindness.

(3) Deafness means a hearing impairment that is so severe that the child is impaired in processing linguistic information through hearing, with or without amplification that adversely affects a child's educational performance.

(5) Hearing impairment means an impairment in hearing, whether permanent or fluctuating, that adversely affects a child's educational performance but that is not included under the definition of deafness in this section.

The Classroom Acoustical Screening Survey Worksheet (AAA, 2011b; Appendix 7.1) contains observation considerations as well as a guide for making classroom acoustical measurements to identify whether classrooms meet ANSI noise and reverberation time standards (e.g., 35 dBA and 0.6 seconds for classrooms less than 10,000 cubic feet, which may be reduced to 0.3 seconds for children with special listening needs).
Deaf/Hard-of-Hearing Students

Student's Name
Date Completed
School
Trade
Teacher Administering Scale
District

Form completed for: _______ Language Arts/English ______ Social Studies _______ Science ______ Other (Please specify)

AT HOME (Please circle answer.)

1. How often does your family use sign language? Never Sometimes Often All the time

2. a. Are there any other family members who have a hearing loss? No Yes
   b. IF YES, circle who: Father Mother Brother Sister Other_________________________

IN SCHOOL- Please circle one answer for each question. If there are no other deaf/hard-of-hearing students in your class(es), ignore questions 7 and 8.

3. How do you like best to communicate with hearing students? Interpreter 1 Sign 2 Speech 3 Speech & Sign 4 Writing Notes 5

4. How do you like best for hearing students to communicate with you? Interpreter 1 Sign 2 Speech 3 Speech & Sign 4 Writing Notes 5

5. How do you like best to communicate with teachers? Interpreter 1 Sign 2 Speech 3 Speech & Sign 4 Writing Notes 5

6. How do you like best for teachers to communicate with you? Interpreter 1 Sign 2 Speech 3 Speech & Sign 4 Writing Notes 5

7. How do you like best to communicate with other deaf/hard-of-hearing students? Interpreter 1 Sign 2 Speech 3 Speech & Sign 4 Writing Notes 5

8. How do you like best for other deaf/hard-of-hearing students to communicate with you? Interpreter 1 Sign 2 Speech 3 Speech & Sign 4 Writing Notes 5

9. Do you typically use an interpreter in class? No Yes

10. How many other deaf/hard-of-hearing students are in your class(es)? 0 1–2 3–4 5 or more
Classroom Participation Questionnaire—Revised

DIRECTIONS:
• Read each sentence.
• Decide how often it happens for you.
• Circle the answer that is best for you.
• Be sure to circle an answer for each sentence.
• The word “understand” is used frequently in this questionnaire. “Understand” is defined as knowing the meaning of what is said or asked.

HERE IS AN EXAMPLE:
How often do you make your bed?
• Notice the circle pictures above each number. They are to help you think about how OFTEN you do something.
• Do you make your bed almost always? If so, you should circle number 4.
• If you almost never make your bed, you should circle number 1.
• If you seldom (not very often) make your bed, you should circle number 2.
• If you often make your bed, circle number 3.

NOW SELECT THE RESPONSE THAT IS BEST FOR YOU.

IF YOU HAVE ANY QUESTIONS PLEASE ASK THE TEACHER NOW!
If you use an interpreter, you understand what your teacher or classmates say through your interpreter. They understand what you say by listening to the interpreter.

If you do not use an interpreter, you understand what your teacher or classmates say by listening to them. They understand what you say by listening to you.

RESPOND TO EACH STATEMENT BASED ON THE WAY YOU USUALLY COMMUNICATE IN YOUR CLASS.
This questionnaire is not part of your schoolwork. It will not be graded. If the questions upset you, you can stop answering them at any time. We need your honest answers. Please read each question carefully. Thanks for your help.

1. I understand my teacher. 1 2 3 4
2. I understand the other students in class. 1 2 3 4
3. I join in class discussions. 1 2 3 4
4. I feel good about how I communicate in class. 1 2 3 4
5. I feel frustrated because it is difficult for me to communicate with other students. 1 2 3 4
6. I get upset because other students cannot understand me. 1 2 3 4
7. I get upset because my teacher cannot understand me. 1 2 3 4
8. I feel relaxed when I talk to my teacher. 1 2 3 4
9. I understand my teacher when she/he gives me homework assignments. 1 2 3 4
10. I understand my teacher when she/he answers other students’ questions. 1 2 3 4
11. I understand my teacher when she/he tells me what to study for a test. 1 2 3 4
12. I understand other students during group discussions. 1 2 3 4
13. I understand other students when they answer my teacher’s questions. 1 2 3 4
14. I feel happy in group discussions in class. 1 2 3 4
15. I feel good in group discussions in class. 1 2 3 4
16. I feel unhappy in group discussions in class. 1 2 3 4
## Classroom Participation Questionnaire—Revised

### Summary Sheet

**Student Name:**  
**Date:**  
**Grade:**  
**Class for which recorded:**

<table>
<thead>
<tr>
<th>Questions</th>
<th>Never</th>
<th>Sometimes</th>
<th>Often</th>
<th>All the Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 How often does your family use sign language?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Are there any other family members who have a hearing loss?</td>
<td>No</td>
<td>Yes</td>
<td>List who:</td>
<td></td>
</tr>
<tr>
<td>3 How do you like best to communicate with hearing students?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 How do you like best for hearing students to communicate with you?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 How do you like best to communicate with teachers?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 How do you like best for teachers to communicate with you?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 How do you like best to communicate with other deaf/hard-of-hearing students?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 How do you like best for other deaf/hard-of-hearing students to communicate with you?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 Do you typically use an interpreter in class?</td>
<td>No</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 How many other deaf/hard-of-hearing students are in your class(es)?</td>
<td>0</td>
<td>1–2</td>
<td>3–4</td>
<td>5 or more</td>
</tr>
</tbody>
</table>

**Desirable ratings are in the 3–4 range.**

1–Almost Never  
2 – Seldom  
3–Often  
4–Almost Always

<table>
<thead>
<tr>
<th>Subscale</th>
<th>Question Number</th>
<th>Questions</th>
<th>Ratings</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understanding Teacher (4)</td>
<td>1</td>
<td>I understand my teacher.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>I understand my teacher when he/she gives me homework assignments.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>I understand my teacher when he/she answers other students’ questions.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>I understand my teacher when he/she tells me what to study for a test.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mean of the Subtotal  

\[ \text{Mean of the Subtotal} = \frac{\text{Total}}{4} = \text{________} \]
### Understanding Student (4)

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>I understand the other students in class.</td>
</tr>
<tr>
<td>3</td>
<td>I join in class discussions.</td>
</tr>
<tr>
<td>12</td>
<td>I understand other students during group discussions.</td>
</tr>
<tr>
<td>13</td>
<td>I understand other students when they answer my teacher’s questions.</td>
</tr>
</tbody>
</table>

**Mean of the Subtotal**  
\[
\frac{\text{_____}}{4} = \text{______}
\]

### Positive Affect (4)

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>I feel good about how I communicate in class.</td>
</tr>
<tr>
<td>8</td>
<td>I feel relaxed when I talk to my teacher.</td>
</tr>
<tr>
<td>14</td>
<td>I feel happy in group discussions in class.</td>
</tr>
<tr>
<td>15</td>
<td>I feel good in group discussions in class.</td>
</tr>
</tbody>
</table>

**Mean of the Subtotal**  
\[
\frac{\text{_____}}{4} = \text{______}
\]

Desirable ratings are in the 1–2 range.

### Negative Affect (4)

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>I feel frustrated because it is difficult for me to communicate with other students.</td>
</tr>
<tr>
<td>6</td>
<td>I get upset because other students cannot understand me.</td>
</tr>
<tr>
<td>7</td>
<td>I get upset because my teacher cannot understand me.</td>
</tr>
<tr>
<td>16</td>
<td>I feel unhappy in group discussions in class.</td>
</tr>
</tbody>
</table>

**Mean of the Subtotal**  
\[
\frac{\text{_____}}{4} = \text{______}
\]

APPENDIX 17-D
SAMPLE PERSONAL AMPLIFICATION MONITORING PLAN

Student's Name: Aiden Hears  Date: August 15, 2016
Teacher: Mrs. Nice  Grade: 2
Hearing Aid Brand/Model: RE-Phonak Supero 411 LE-Phonak Supero 411
Cochlear Implant: 
Hearing Assistance Device: Brand/Model: Phonak Campus SX/MLxS

1. Individual responsible for basic monitoring of device(s):
   Teacher:
   Nurse:
   Aide: Mrs. Health Aide
   Audiology Asst:
   Self monitoring by student: Check battery

2. Where will device(s) be monitored? General education classroom ____ Special education classroom ____ Nurse's office ____ Other: ______

3. When will device(s) be monitored (daily/weekly and time of day)? Daily at beginning of school day

4. Procedures used to monitor device(s):

| Basic Check By: Mrs. Health Aide | 1. Verify that HA/FM is turned on and working.  
| 2. Conduct Ling Six-Sounds test. |
| Troubleshooting Strategies By: Mrs. Health Aide | Hearing aid check: battery, earmold, tubing, intermittency and static  
| FM system check: battery, FM connection and channel, intermittency, and static |
| Advanced Check By: Dr. Audiology | 1. Verify status using basic troubleshooting strategies.  
| 2. Conduct electroacoustic check. |

5. What will occur if device is malfunctioning? Audiologist will send hearing aid home with note indicating problem so that parents can take it to their dispensing audiologist for repair; school will continue to provide amplification access with FM system by adding a school-owned receiver.

Parent Approval of Plan:
I agree with amplification monitoring plan. Initials _____ Date_____

Courtesy of Cheryl DeConde Johnson.
Objectives

- Understand the impact that hearing loss has on literacy acquisition in school-age children in relation to a multimodal model of language.
- Describe the roles and responsibilities speech language pathologists and audiologists have in relation to the acquisition of literacy skills in children with hearing loss.
- Explain current and widely accepted theoretical frameworks for reading and writing and how these apply to children with hearing loss using current research.
- Provide clinical recommendations for supporting literacy acquisition in children with hearing loss.
Introduction

Literacy is an important functional outcome for children with hearing impairments (HI) as it has both social and academic implications, the latter of which contribute to an individual’s ability to access higher education and gainful employment. Advances in hearing assistive technology (HAT) have allowed for many children born with HI to receive appropriate amplification early in life resulting in improved language learning that subsequently results in improved literacy outcomes. Though the gap is closing, children with HI continue to fall below their peers with normal hearing (NH) on measures of literacy, with a wider gap for children who were later identified as HI, and an even wider gap for children who do not rely on acoustic input. The purpose of this chapter is to provide speech-language pathologists (SLPs), audiologists (AUDs), and other interested practitioners an overview of clinically relevant information about literacy in children with HI.

Language and Literacy

Multimodal Language Framework

To understand literacy, first one must understand how literacy is part of a multimodality language framework and that the acquisition of literacy is contingent upon the interrelationships between listening, speaking, reading, and writing. One of the concerns of SLPs and AUDs with regard to children with HI is to improve access to oral language for listening and speaking purposes. An equally important concern commensurate with oral language outcomes is written language outcomes including reading and writing. Research has clearly demonstrated that language extends across four modalities to include speaking, listening, reading, and writing. One must consider each of these domains across each modality of language. That is to say that each domain can be heard, spoken, read, and written, and contributes to a comprehensive multimodal language framework. For example, at the phonological level of language, phonemes can be heard or discriminated, articulated, decoded as part of reading, and encoded (spelled) as part of writing. Likewise, each of the other language domains, morphology, syntax, semantics, and pragmatics, must be considered within the context of each of the four modalities of language. A consideration that will be elaborated upon throughout this chapter using the terms language modality (speaking, listening, reading, writing) and language domains or levels of language (phonology, morphology, syntax, semantics, pragmatics/discourse).

For the individual with HI, the relationships among four language modalities and the shared and
unique skills associated with each modality must be contextualized relative to that individual. As a brief example, an individual with a moderate hearing loss would benefit from HAT to allow the unique skill of hearing to contribute to the shared skill of language comprehension. Another example would be the profoundly hard-of-hearing individual who lacks the unique skill of hearing and so uses manual forms of communication to contribute to the shared skill of language comprehension. For this individual, the hand and mouth play a role in expressive language, though differently than the normal hearing person, while the eyes play a role in comprehending language for “listening” as well as for reading written language.

**Literacy**

At a superficial level, literacy is the ability to read and write in the language of one’s country, region, or native tongue. However, a more in-depth definition of literacy has been adopted by the National Institutes of Health (NIH)’s National Institute of Child Health and Human Development (NICHD, 2000), based on governmental legislation (National Literacy Act of 1991). This definition states that, “Literacy means an individual’s ability to read, write, and speak in English, and compute and solve problems at levels of proficiency necessary to function on the job and in society, to achieve one’s goals, and develop one’s knowledge and potential.” By this definition, the charge of educators and the public education system goes beyond teaching basic reading and writing; rather, reading and writing lay the foundation for later complex problem solving and access to the workforce. Being literate in a modern day society is not just about the ability to read and write but to do this for learning, social, and workforce purposes. Moreover, being literate means that in addition to the basic ability to read and write in one's language, it is the ability to think, synthesize, analyze, and calculate written language that goes beyond basic reading and writing ability.

The Role of SLPs and AUDs in Literacy Acquisition for Children with HI

It is the position of the American Speech Language Hearing Association (ASHA, 2001) that “… SLPs play a critical and direct role in the development of literacy for children and adolescents with communication disorders…” and is meant to include individuals with HI who are considered to have communication disorders. Note that this has been the official position of ASHA since 2001; however, it is only in recent years that SLPs have a clear understanding of the relationships between language and literacy, especially for practitioners in school settings.

Success in literacy is not just dependent upon a solid foundation of oral language but also a reciprocal relationship between language and literacy (ASHA, 2001; Fitzgerald & Shanahan, 2000; Nelson, 2010). That is to say, as oral language develops so does literacy, and as literacy develops so does oral language. This is explicated quite well as part of ASHA’s position statement on the roles and responsibilities of SLPs with respect to reading and writing (ASHA, 2001). As part of that document four rationales are provided for the consideration of language and literacy by SLPs. These are paraphrased below, and it is suggested by the author of this chapter that these also provide a rationale for AUDs’ consideration of language and literacy for children whom they serve.

1. Oral language provides the foundation for the development of reading and writing. Children develop oral language abilities much younger than reading or writing emerges; however, the foundation for later modalities of language (reading and writing) is set by oral language.
2. Oral and written language have a reciprocal relationship such that even from very early on, the introduction of print to developing children augments and supports the growth of oral language.
3. Children with spoken language difficulties frequently have difficulties with learning to read and write and, conversely, children with reading and writing difficulties frequently have a history or concurrent deficit in oral language.

4. Instruction in oral language can support growth in written language, and instruction in written language can result in growth in oral language.

More recently, the reauthorization of the Elementary and Secondary Education Act (U.S. Department of Education, 2015) includes an amendment that ensures educational agencies can include AUDs and SLPs in delivering literacy services in schools. Thus, SLPs and AUDs play an important role on educational teams for children with HI and have a responsibility to be part of the Individualized Education Plan (IEP) process for children whom they serve. An IEP is a federal- and state-mandated educational requirement that ensures an individualized education for school children with disabilities so that they may have equal access to the curriculum of their nondisabled peers (U.S. Department of Education, 2004). For children with HI, this means that IEP teams must ensure that an individual’s hearing status is accounted for so they may receive equal access to curriculum as their NH peers. It is not the sole responsibility of the classroom teacher, special educator, or teacher of the deaf and hard of hearing to improve literacy in children with HI, rather all practitioners working with the child share a stake in the acquisition of reading and writing. Moreover, each practitioner can make an important contribution to improving outcomes for these children as each has their own unique knowledge that can be shared to support other areas of development. Therefore, the onus is on the practitioner, SLP or AUD, to ensure that they are part of the IEP team’s decision-making process for children whom they serve, whether their services are provided in school or other clinical settings.

Throughout this chapter, information for supporting language and literacy development for children with HI will be provided, specifically for SLPs and AUDs, with consideration that each practitioner is part of an IEP team supporting children with HI in school settings. As an example, the AUD is the expert in conducting audiological evaluations, interpreting audiograms, and providing and maintaining HAT, while the SLP is the expert in using that information to provide treatment for auditory processes and speech production purposes. In clinical practice, these individuals work together to design oral/aural language treatments to meet the needs of the individual with HI. Taking that a step further to literacy needs, these two individuals work together to identify goals for auditory and speech purposes and should also consider how these same issues manifest in the reading and writing of children with HI. Only the SLP or AUD would have a clear understanding of an audiogram for a child with HI and could indicate what specific sounds would be a challenge for that individual in relation to learning how to read. This is important information for an IEP team who is creating and implementing IEP goals relevant to decoding and spelling as part of literacy acquisition for the child with HI.

Children with Hearing Impairments

Hearing impairment is a broad definition that is meant to include any individual that does not exhibit hearing acuity considered within normal limits; it is discussed in a variety of ways throughout this textbook. For the purposes of this chapter, the scope of the discussion is limited to preschool and school-age children, approximately ages 3 through 21 who have IEPs mandated by the Individuals with Disabilities Education Act (IDEA; U.S. Department of Education, 2004), and receive services under the qualifying category of hearing impairment or deafness. Children who receive services under the qualifying category of hearing impairment are children who present with permanent or fluctuating hearing that adversely affects educational performance (U.S. Department of Education, 2004). Children in
this category do rely on acoustic input through the use of HAT including cochlear implants (CIs) and/or hearing aids (HAs), or naturally on their own, though the signal may not be equivalent to normal hearing peers (e.g., unilateral, mild, or conductive hearing loss). Children who receive services under the qualifying category of deafness are children who present with severe or profound hearing loss that impairs the processing of linguistic information with or without HAT (U.S. Department of Education, 2004). Children in this category generally do not rely on acoustic input whether or not they use HAT and oftentimes communicate manually via American Sign Language (ASL). Not included in this chapter are children with hearing loss along with additional disabilities, such as deaf-blindness, autism, or intellectual disabilities.

The distinction between children with HI who do and do not rely on acoustic input is an important one to address as part of this chapter. Though both groups fall under the umbrella term of HI, there are clear differences in the linguistic experience of these children. For children who do rely on acoustic input, they likely have linguistic experience from a young enough age that their oral language abilities, though delayed or disordered, are experienced through the ear and associated neurological mechanisms related therein. For children who do not rely on acoustic input, their linguistic experience differs as they likely use ASL, which is a uniquely different language system from spoken English and is processed through the eye and associated neurological mechanisms related therein. It is likely that each language, whether oral or manual, utilizes similar neurological mechanisms for processing and expression (e.g., MacSweeney, Waters, Brammer, Woll, & Goswami, 2008). A discussion of the differences in how oral versus manual languages develop and are processed is beyond the scope of this chapter. However, a basic understanding that manual forms of communication are uniquely different linguistic systems as compared to spoken language is important foundational knowledge for understanding literacy outcomes in children with HI.

As an example, we shall compare two hypothetical children born profoundly hard of hearing in the United States where American English is spoken; one to hearing parents and one to deaf parents. The child born to hearing parents receives a cochlear implant within the first year of life and subsequently develops spoken American English skills, with the help of his parents and, of course, interventionists such as SLPs and AUDs. When that child is introduced to print (in American English) and literacy education begins, he has oral language experience with the language that he now must master in written form. The child's oral language has set the foundation for written language acquisition. The child born to deaf parents does not receive a cochlear implant as the parents are deaf and fluent in ASL and made the choice to raise their child in this manner. Because the parents are fluent speakers of ASL, this child develops manual language skills that are considered developmentally appropriate and fluent for monolingual speakers of ASL. When that child is introduced to print (in American English) and literacy education begins, there is no connection between the child's home language (ASL) and the language of school (American English). The first child missed one whole year of oral language development while the second child had uninterrupted language development in ASL; however, the first child is far more likely to surpass the second child in literacy acquisition.

Thus the challenge for children who do not rely on acoustic input and whose first language is ASL, is that they must learn standard American English as they learn how to read and write in that language. This is referred to as a bilingual-bicultural approach to deaf education (e.g., Hoffmeister & Caldwell-Harris, 2014; Morgan, 2002; Rathmann, Mann, & Morgan, 2007) and is comparable to a child being reared in a Cantonese or Mandarin speaking home and then expected to learn American English in written form without any oral language experience in American English. There is a common misconception that ASL is American English in manual form with similar linguistic features of syntax, semantics, morphology,
and phonology; this is simply not the case. ASL has its own features of syntax, semantics, morphology, and phonology, and is just as uniquely different from American English as Cantonese or Mandarin is from American English. What is common between ASL and American English is that both follow linguistic rules for each language across language domains of phonology, morphology, semantics, syntax, and discourse. This is important to consider because it is not that the child who communicates in ASL does not have developmentally appropriate language; rather the child has a fully operational linguistic system in a language different from that of written American English. An important consideration, then, is to provide the child who communicates in ASL with language support to develop written American English that embellishes the age-appropriate language skills the child has in ASL (e.g., Hoffmeister & Caldwell-Harris, 2014), a challenge that continues to perplex researchers and clinicians.

The challenge for children who do rely on acoustic input, whether through CI or HA, is a depleted acoustic signal and so a great deal of phonological information may be lost. This becomes a problem because the 46 distinct phonemes (and hundreds of allophonic variations) of the English language are represented by over 500 spelling patterns derived from different languages from around the world. Take as an example two simple words: beat, bet. The distinction between these two words, acoustically, is the difference in the middle vowel, that difference is tense versus lax production of a vowel in the same area of the mouth. The meaning that changes, however, is tremendous, not to mention that each of those words can have multiple meanings and be used as different parts of speech (noun vs. verb). So even for children with access to acoustic input, the complex phonology of the English language in spoken and written forms becomes a challenge toward acquiring literacy in English.

To summarize, children with HI, whether reliant on acoustic input or not, face unique challenges toward acquiring literacy in English. These challenges are observed for all children with HI; however, these differ in breadth and scope based on reliance on acoustic input and can be observed in one or more language domains: phonological, morphological, semantic, syntactic, and discourse.

**Operationalizing Theories of Reading and Writing**

To best operationalize literacy, two widely accepted theoretical models of reading and writing are defined and described: the simple view of reading (Hoover & Gough, 1990) and the simple view of writing (Berninger & Amtmann, 2003; Berninger et al., 2002). Do not let the term simple underestimate the enormous task children have of acquiring literacy skills, and the supports needed from practitioners working with school-age children with HI including SLPs and AUDs. These views for the constructs of reading and writing aim to provide simple yet robust theories from which practitioners can work to support literacy acquisition for children with HI.

Descriptions of each theoretical framework are provided to describe the cognitive processes needed for reading and writing, and should be considered by the reader as housed within the larger multimodal language framework described earlier. Each theory will be defined and described relative to children with NH and typical literacy acquisition, followed by considerations for children with HI that do and do not rely on acoustic input.

**The Simple View of Reading**

According to the simple view of reading (Hoover & Gough, 1990), reading comprehension (RC) is the product of decoding (D) and linguistic comprehension (LC), formulaically represented as: RC = D × LC. This simple yet robust theory has decades of research to support that both decoding and linguistic comprehension contribute to reading comprehension, for all individuals across the lifespan.

**Decoding**

Decoding is the ability to follow the rules of print by understanding the phoneme-grapheme association
between sounds and letters, referred to as phonics (Nelson, 2010; Schuele & Murphy, 2014). Decoding can be measured at the phoneme level (e.g., Cunningham, 2005) whereby an individual can produce a sound associated with a letter or set of letters (e.g., “sh” represents phoneme /ʃ/). Decoding can also be measured at the semantic or morphological levels (e.g., Catts, Fey, Tomblin, & Zhang, 2002; Roth, Speece, & Cooper, 2002) whereby an individual can decode sets of words with appropriate rate and accuracy referred to as word attack or word recognition skills. As children develop their decoding skills, they learn to decode at the phonological, morphological, and eventually semantic levels of language. Notably, there is no specific age or grade where an individual is expected to transition from phoneme to word-level decoding skills and a reader of any age may come in contact with a word that requires decoding at the phoneme or morphological levels.

To support the acquisition of decoding skills in school-age children, whether they struggle with reading or not, the National Institutes of Child and Human Development (NICHD, 2000) recommends providing direct instruction and training in phonemic awareness, phonics, and fluency skills. Phonemic awareness skills are the ability to segment, blend, and manipulate phonemes within words and to do so without print (Schuele & Murphy, 2014). For children who are typically developing this is a skill that is expected to emerge around 4 or 5 years old, with supports from the teachers and parents in that child’s life. For children who are at risk for academic failure, acquisition of this skill is often not a part of the child’s learning experience or they simply require more exposure to these skills in order to decode when introduced to print (Wise, Sevcik, Morris, Lovett, & Wolf, 2007). Phonics is the knowledge of phoneme-grapheme correspondence and is generally taught during the primary school years (grades K through 3). Phoneme-grapheme or sound-letter correspondence in American English is challenging because of the 46 phonemes, represented by 26 letters, across more than 500 acceptable spelling patterns. Fluency is the ability to read text with appropriate rate, pause, and intonation and is the result of well-developed decoding skills and thus intact phonemic awareness and phonics skills. Fluency is generally measured by accounting for both the rate and accuracy when a child reads out loud (Wiederhold & Bryant, 2012).

Linguistic Comprehension

Linguistic comprehension is simply that, the ability to comprehend language and is similar to how an SLP or AUD might measure oral language abilities of a child on his or her caseload. However, within the simple view of reading linguistic comprehension is contingent upon decoding skills. That is to say, in order for an individual to linguistically comprehend written text she or he must be able to decode that text. An individual with intact decoding and normal language abilities should have little difficulty comprehending written text. An individual with delayed or disordered linguistic comprehension will have difficulty comprehending written text that is not commensurate with her or his language ability even if she or he can decode the text. Contrastively, an individual who struggles to decode text may be able to understand the linguistic information presented in the text as can be observed when a child is able to comprehend a story read to them.

To support linguistic comprehension skills in school children, whether they struggle with reading or not, the NICHD (2000) recommends providing direct instruction and training in vocabulary and text comprehension ability. Vocabulary has been found by researchers as one of the more robust indicators of a child’s linguistic comprehension with regards to reading (e.g., Scarborough, 2001), and can be considered a bridge between decoding and linguistic comprehension. Simply put, the more words a child knows or the larger his or her vocabulary, the more ease he or she will have with linguistic comprehension of written language. Text comprehension is a more broadly defined area of reading comprehension and includes all that an individual can do to gain meaning from written text. Text comprehension instruction according to the NICHD
(2000) is instruction with understanding overall text and includes being able to gain meaning by summarizing, making inferences, and drawing conclusions.

The Simple View of Reading in Children with Hearing Loss

Considering children with HI as those that do and do not rely on acoustic input, different implications can be made for each group of children with regard to the simple view of reading. The child with HI who benefits from HAT may be challenged with both decoding and linguistic comprehension but in different ways than his or her peers who do not rely on acoustic input and perhaps more similarly to children with NH who are struggling readers. For the child with HI who does not have access to acoustic input and uses ASL or other modes of communication outside of aural/oral, the challenges for acquiring reading skills in the simple view of reading framework vary greatly from his or her HI peers who do rely on acoustic input. Research has demonstrated a clear pattern that, based on measures of reading, children with HI who benefit from HAT continue to fall slightly below their NH peers (e.g., Ambrose, Fey, & Eisenberg, 2012; Davis, Elfenbein, Schum, & Bentler, 1986; Halliday & Bishop, 2005), and that children without access to acoustic input and/or use manual communication as their primary language fare more poorly than peers with HI and NH (e.g., James et al., 2005; Kyle & Cain, 2015; Kyle & Harris, 2010; Marschark et al., 2009; Most, Aram, & Andorn, 2006; Nittrouer, Caldwell, & Hollowman, 2012; Sharifi, Kakojoibari, & Sarmadi, 2010; Vermeulen, van Bon, Schreuder, Knoors, & Snik, 2007).

With regard to decoding, the child who does rely on acoustic input may be challenged with phonological and phonemic awareness as well as decoding when compared to peers with NH. Research has demonstrated that children who benefit from HAT still have difficulties with phonological levels of language processing when compared to peers with NH (Ambrose et al., 2012; Briscoe, Bishop, & Norbury, 2001; Geers & Hayes, 2011; Halliday & Bishop, 2005; Johnson & Goswami, 2010). Thus, children with HI will likely have difficulties with auditory discrimination between phonemes depending upon how their audiogram reads, with the most common example of differentiating between the highest frequency sounds: /s/, /ʃ/, /j/, and /θ/. This will impact decoding skills in terms of phonemic awareness and phonics because of a decreased ability to differentiate these sounds. This may even occur with vowel sounds even though they are lower in frequency, as oftentimes vowel sounds may only be different on one feature such as tense/lax manner or high/high-mid/mid place of production. It may be a challenge for the hearing-impaired individual to accurately discriminate between vowel sounds, which plays an integral role in decoding text. Recall the earlier example of reading beat vs. bet. Thus, it is important for practitioners to consider that the auditory training provided to process and discriminate these sounds for listening purposes will also play a role in discriminating these sounds for reading purposes, namely for decoding written text.

With regard to linguistic comprehension, the child who does rely on acoustic input may still present with an overall language delay or disorder secondary to her or his hearing loss. Oftentimes this manifests itself in lower vocabularies of children with HI compared to NH peers (e.g., Coppens, Tellings, Verhoeven, & Schreuder, 2011; Johnson & Goswami, 2010) and will impact linguistic comprehension relative to reading comprehension. As an example, Kyle and Cain (2015) found that children with HI who used CIs had poorer comprehension than age-matched peers and performed like poorer readers within the NH group. This suggests that children with HI who do rely on acoustic input perform more similarly to struggling readers rather than those with language or learning disorders. Notably, research has indicated that early detection and intervention of hearing loss results in better literacy outcomes during the school-age years (Archbold et al., 2008; Ching, Day, & Cupples, 2014; Connor & Zwolan, 2004; Johnson & Goswami, 2010; Lee, Yim, & Sim, 2012).
Decoding for the child with HI who does not rely on acoustic input will be a challenge because of the lack of experience or ability to teach phonemic awareness and phonics skills because the child cannot process the phonemic signal acoustically. Though there is a visual component and speech-reading has been linked to decoding ability (Kyle, Campbell, & MacSweeney, 2016; Kyle & Harris, 2010), there is far less phonemic information that can be captured with these approaches. The challenge for practitioners here is to teach decoding skills without the support of processing phonemic signals acoustically and the subsequent lack of phonemic awareness and phonics skills. There have been some approaches that have shown success at teaching phonics in a visual manner (Tucci, Trussell, & Easterbrooks, 2014); however, the research still suggests a larger gap in decoding ability for children who do not rely on acoustic input compared to HI peers that do and NH peers (e.g., James et al., 2005). Current research suggests that speech-reading and speech articulation abilities of children with HI can be used as a proxy variable for measuring decoding (e.g., Johnson & Goswami, 2010; MacSweeney et al., 2008). Perhaps it is the case that training speech articulation and reading abilities would support improved decoding, something that requires further study.

Linguistic comprehension for the child with HI who does not rely on acoustic input will be a challenge because of the language delays and disorders that have been associated with deafness and are similar to those discussed earlier for children who benefit from HAT. However, there needs to be additional considerations of linguistic system from which the child is working from, specifically ASL, and the bilingual implications this has for learning to read written English (Dammeyer, 2014; Hoffmeister & Caldwell-Harris, 2014). Children who communicate in ASL and then asked to read in English will be challenged because of syntactic and discourse reasons as these rules differ drastically between the two languages. This is far more evident in writing samples of children who are deaf (discussed in the next section); however, in a multimodal language framework, it is important to consider what writing can tell us about reading. Thus, given the lack of intervention research (Williams, 2012) and the demonstrated importance that vocabulary plays in reading comprehension (Scarborough, 2001), vocabulary instruction in English is a feasible area of intervention for children with HI to support reading comprehension.

The Simple View of Writing

According to the simple view of writing (Berninger & Amtmann, 2003; Berninger et al., 2002), writing is the triangular relationship among transcription (spelling, handwriting, keyboarding), text generation, and executive function skills, all dependent upon working memory. In addition to the simple view of writing, Hayes and Berninger (2014) provide a theoretical framework for the writing process. Combined, these frameworks provide current and widely accepted understanding for written expression in school-age children and will both be referenced in this section.

Transcription

Transcription skills include handwriting, keyboarding, and spelling for the purposes of transcribing language into written form. Handwriting and keyboarding are both motor skills that develop during the preschool and early elementary years when children are first exposed to writing implements (crayons, pencils, pens). Handwriting development begins when the child first begins to draw (Berninger, 2000) and becomes automatic toward the end of primary grade schooling (Abbot & Berninger, 1993; Berninger & Swanson, 1994). Research has indicated that elementary school children fare better on writing tasks when using paper and pencil formats (e.g., Connelly, Gee, & Walsh, 2007), although with proper training in keyboarding children can do equally as well (e.g., Christensen, 2004). Furthermore, nationwide reports of writing suggest that students with
experience and training in keyboarding and computer technologies fare better on assessments of writing in grades 8 and 12 (National Center for Education Statistics, 2012). Spelling is a cognitive-linguistic skill that requires language at the phoneme, morpheme, and semantic levels for encoding (i.e., spelling) written language. In typically developing children these skills develop throughout the primary grade years, and are expected to be automatized within long-term and working memory by the end of the intermediate grade years (Berninger & Swanson, 1994; McCutchen, 1996). Spelling abilities will continue to develop across compulsory years of education as school-age children encounter new vocabulary and spelling patterns, with approximately 3% misspelled words in students grades 4 through 9 considered a normal developmental pattern (Bahr, Silliman, Berninger, & Dow, 2012).

**Text Generation**

Text generation is the coding of ideas into strands of language first consciously, though not out loud, and then utilizing transcription skills to produce written language at the semantic, syntactic, and discourse levels (Berninger et al., 2010; Hayes & Berninger, 2014). Research has indicated that primary grade children generate text at the semantic and syntactic levels and that it is not until the intermediate grades that children can produce longer written text at the discourse level (Abbott & Berninger, 1993; Berninger & Swanson, 1994), while accounting for planning and revising strategies (Berninger, Whitaker, Feng, Swanson, & Abbott, 1996; Garcia & Fidalgo, 2008; Koutsoftas & Gray, 2013; Whitaker, Berninger, Johnston, & Swanson, 1994). Another way to think of text generation is the expressive language associated with writing, very similar to coding ideas into linguistic form for spoken language purposes, except with the added need for transcribing language into written form. In this way, it is easy to understand text generation in the context of a multimodal language framework for children with NH and those with HI.

**Executive Function Skills**

Executive function skills are higher-level cognitive skills needed for coordinating transcription and text-generation processes in relation to writing in both developing and proficient writers (Hayes & Berninger, 2014; Rijlaarsdam & van den Berg, 2006). Specifically, the following executive function skills have been identified by research in relation to the writing process: conscious attention, planning, reviewing, revising, and self-regulation strategies (Berninger & Amtmann, 2003; Graham & Harris, 2005; Hayes & Berninger, 2014). Research has indicated that typically developing writers only begin to show proficiencies with executive function skills needed for writing toward the end of the intermediate grade years (Berninger et al., 1996; Garcia & Fidalgo, 2008; Koutsoftas & Gray, 2013; Whitaker et al, 1994). Proficient adult writers are able to coordinate processes and engage in writing in a recursive manner, meaning that they can engage in one or more writing processes (e.g., planning, writing, revising) in no particular order (Hayes & Flower, 1980). It is important to consider the task environment as part of the writing process (Hayes & Berninger, 2014), which includes the audience and purpose for writing alongside the text written so far. For children to consider the task environment, they must exercise their executive function skills while engaging in transcription and text generation.

**The Simple View of Writing in Children with Hearing Loss**

There is a paucity of research regarding written expression in children with HI; however, the research that does exist suggests that children with HI fare far more poorly than peers with NH on writing tasks (Arfé, 2015; Geers & Hayes, 2011; Spencer, Barker, & Tomblin, 2003). Within the group of children with HI, those who rely on ASL fare more poorly than those who benefit from HAT on written expression (Burman, Evans, Nunes, & Bell, 2008; Koutsoftas, Welling, & Odiase, 2015; Most et al., 2006). Given the lack of research on written
expression in children with HI, it is difficult to
describe the underlying challenges that contribute
to poor writing in children with HI. Using the sim-
ple view of writing to understand written expression
in children with HI, we can examine each compo-
nent and speculate or state what is known based on
available research.

Considering children with HI as those that do
and do not rely on acoustic input, different impli-
cations can be made for each group of children with
regard to the simple view of writing. Of the three
components of the simple view of writing, text
generation and transcription, specifically spelling,
would be most deficient in children with HI. The
child with HI who benefits from HAT may be chal-
lenged with both transcription and text generation
but in different ways than his or her peers who
do not rely on acoustic input and more similarly
to children with NH who are struggling writers.
For the child with HI who does not have access to
acoustic input and uses ASL or other modes of com-
munication outside of aural/oral, the challenges for
acquiring writing skills in the simple view of writ-
ing framework vary greatly from his or her HI peers
who do rely on acoustic input.

For the child with HI who does rely on acoustic
input, writing will be a challenge for transcription
and text generation. If we assume related linguis-
tic processes between reading and writing, then we
could expect the following difficulties with writing.
For transcription, similar phonemic, morpholog-
ical, and semantic language difficulties that result
in poor decoding would likely impact encoding
(spelling) for children with HI, consistent with their
hearing profiles (e.g., Geers & Hayes, 2011). Spelling
errors would be consistent with the child’s level of
hearing acuity and the phonological, orthographic,
and morphological knowledge she or he brings to
the writing process. For spelling, it is not just that
children will HI will produce more spelling errors,
but their difficulties with spelling will impact the
words they select to use when writing because chil-
dren tend to use words they know how to spell.
For text generation, difficulties the child has with
expressive language at the semantic, syntactic, and
discourse levels could be expected in writing, and
in general written language deficits tend to present
worse than spoken language deficits (e.g., Scott &
Windsor, 2000). Expressive writing for children
with HI who do rely on acoustic input would likely
reflect their expressive spoken language skills. Cer-
tainly this is an area that requires further study.

For the child with HI who does not rely on
acoustic input, writing will be a challenge for sim-
ilar reasons to his or her HI peers and also for
unique reasons associated with the bilingualism
associated with communicating in ASL. Research
has indicated that children with HI who do not rely on acoustic input fare very poorly on expres-
sive writing tasks (Burman et al., 2008; Koutsoftas
et al., 2015; Most et al., 2006). Something to con-
sider here is that these children are communicating
using writing, especially via electronic formats for
social engagement purposes; however, the written
expression reflects the linguistic structure of ASL
rather than standard English. When these same
individuals are asked to produce writing samples for
research studies which are then evaluated in relation
to standard English, the deficiencies in writing are
glaring. Children with HI who use manual forms of
communication come to the writing process ready
to express themselves in writing using the linguistic
structure of ASL, not standard American English.
For these children, text-generation difficulties asso-
ciated with the simple view of writing are similar to
the difficulties with linguistic comprehension rela-
tive to the simple view of reading discussed earlier.
Given the relationships between reading and writ-
ing within the multimodal language framework set
forth earlier, perhaps it would benefit children who
use manual communication to engage in literacy
programs that connect reading and writing using a
bilingual bicultural approach (Hoffmeister & Cald-
well-Harris, 2014), something that warrants further
study.

Speculatively, executive function skills and tran-
scription, specifically handwriting or keyboarding,
would not be expected to be impacted by hearing
loss or deafness. If one assumes that hearing loss does not impact executive function skill, then we can assume that the writing skills related to executive functions are also not impacted. Of course, individual child profiles would shed light on this and SLPs and AUDs are encouraged to consider the child’s executive function in relation to the simple view of writing. We can also assume that the motor skills of handwriting or keyboarding needed for transcription are not impacted by hearing loss. Again, individual profiles for children with HI would be important to consider and a child with fine motor difficulties may also have difficulties with handwriting or keyboarding. Of note, both executive function and motor skills are taught within educational settings; therefore, the language deficits associated with HI may impact the ability to develop the skills through traditional educational approaches.

**Interventions for Reading and Writing in Children with HI**

With an understanding of how hearing loss impacts literacy acquisition from a multimodal language model and an introductory understanding of current theories of reading and writing, a summary of the current intervention research is presented. Luckner, Sebald, Cooney, Young, and Muir (2005) conducted a systematic review of 22 literacy research studies in deaf education and concluded that there was limited data to establish evidence-based practices. This was based on a few well-designed group studies, no two studies examining the same dimension of literacy, and no systematic replication of findings. Therefore, the following review of literacy intervention research attempts to organize studies within the frameworks of the simple view of reading (Hoover & Gough, 1990) and the simple view of writing (Berninger & Amtmann, 2003; Hayes & Berninger, 2014), and makes the distinction between feasibility and efficacy of interventions. An intervention is feasible if there is a demonstrated relationship between the intervention and outcome variable, supported by lower level observational studies with controls and nonrandomized controlled trials (ASHA, 2016). An intervention is efficacious if there is a demonstrated relationship between the intervention and outcome variable, supported by well-designed nonrandomized and randomized controlled trials (ASHA, 2016). There are many reading and writing interventions for children with HI that have potential or demonstrated feasibility and fewer interventions that have demonstrated efficacy.

**Reading Interventions**

Intervention studies that have examined reading interventions for children with HI that have focused on the decoding and phonological aspect of reading instruction (Bergeron, Lederberg, Easterbrooks, Miller, & Connor, 2009; Tucci et al., 2014; Ye, Spychala, Harris, & Oetting, 2013; Yi-Hui, 2014) show feasibility, especially for children who utilize HAT. Similarly, intervention studies that have focused on reading comprehension or more than one component of the simple view of reading have also demonstrated feasibility (Charlesworth, Charlesworth, Raban, & Rickards, 2006; Mich, Pianta, & Mana, 2013; Wang & Paul, 2011).

The challenge for teaching decoding to children with HI is that this skill is dependent upon deciphering heard language at the phoneme level and then associating distinct phonemes with various spelling patterns. From a multimodal language perspective, the challenge is to provide children with HI an alternative manner for learning phoneme-grapheme associations that bypasses acoustic pathways and supports phonological level learning. Visual Phonics (Narr & Cawthon, 2011) is an approach that incorporates a system of 45 hand and symbol cues that represent the phonemes of spoken English to support children with HI’s decoding skills. In doing so, this approach provides visual information to support the learning of phonological level language. This approach has demonstrated feasibility and efficacy to support the acquisition of decoding skills in children with varying degrees and types of HI.
at different grade levels including preschool (Beal-Alvarez, Lederberg, & Easterbrooks, 2012; Bergeron et al., 2009; Smith & Wang, 2010), elementary (Bergeron et al., 2009; Narr, 2008; Trezek & Wang, 2006; Trezek, Ye, Woods, Gampp, & Paul, 2007), and middle school (Trezek & Malmgren, 2005). For children who do rely on acoustic input or benefit from HAT, this approach can be provided in addition to traditional phonics instruction (Ye et al., 2013). For children who do not rely on acoustic input, this approach can be the primary means to teach phonological information alongside orthographic information for decoding purposes. This is supported by research that shows a relationship between speech reading and phonological abilities (Kyle et al., 2016; Kyle & Harris, 2010) suggesting a visual component associated with phonological learning.

The challenge for supporting linguistic comprehension as part of the simple view of reading (Hoover & Gough, 1990) for children with HI is highly dependent upon the child's language abilities and means of communication. Children with HI who benefit from HAT and use spoken language present more similarly as struggling readers (Briscoe et al., 2001; Nelson & Crumpton, 2015; Park & Lombardino, 2012), so approaches designed for struggling readers are feasible ways to target reading deficits based on an individual's profile. Studies that have examined linguistic comprehension for reading in children with HI who benefit from HAT and use spoken language include the use of a reading recovery program (Charlesworth et al., 2006), and the use of audiovisual technology to support comprehension (Mich et al., 2013; Wang & Paul, 2011). Longitudinal studies of children with HI during early childhood years indicates the following variables as related to later reading comprehension: vocabulary, syntax, letter-sound knowledge, speech-reading (Geers & Hayes, 2011; Johnson & Goswami, 2010; Kyle et al., 2016; Kyle & Harris, 2010; Nelson & Crumpton, 2015; Nitrourer et al., 2012; Spencer et al., 2003). Findings from these studies suggest these variables are malleable and that interventions designed to improve these skills are feasible for gains on reading comprehension; however, programmatic lines of research toward this are few. The Center on Literacy and Deafness (Easterbooks et al., 2015) is currently examining child-by-instruction interactions within classrooms that can be better assessed and targeted for improving reading instruction to children with HI. Outcomes of this work are forthcoming and should provide approaches for reading instruction that are efficacious for children with HI.

For children with HI who use ASL or other manual forms of communication, the challenge is two-fold; first, the child must learn the spoken language (e.g., American English), and then develop more sophisticated skills in order to comprehend increasingly complex levels of written text. Interventions that account for the language abilities of children who use ASL in a bilingual/bicultural approach to reading instruction have the most support in the research literature (Allen, Letteri, Songa Hoa, & Daqian, 2014; Dammeyer, 2014; Hoffmeister & Caldwell-Harris, 2014; Huremovic & Sulejmanovic, 2011; Roos, 2013; Strong & Prinz, 1997; Trezek & Mayer, 2015), though only supporting the feasibility of this approach. More research is needed on the efficacy of these approaches, which is also a consensus among experts (e.g., Allen et al., 2014; Hoffmeister & Caldwell-Harris, 2014). One study found that children with HI in preschool, who used ASL as primary form of communication, showed gains in both ASL and literacy skills following the use of an ASL video series to support language and literacy development (Golos & Moses, 2013). Others have suggested that higher level language skills including metacognition (Strassman, 1997) and discourse level comprehension skills (Sullivan & Oakhill, 2015) should be targeted in children with HI. Trezek and Mayer (2015) found that the use of an informal reading inventory was a feasible way to assess areas of reading instruction for children with HI and is something that can easily be replicated by practitioners working with children with HI to improve literacy. Ye and Williams (2014) suggest that instructional approaches that align with
the NICHD (2000) recommendations for reading instruction focused on phonemic awareness, phonics, fluency, vocabulary, and text comprehension would also support reading development for children with HI, despite the lack of available research specific to children with HI.

**Writing Interventions**

There is a paucity of research on written expression in children with HI, so limited empirical information is reviewed here. Importantly, children with HI who benefit from HAT and use spoken English will present with deficits in writing that are very different from children with HI who use ASL. The former group will present more like struggling writers that need support in transcription, text generation, and executive function skills related to writing. The latter group will need a bilingual/bicultural approach to writing instruction (Hoffmesiter & Caldwell-Harris, 2014; Rathmann et al., 2007) for similar reasons discussed earlier. One intervention study examined writing instruction in children who use ASL, named the Strategic and Interactive Writing Instruction (Wolbers, Dostal, & Bowers, 2011), reported significant gains in writing following a year-long intervention.

There is a consensus among experts, primarily based on systematic literature reviews, that the current state of empirical knowledge for improving writing in children with HI is poor (Rathmann et al., 2007; Strassman & Schirmer, 2012; Williams & Mayer, 2015) and requires attention by researchers. Williams and Mayer (2015) conducted a systematic review on writing development, instruction, and assessment for deaf children ages 3 to 8 published between 1990 and 2012. Key findings indicated problems with research designs and methodologies, and poorly conceptualized theoretical frameworks. Interventions reviewed focused on spelling and word-level written language, with assessment of writing largely overlooked, and a need for study of connected written discourse in children with HI. That is to say, little is known about writing intervention beyond the word level. Strassman and Schirmer (2012) reviewed 16 studies of writing instruction and found that teaching approaches included: process approach, instruction on quality, writing for content, and feedback. Again, the need for more research in this area was highlighted as an important finding by these authors. Rathmann et al., (2007) conducted a review on written language skills in children who are considered bilingual ASL/English with the key finding that children exposed to sign language from early childhood achieved the highest levels of bilingualism and became skilled readers and writers.

Although there is a lack of efficacy research on writing interventions for children with HI, research has identified some feasible areas for writing instruction. Studies have shown that children with HI produce shorter stories, with less complex syntax, poor spelling and grammatical accuracy, and poorer quality, structure, and organization (Arfé, 2015; Bowers, Dostal, McCarthy, Schwarz, & Wolbers, 2015; Burman et al., 2008; Geers & Hayes, 2011; Massone & Baez, 2009; Most et al., 2006; Nelson & Crumpton, 2015; Spencer et al., 2003). Any of these skills can be considered feasible areas of instruction for writing until more systematic intervention research takes place. Notably, observations of writing difficulties are consistent with the research on reading difficulties in children with HI. Given the multimodal language framework suggested in this chapter, perhaps it is time to examine the interrelationships of literacy skills and conduct interventions that expound the supportive relationship reading and writing have with each other. As an example, spelling has been found to be an area of difficulty for children with HI and linguistic approaches used to assess spelling (Bowers et al., 2015) can also guide decoding instruction for the same child.

There are two additional approaches or frameworks for writing instruction that have demonstrated success with struggling writers with NH, and are summarized here as feasible approaches for writing instruction for children with HI. First, an instructional strategy provided in Berninger (2009) provides a simple yet robust idea for written
expression, paraphrased as follows: *If you can think you can say it, and if you can say it you can write it.* This strategy can be applied to all children because thinking and talking about what you want to write is an important component of the writing process (Hayes & Berninger, 2014). This approach reminds students and teachers that writing is a process that needs to be broken into component parts in order to produce a written product. For children who use manual forms of communication, this strategy should be modified to suggest that *if you can think it you can sign it, and if you can sign it you can write it.* For this strategy, however, the written product will reflect the language structure of ASL and will need to go through an additional revision process to reflect English language structure. Second, self-regulated strategy development (SRSD; Graham & Harris, 2005) is one of the most well-accepted and evidence-based approaches for supporting struggling writers. At the basic level, the SRSD approach considers the skills expected developmentally by a child to engage in the writing process, and provides direct instruction and repeated practice toward each skill (Graham & Harris, 2005). SRSD resources that are commercially available (e.g., Graham & Harris, 2005) provide a variety of exemplar mnemonics alongside lesson plans to target writing process skills. There is ample research supporting this approach as effective for improving writing outcomes (e.g., Graham & Perin, 2007); however, research on SRSD for children with HI is non-existent. This may be because children with HI do not struggle with the self-regulation component of writing, but more likely a result of the general dearth of research on written expression in school-age children. Future research should examine the feasibility and efficacy for improving writing in children with HI using SRSD.

**Summary**

This chapter provided an overview of language and literacy needs in children with HI who do and do not have access to acoustic input. There is much known about reading and writing development in children with NH, with less known about children with HI who do have access to acoustic input via HAT, and even less known about children with HI who do not have access to acoustic input and rely on manual forms of communication. Comparing reading and writing research, there is far more research available to understand the underlying difficulties in reading than writing, and the same pattern holds true for intervention research. In this chapter, a multimodal language framework was provided to understand the relationships between spoken and written language in children and allowed for a clearer understanding of the challenges children with HI faces in acquiring language and literacy. The roles and responsibilities of SLPs and AUDs with respect to literacy instruction were set forth and examples provided to put this into action. Simple and robust theories of reading and writing were described and explained in the context of typically developing and normal hearing children, and then contextualized for children with HI who do and do not rely on acoustic input. The chapter ended with a review of current available intervention research for reading and writing, with a clear pattern that more intervention research is needed for both reading and writing in children with HI. In conclusion, it is up to the practitioner to use his
or her clinical expertise, along with a child’s individual profile and the current best evidence, to develop and implement interventions for children with HI to improve literacy skills.

**Note from the Author**

As an undergraduate student in speech-language pathology, I took a language disorders course taught by a professor with extensive knowledge of the current status of language and literacy outcomes for children who were deaf or hard of hearing. At that time (the very late 90s), that professor provided us with a review of current research and it was the very first time I heard the term “fourth-grade ceiling” in relation to children with HI. The point the instructor made was that regardless of method of teaching—ASL, fingerspelling, or exact signed English—children who were deaf were not testing above a fourth-grade level at the end of their compulsory education. Fast forward to the present day: The review of research I conducted for this chapter revealed a strikingly similar pattern to the state of research 15 years prior. What is promising are the gains that have been made in early identification and early intervention and the widespread use of HAT, including cochlear implantation. What continues to remain the case is that the literacy outcomes for children who utilize ASL continue to fall far below peers with NH and peers with HI who benefit from HAT. Contextualize this to an era where young people, adults, and even your professors spend more time reading and writing for social, academic, and career purposes, and it makes for a pressing area of study for research and clinical purposes. Clearly, more research is needed as to the efficacy of interventions for reading and writing in children with HI regardless of reliance on acoustic input. In the meantime, the information in this chapter provides practitioners with an evidentiary base for developing assessments and interventions for reading and writing for children with HI.

**Discussion Questions**

1. Describe what the author considers a *multimodal language framework* and how this ties in with the five language domains.

2. After reading the broader definition of *literacy*, how do you think hearing loss affects daily life in and out of the classroom for those children with HI who continue to fall below their NH peers on measures of literacy?

3. Discuss the reciprocal relationship between oral and written language across language domains, specifically the relationships between reading and writing.

4. Explain common differences between children with HI who *do* and *do not* rely on acoustic input. How might these differences impact their acquisition of literacy skills?

5. Discuss the difference in reading skill difficulties between children with NH and children with HI who *do* and *do not* rely on acoustic input.

6. Discuss the difference in writing skill difficulties between children with NH and children with HI who *do* and *do not* rely on acoustic input.
7. Explain why decoding is especially difficult for students with HI, and how difficulties with decoding would differ between children with HI who do rely on acoustic input and those who do not.

8. Describe one approach or framework that can be used to assess and provide instruction for children with HI who struggle with reading.

9. Describe one approach or framework that can be used to assess and provide instruction for children with HI who struggle with writing.

References


and high schools – A report to Carnegie Corporation of New York. Washington, DC: Alliance for Excellent Education.


CHAPTER 19

DIAGNOSIS AND TREATMENT OF AUDITORY PROCESSING DISORDERS: A COLLABORATIVE APPROACH

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KEY TERMS

- Amblyaudia
- Attention-deficit/hyperactivity disorder (ADHD)
- Auditory discrimination
- Auditory processing (AP)
- Auditory processing disorder (APD)
- Autism spectrum disorder (ASD)
- Auditory training (AT)
- Bellis/Ferre model
- Binaural integration
- Binaural interaction
- Binaural separation
- Buffalo model
- Central auditory nervous system (CANS)
- (Central) auditory processing ([C]AP)
- (Central) auditory processing disorders ([C]APD)
- Comorbidity
- Compensatory strategies
- Dichotic auditory training (DAT)
- Dichotic listening
- Electroacoustic measures
- Electrophysiological measures
- Environmental/classroom modifications
- Formal auditory training
- Informal auditory therapy
- Low-redundancy speech
- Metalinguistic
- Monaural low-redundancy training
- Plasticity
- Temporal processing/sequencing

OBJECTIVES

- Describe characteristics associated with a (central) auditory processing disorder (APD).
- Associate specific tests used to assess APD with specific auditory skills.
- Identify intervention strategies associated with specific auditory processing deficits.
- Discuss a collaborative model between the speech-language pathologist and audiologist when addressing the diagnostic and intervention needs of an individual with an APD.
Introduction

There is an endless debate on the association between auditory processing and language. Some professionals question whether a deficit in auditory processing skills is nothing more than a reflection of a delay or disorder in language. However, neuroscience research has linked difficulties with auditory processing tasks specifically to the central auditory nervous system (Musiek, Kibbe, & Baran, 1984; Musiek et al., 2005). Due to this evidence, it is inferred that deficits in auditory processing can be the basis for complications in language and learning. With that in mind, this chapter will review information on what constitutes an auditory processing disorder (APD) and what type of treatment strategies are being used to address deficits in these areas. In addition, a model is presented that promotes a collaborative framework between the speech-language pathologist (SLP) and audiologist (AUD) when working with individuals with auditory processing deficits.

Definition

In 2005, the American Speech-Language-Hearing Association (ASHA) created a task force to further define the diagnosis of and interventions for (central) auditory processing disorders ([C]APD). The document that was generated from this collaborative effort was used to update the previous document (ASHA, 1996), which defines the role of the audiologist within the scope of practice for (C)APD. As a result, ASHA (2005) provided this definition, which is often referred to by many professionals:

Central auditory processing ([C]AP) refers to the efficiency and effectiveness by which the central nervous system (CNS) utilizes auditory information…. (C)APD may co-exist with other disorders (e.g., attention-deficit/hyperactivity disorder (ADHD), language impairment, and learning disability)…. (p. 2)

Auditory processing (AP) describes how information is processed after it leaves the peripheral auditory structures (outer, middle, and inner ear). There are two core categories of evaluation protocols used to assess auditory processing skills. The first category includes behavioral tests, which assess the functional capabilities of the auditory system. The second category for evaluating AP is the use of electrophysiologic measures.

It is also important to note the various terms that are used to describe an auditory processing disorder. As noted above, ASHA (2005) and American Academy of Audiology (AAA; 2010) utilizes the term (central) auditory processing ([C]AP). Various references may also refer to the use of central auditory processing (CAP), without the brackets. For the purpose of this chapter, the name auditory processing (AP) is utilized, which reflects the position statement of the Educational Audiology Association (EAA; 2015). This expression seems to be more appropriate since it is difficult to pinpoint a breakdown in the processing of auditory information to solely the central auditory nervous system. APD that is associated with a neurodevelopmental disorder observed in children can be very controversial as to whether it occurs due to a disorder in the central auditory system alone, since attention, memory, and language are so closely tied in to auditory perception (Moore, Rosen, Bamiou, Campbell & Sirimanna, 2013). It may be more useful to concentrate efforts on treating deficits in auditory perceptual abilities, without emphasizing the primary cause.

A court ruling that occurred on August 2, 2012 offered a legal definition of how auditory processing disorders are to be addressed in the school setting. A ruling was issued in the case of U.S. Ninth Circuit Court of Appeals in E.M. v. Pajaro Valley Unified School District that an auditory processing
disorder (APD) is considered an eligible criterion for special education services under the Individuals with Disabilities Education Act (IDEA; 2004). Reliant on the individual’s needs, an APD shall be classified under speech or language impairment, specific learning disability, or other health impairment. The ruling further recognized that testing and diagnosis should be completed by an audiologist.

Behavioral Testing
Behavioral tests are associated with the assessment of auditory-cognitive skills rather than true sensory processing abilities because it is often difficult to separate auditory sensory processing skills from various cognitive abilities. For example, speech-in-noise testing provides diagnostic information on how well an individual comprehends speech in the presence of competing messages or sounds. Many factors, such as attention, cognition, and/or language capabilities, can influence an individual’s performance on speech-in-noise tests.

Electroacoustic and Electrophysiological Testing
Electroacoustic and electrophysiological measures include a variety of protocols that can range from otoacoustic emissions to auditory-evoked response testing (i.e., auditory brainstem response, middle latency response, cortical event-related potentials) to functional imaging. Electrophysiological recordings of the central and peripheral neural auditory pathway and auditory cortex reflect neural functions and processes involved in neural coding for speech. Electrical potentials from the central auditory nervous system (CANS) are recorded in response to acoustic stimuli presented to the ear. They are beneficial in confirming a neurological disorder and identifying possible sites of lesion. By minimizing cognitive and language influences associated with performance on behavioral tests, these measures provide a clearer picture of the actual auditory–sensory processing capabilities of the CANS. This explains why abnormal electroacoustic and electrophysiological results do not give information on the skill level an individual possesses for various auditory behaviors.

Electrophysiological tests have also been used to measure auditory processing outcomes for children receiving auditory training (AT). Wilson, Arnott & Henning (2013) completed a systematic review of studies relating to electrophysiological outcomes and found that neurophysiological changes have been documented in children after AT. However, limited studies met their criteria for examination, restricting the data available for review. Also, data reflects only electrophysiological outcomes and does not provide insight on the effects of behavioral performance.

Although these tests provide information on auditory–sensory capabilities of the CANS, information is still needed on the actual functional skill level and what auditory skill deficits are being experienced by an individual with abnormal nonbehavioral test results. This is where behavioral tests are needed because they reflect auditory–cognitive processes and can present a profile of functional auditory abilities. For example, you can take two individuals with known lesions in the same area along the CANS who may exhibit similar abnormal results on auditory-evoked response tests, but each may exhibit varying severity and symptoms in behavioral skills related to audition.

Who Should Be Referred for APD Testing?
APD can manifest itself in many different ways, and some of the same behavior patterns are shared with comorbid conditions such as ADHD, language difficulties, and/or learning disabilities. This makes it difficult to determine when a referral for APD testing is appropriate. As with any other referral process, incorporation of a multidisciplinary team is helpful in navigating through behaviors or characteristics related to a variety of conditions. Screening
is also difficult because there is no gold standard for screening protocols when assessing for APD. There are screening tools available specifically dedicated to the rudimentary detection and referral of a suspected APD [e.g., Differential Screening Test for Processing (Richard & Ferre, 2006); Multiple Auditory Processing Assessment (Schow, Chermak, Seikel, Brockett, & Whitaker, 2006)]. Nonetheless, the AAA (2010) has expressed the need for more efficient screening tools that accurately identify individuals at risk for APD. This is difficult because there is some controversy about the definition of what truly constitutes a disorder in AP skills; however, there is some consensus among professionals as to behaviors likely seen in individuals with a deficit in AP skills (AAA, 2010; Johnson & Seaton, 2012; Keith, 2009a, 2009b). It is important to note that no one behavior exclusively represents an APD, but a combination of characteristics would lead to the suspicion that an evaluation is warranted. Through self-reporting, behavioral observations, and preliminary testing by the teacher, SLP, or AUD, the following behaviors may be evident:

- Listening behaviors consistent with an individual who has a hearing loss; however, normal hearing has been confirmed.
- Difficulty comprehending speech in the presence of noise or in poor acoustics due to reverberation.
- Decreased attention to auditory information when compared to attention to visual information.
- Inconsistent or inappropriate responses to auditory information or requests made by others.
- Difficulty comprehending and following rapid speech.
- Breakdown in following directions or remembering auditory instructions.
- Regularly asks for information or directions to be repeated or rephrased.

- Lack of ability to detect and produce changes in prosody of speech; can be reflected in poor musical abilities.
- Poor phonological/phonemic awareness skills.
- Poor auditory discrimination skills for speech sounds.
- Difficulty localizing to the source of an auditory signal.
- Weaknesses in speech-language or psychoeducational tests with an emphasis on auditory comprehension or auditory-related skills.
- Difficulty learning a new language.

**Appropriate Age and Skills for Testing**

When referring a child for APD testing, it is recommended that test results for children under the age of 7 years be interpreted with caution because there is increased inconsistency and variability, and weaker reliability on performance for AP tests (ASHA, 2005). In addition, normative data are limited for children under 7 years for a variety of behavioral tests used to assess AP abilities. There are some tests available that provide norms for younger children [e.g., Staggered Spondaic Word (SSW; Katz, 1962); SCAN-3:C Tests for Auditory Processing Disorders in Children (Keith, 2009b)]. Behavioral checklists for listening and communication, along with tests of language and/or cognition, can help identify younger children “at risk” for auditory processing that should be followed (Moore, Rosen, Bamiou, Campbell & Sirimanna, 2013). Once considered “at risk” it is imperative that any symptoms relating to auditory perceptual difficulties receive direct intervention.

As with very young children, individuals with significant cognitive deficits may not be likely candidates for behavioral testing when assessing for APD. Due to the complexity of test materials and the demands on language, memory, and attention, APD testing may be inappropriate (ASHA, 2005; Bellis, 2003). If an individual has other global cognitive issues, an APD would be difficult to segregate.
This same question may arise when a child diagnosed with autism spectrum disorder (ASD) is referred for an APD evaluation. It is known that children with ASD can have difficulty receiving, filtering, organizing, and making use of sensory information, which includes the sensation of hearing. For children with ASD, it is evident that testing for APD would not lead to a specific diagnosis in this area. Due to the characteristics associated with ASD, an etiology has already been identified that explains why the child may have difficulty comprehending auditory information. However, children with ASD can have varying degrees of cognitive function. If a child has adequate cognitive abilities to complete the demands of testing, the audiologists may be able to provide specific data on which auditory skills pose the most difficulty, and in turn may offer valuable insight on intervention strategies for the child. However, if the child cannot meet the demands for testing, a referral should not be considered. This is a decision best made by the multidisciplinary team, or at least with the cooperation of the AUD and the SLP.

Comorbidity of APD

This quandary leads into the discussion of comorbidity of an APD and language/learning disabilities. There are varying opinions regarding the relationship of auditory processing disorders and deficits in language. Some professionals believe APD is nothing more than a reflection of a true language disorder or delay. However, a number of other professionals consider auditory processing difficulties to exist independently of language disorders or delays, but manifest themselves in a similar fashion. The latter is supported by research that has linked various auditory processing skills to specific anatomical sites along the central auditory nervous system (Barmiou, Musiek, & Luxon, 2001; Bocca, 1958; Bocca & Calearo, 1963; Bocca, Calearo, & Cassinari, 1954; Bocca, Calearo, Cassinari, & Migliavacca, 1955; Calearo & Lazzaroni, 1957; Clarke, Lufkin, & Zaidel, 1993; Kimura, 1961; Musiek, 1983; Musiek, Kibbe, & Baran, 1984; Musiek et al., 2005). Abnormal function in one of these central auditory areas can lead to an APD, triggering language and learning difficulties.

Language Delay/Deficit

It is evident that listening and language skills are interwoven and at times may be very difficult to separate in behavioral testing. Poor performance on listening tasks can be strongly reflected in language abilities, and vice versa. Thus, it is logical to assume that a child who has difficulty with behavioral tests may display symptoms of a language delay or deficit, thereby affecting academic performance. If auditory input is compromised, causing a child to receive degraded linguistic signals, the development of vocabulary, syntax, and semantics may be affected. Poor performance on behavioral tests may be described as an auditory–cognitive processing deficit, because it is so difficult to separate these domains with the use of behavioral assessments.

An example of the relationship between auditory processing and language can be seen in a study conducted by Richards and Goswami (2015). They investigated auditory processing abilities for discrimination of psychoacoustic tasks of amplitude rise time, frequency, duration, and intensity. Data was also collected on performance of lexical and phrasal stress tasks. They compared performance on these tasks for 12 children diagnosed with specific language impairment (SLI) and 10 typically developing controls, between the ages of 8 and 12 years. The SLI group scored significantly lower on sensitivity to rise time and sound frequency discrimination, along with linguistic stress tasks when compared to the controls. It was hypothesized that poor auditory skills in rise time and frequency may relate to difficulty in processing stress patterns of speech, thus having a negative impact on the development of language.

In light of these observations, it is more productive to spend less time focusing on whether poor performance on behavioral tests for APD
are specific to an APD or to a language deficit. By taking a psychoeducational approach, less time can be spent debating the etiology of deficits for auditory-related skills and more time spent on the effects these auditory weaknesses have at home and at school. Then, intervention can begin sooner and more efficiently.

**Attention-Deficit/Hyperactivity Disorder**

Attention-deficit/hyperactivity disorder (ADHD) and learning disabilities are among the conditions that share many of the same behavioral characteristics as APD and may coexist. As discussed earlier, differential diagnosis can be extremely difficult when using behavioral tests because of the influence of cognition, attention, motivation, and language skills on all of these disabilities. However, in spite of these influences, a behavioral APD assessment battery can offer valuable information on specific auditory skills that may be difficult for a child. This information on auditory–cognitive processing, used in collaboration by a multidisciplinary team of educational professionals, can lead to the development of a finely tuned treatment plan that focuses on the individual needs of the child.

ADHD and APD may co-exist. Tillery, Katz, and Keller (2000) completed a study on 32 children diagnosed with ADHD who were successfully medicated to control attentional behaviors and who were diagnosed with a significant APD. These children were tested while medicated and again with a placebo. A double-blind design was used. Three AP evaluation tools were completed on each child, along with the Auditory Continuous Performance Test (ACPT; Keith, 1994). Results showed no significant difference on performance for tests focusing on AP. However, there was a significant difference on scores of the ACPT for the medicated condition versus the nonmedicated condition. Scores were significantly better ($p < 0.001$) for children when medicated. This study suggests that the ACPT can provide insight into attention. It also indicates a well-designed test protocol for AP can identify children with AP even with ADHD.

**Sensory Integration**

Children referred for testing with sensory integration or other global diagnoses can be evaluated for APD similarly to children with ASD. However, when working with such children, it should be explained to the parents that the presenting difficulties cannot be labeled as an auditory processing disorder alone, because there are sensory issues already present. The results of the evaluation would identify strengths and weaknesses in auditory behaviors. Therapeutic goals can then be fashioned to address the weaknesses that may improve performance in school. However, if the child fails all the tests, then the results will not yield useful information. This often indicates significant global factors.

**The Audiologist and the Speech-Language Pathologist: Working Together in Diagnosing APD**

Audiologists have the capability of investigating neurological components related to AP skills. For example, Banai, Nicol, Zecker, and Kraus (2005) introduced speech-evoked auditory brainstem response (ABR) testing, which has shown neurological processing at the level of the brainstem for the temporal aspects of speech. Although this information is extremely valuable in detecting lesions for children who have difficulty discriminating speech sounds, diagnostic information still must be correlated to functional performance of that child in the home and school. In order to assess a child’s educational needs, information about functional performance is needed. Behavioral tests for APD reflect real-life skills and may be more practical
when addressing the educational needs of a child. Evaluation tools used for the assessment of auditory processing skills can be utilized to provide valuable information on a child’s auditory–cognitive, functional listening abilities that may be inhibiting successful performance in school. However, testing should not stop here. The SLP should also be involved in the diagnostic process in order to offer further insight into the child’s language abilities affected by deficits in auditory skills.

## Collaborative Model

The need for a collaborative model between the speech-language pathologist and the audiologist is truly justified. Although a multidisciplinary approach with a diverse group of medical and educational professionals is always preferred, APD assessment should at minimum include a partnership between the AUD and the SLP. As stated earlier, if a child exhibits poor performance on functional tests that assess auditory skills, it is likely the auditory skill deficits may be associated with delays or deficits in language performance. However, it is unreasonable to make general judgments about a child’s language skills based purely on his or her performance on tests that assess auditory skills. In return, it is unrealistic to assume poor performance on language tests can predict AP skills. This is also a problem when clinicians try to categorize or infer language and learning deficits based on the results from an APD evaluation alone. It is unfair to make recommendations for intervention based on a “profile” of the child, rather than actually focusing on the child’s unique needs. A more efficient process would incorporate information provided by the AUD on how deficits in auditory skills may be affecting the development of language, while the SLP investigates how auditory deficits affect language skills. In turn, an intervention plan, reflecting the educational needs of the child, can then be established. McNamara and Richard (2012) have recommended a collaborative diagnostic model to address children who are suspected of having an APD (see Figure 19.1). The process would involve dialogue between the audiologist and speech-language pathologist at the point of initial referral. The speech-language pathologist may complete preliminary screenings to check auditory-related skills. Examples of screening tests that are available include the following:

- Auditory Skills Assessment (Geffner & Goldman, 2010)
- Differential Screening Test for Processing (Richard & Ferre, 2006)
- SCAN-3 for Children: Tests for Auditory Processing Disorders – Screening Subtests (Keith, 2009a, 2009b)
Once all information has been reviewed, deficit behaviors would then be categorized according to their characteristic patterns. Tagging behaviors under categories that directly correlate to specific problems in the classroom can be helpful. Categories would include language sorts such as phonology, semantics, syntax/morphology, reasoning, discourse, pragmatics, and literacy, because deficiencies in auditory skills would most likely be reflected in one or more of these language areas. From a qualitative analysis of the case history, a cooperative conclusion would be reached between professionals regarding the extent and type of testing needed. This may involve a team of professionals or just collaboration between the audiologist and speech-language pathologist. As Richard (2007) explains, the SLP role falls in the investigation of problems during the analysis of the acoustic signal, whereas the AUD’s role lies in the evaluation of the transference of the acoustic signal through the CANS.

Upon agreement regarding a diagnostic plan, the AUD should initially complete the evaluation. These results can then be shared with the SLP, because functional performance on auditory tests may provide further understanding of the effects on language. If completed in this manner, the SLP will have available the auditory skills performance data, along with a behavioral profile of language concerns, to guide the speech-language evaluation process. Once the SLP has completed an evaluation focusing on the specific deficits in the child’s language, it is time again to discuss results and intervention strategies with the AUD. This will ensure that the child receives a tailor-made strategic plan that will address areas of concern that are explicit to his or her needs. This model focuses on functional skill deficits and how these impact performance in school and daily living. With implementation of this cooperative model, functional skill deficits can be addressed in hopes that academic and psychosocial progress is realized.

In order for this model to work efficiently, several issues need to be discussed. First, it is important that the SLP incorporates evaluation tools that not only address basic language skills, but also assess higher level language function. As with any child who experiences auditory deficits (deaf, hard of hearing, auditory processing), skills for abstract, critical-thinking, and language processing may pose challenges. This also includes **metalinguistic analysis**, due to problems in applying the rules of language to incoming auditory input. Furthermore, testing should involve phonological/phonemic awareness skills, because problems with discriminating speech may correlate with abnormal auditory processes (Banai & Kraus, 2007).

Second, because there is no gold standard for evaluating an APD, the AUD needs to clarify how and why to evaluate for this disorder. It is true that better reliability and validity is needed for evaluation tools used for assessing AP skills (Friberg & McNamara, 2010). Many APD tests do not meet the criteria for diagnostic accuracy and test validity. In addition, AUDs must establish the best standard for determining when a child falls within the clinical population for an APD. Because of this, AUDs need to evaluate with the understanding that no one assessment tool is sufficient for the diagnosis of an APD; rather, a variety of assessment tools need to be used to confirm the presence or absence of an APD. This would include comprehensive case history information that provides insight into hearing, medical, educational, social, developmental, and communicative status (AAA, 2010). Questionnaires and surveys completed by the student, parent, and/or teacher include behavioral observations and are very useful as part of the diagnostic battery. The questionnaires include inquiries on how auditory behaviors affect academic, social, and communication abilities for the child referred for APD testing. These surveys assist in planning for testing and in intervention protocols. Several commonly used auditory behavior observation tools are the Children’s Auditory Performance Scale [(CHAPS); Smoski, Brunt, & Tannahill, 1998], Fisher’s Auditory Problems Checklist.
Behavioral tests assess auditory skills in the areas of sound localization/lateralization and binaural interaction, dichotic listening, temporal processing/patterning, low-redundancy speech tasks, and auditory discrimination (AAA, 2010). Through collaboration with other professionals and the interpretation of multiple cross-check testing data (including that gathered from nonbehavioral tests), a diagnostically accurate conclusion can be reached.

The AP Test Battery: What Does It Mean?

Historically, behavioral tests for APD originated from studies on individuals with known sites of lesions within the CANS; for example, difficulty with dichotic listening tests has shown increased sensitivity for lesion studies of the CANS (Fifer, Jerger, Berlin, Tobey, & Campbell, 1983; Katz, 1962; Meyers, Roberts, Bayless, Volkert, & Evitts, 2002; Musiek, 1983). These studies have guided the conceptual framework for a majority of the tests utilized today for the assessment of AP skills. However, a better protocol for the future development of behavioral tests that assess auditory–cognitive abilities may be to link reliability and validity measures to specific weaknesses in auditory skills that children may be experiencing; nonbehavioral tests, in contrast, may be used to provide auditory sensory processing information related to the status of the CANS.

Although the AAA (2010) and ASHA (2005) recommend the incorporation of electrophysiological measures when evaluating and diagnosing APD, this is not feasible for all children due to cost and accessibility. Even though electrophysiological tests have the potential to provide a description of abnormal neurological function, this type of testing does not offer information on the type and degree of behavioral problems a child experiences, nor does it change the intervention plan. In turn, behavioral tests offer a characteristic profile on performance for auditory skills, which may be associated with academic, social, or communication abilities. This information, along with data on speech, language, and academic abilities, enables professionals to better address deficits in specific skill areas. Therefore, this section will focus on the explanation of specific categories of behavioral tests utilized for the evaluation of a suspected APD. Likewise, much of the discussion will pertain to school-age children because this is the population in which symptoms initially occur and in which deficits in auditory processing are most noticeable. However, it is important to be aware that many of the characteristics discussed in children are also found in adults.

Dichotic Listening

Dichotic listening tests are useful for providing information on the function of the left and right hemispheres and the transfer of auditory information between hemispheres (Keith & Anderson, 2007). Dichotic tests involve the presentation of competing messages to each ear in a simultaneous manner. Binaural integration requires the participant to repeat back what is heard in both ears, whereas binaural separation tasks involve the repetition of stimuli presented to one ear while the stimuli in the opposite ear are ignored. Stimuli can range from digits to phonemes, words, or sentences (see Table 19.1).

Dichotic listening tests are diagnostically significant in that during the transmission of the dichotic signal, information is transferred through the dominant contralateral pathways (Keith & Anderson, 2007). Many individuals have left hemispheric dominance for language, so dichotic testing offers valuable insight into the development and function of the right versus left hemisphere and of the corpus callosum, which connects both hemispheres (see Figure 19.2). This also clarifies why children often perform better on linguistically based right ear tasks versus left ear tasks during
### TABLE 19.1  Behavioral Tests for (Central) Auditory Processing

<table>
<thead>
<tr>
<th><strong>Dichotic Speech Tests</strong></th>
<th><strong>Age Range</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Binaural Integration</td>
<td></td>
</tr>
<tr>
<td>Competing Environmental Sounds Test</td>
<td>3–12 years</td>
</tr>
<tr>
<td>Dichotic Consonant-Vowel (CV) Test</td>
<td>7 years–adult</td>
</tr>
<tr>
<td>Dichotic Digits Test</td>
<td>5 years–adult</td>
</tr>
<tr>
<td>Dichotic Rhyme Test</td>
<td>8 years–adult</td>
</tr>
<tr>
<td>Dichotic Sentence Identification Test</td>
<td>7 years–adult</td>
</tr>
<tr>
<td>Multiple Auditory Processing Assessment (MAPA) Dichotic Digits</td>
<td>8 years–adult</td>
</tr>
<tr>
<td>SCAN-3-C/A Competing Words Subtest</td>
<td>5 years–adult</td>
</tr>
<tr>
<td>Staggered Spondaic Word Test (SSW)</td>
<td>5 years–adult</td>
</tr>
<tr>
<td>Binaural Separation</td>
<td></td>
</tr>
<tr>
<td>Competing Sentences Test</td>
<td>7 years–adult</td>
</tr>
<tr>
<td>MAPA Competing Sentences</td>
<td>8 years–adult</td>
</tr>
<tr>
<td>SCAN-3-C/A Competing Sentences Test</td>
<td>5 years–adult</td>
</tr>
<tr>
<td>Synthetic Sentence Identification–Contralateral (SSI-CCM)</td>
<td>8 years–adult</td>
</tr>
<tr>
<td><strong>Monaural Low-Redundancy Tests</strong></td>
<td></td>
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<tr>
<td>Auditory Closure</td>
<td></td>
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<tr>
<td>Dept of VA High-Pass Filter</td>
<td>Adult</td>
</tr>
<tr>
<td>Dept of VA Low-Pass Filter</td>
<td>Adult</td>
</tr>
<tr>
<td>Dept of VA 45% Time-Compressed Speech</td>
<td>Adult</td>
</tr>
<tr>
<td>Dept of VA 65% Time-Compressed Speech</td>
<td>Adult</td>
</tr>
<tr>
<td>NU-6 Low-Pass Filter</td>
<td>7 years–adult</td>
</tr>
<tr>
<td>NU-6 Time Compressed</td>
<td>7 years–adult</td>
</tr>
<tr>
<td>NU-6 Time Compressed + Reverberation</td>
<td>7 years–adult</td>
</tr>
<tr>
<td>SCAN-3-C/A Filtered Words Subtest</td>
<td>5 years–adult</td>
</tr>
<tr>
<td>SCAN-3-C/A Time-Compressed Sentences</td>
<td>5 years–adult</td>
</tr>
<tr>
<td>Time-Compressed Monosyllabic Word Tests</td>
<td></td>
</tr>
<tr>
<td>Time-Compressed Sentence Test</td>
<td>6–11 years</td>
</tr>
<tr>
<td>Auditory Figure/Ground</td>
<td></td>
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<tr>
<td>Bamford-Kowal-Bench Speech-in-Noise Test (BKB-SIN)</td>
<td>4–14 years</td>
</tr>
<tr>
<td>Discrimination of PB-K in Noise (PBKN)</td>
<td>Grades K–5</td>
</tr>
<tr>
<td>Listening in Spatialized Noise-Sentence Test (LiSN)</td>
<td>6–11 years</td>
</tr>
<tr>
<td>Dept of VA Synthetic Sentences</td>
<td>Adult</td>
</tr>
<tr>
<td>MAPA Monaural Selective Auditory Attention Test (SAAT)</td>
<td>8 years–adult</td>
</tr>
<tr>
<td>MAPA Speech-in-Noise for Children and Adults (SINCA)</td>
<td>8 years–adult</td>
</tr>
<tr>
<td>Pediatric Speech Intelligibility Test (PSI)</td>
<td>3–7 years</td>
</tr>
<tr>
<td>Quick SIN</td>
<td>Adult</td>
</tr>
<tr>
<td>SCAN-3-C/A Auditory Figure Ground Subtest</td>
<td>5 years–adult</td>
</tr>
<tr>
<td>Selective Auditory Attention (SAAT) Test</td>
<td>5 years–adult</td>
</tr>
<tr>
<td>Speech-in-Noise (SPIN) Test</td>
<td></td>
</tr>
<tr>
<td>Speech-in-Noise W-22 (Katz Battery)</td>
<td>5 years–adult</td>
</tr>
<tr>
<td>Synthetic Sentence Identification–Ipsilateral (SSI-ICM)</td>
<td>8 years–adult</td>
</tr>
<tr>
<td><strong>Temporal Processing and Patterning Tests</strong></td>
<td></td>
</tr>
<tr>
<td>Temporal Resolution</td>
<td></td>
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<tr>
<td>Auditory Fusion Test–Revised</td>
<td>3 years–adult</td>
</tr>
<tr>
<td>Gaps-In-Noise Test</td>
<td>6 years–adult</td>
</tr>
<tr>
<td>MAPA Gap Detection Test (AFT-R)</td>
<td>8 years–adult</td>
</tr>
<tr>
<td>Random Gap Detection Test</td>
<td>5 years–adult</td>
</tr>
<tr>
<td>SCAN-3-C/A Gap Detection</td>
<td>5 years–adult</td>
</tr>
</tbody>
</table>
**TABLE 19.1** Behavioral Tests for (Central) Auditory Processing (Continued)

<table>
<thead>
<tr>
<th>Dichotic Speech Tests</th>
<th>Age Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temporal Ordering</td>
<td></td>
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<tr>
<td>Duration Pattern Test</td>
<td>8 years–adult</td>
</tr>
<tr>
<td>MAPA Duration Patterns Binaural</td>
<td>8 years–adult</td>
</tr>
<tr>
<td>MAPA Pitch Pattern Test</td>
<td>8 years–adult</td>
</tr>
<tr>
<td>MAPA TAP test</td>
<td>8 years–adult</td>
</tr>
<tr>
<td>Pitch Pattern Test</td>
<td>6 years–adult</td>
</tr>
<tr>
<td><strong>Binaural Interaction Tests</strong></td>
<td></td>
</tr>
<tr>
<td>Binaural Interaction CVC Fusion Test</td>
<td>7 years–adult</td>
</tr>
<tr>
<td>Intraural Intensity Difference Tonal Patterns (IID)</td>
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</tr>
<tr>
<td>Masking Level Difference (MLD)</td>
<td>5 years–adult</td>
</tr>
<tr>
<td>Rapidly Alternating Speech Perception (RASP)</td>
<td>5 years–adult</td>
</tr>
<tr>
<td>Sound Lateralization &amp; Localization</td>
<td>Adult</td>
</tr>
<tr>
<td>Spondee Binaural Fusion</td>
<td>7 years–adult</td>
</tr>
<tr>
<td><strong>Auditory Discrimination</strong></td>
<td></td>
</tr>
<tr>
<td>Difference Limen for Intensity</td>
<td>Adult</td>
</tr>
<tr>
<td>Difference Limen for Frequency</td>
<td>Adult</td>
</tr>
<tr>
<td><strong>Phonemic Decoding</strong></td>
<td></td>
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<tr>
<td>Phonemic Synthesis Picture Test (PSPT)</td>
<td>4–7 years</td>
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<tr>
<td>Phonemic Synthesis Test (PST)</td>
<td>6 years–adult</td>
</tr>
<tr>
<td><strong>Additional Behavioral Tests</strong></td>
<td></td>
</tr>
<tr>
<td>Auditory Continuous Performance Test (ACPT)</td>
<td>6–11 years</td>
</tr>
<tr>
<td>Auditory Processing Abilities Test (APAT)</td>
<td>5–12 years</td>
</tr>
<tr>
<td>Differential Screening Test for Processing</td>
<td>6–12 years</td>
</tr>
<tr>
<td>Functional Listening Evaluation (FLE)</td>
<td>4 years–adult</td>
</tr>
<tr>
<td>Test of Auditory Processing Skills, 3rd ed. (TAPS)</td>
<td>5 years–adult</td>
</tr>
<tr>
<td><strong>Questionnaires and Checklists</strong></td>
<td></td>
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<tr>
<td>Buffalo Model Questionnaire (BMQ)</td>
<td>6 and older</td>
</tr>
<tr>
<td>Children’s Auditory Performance Scale (CHAPS)</td>
<td>7 and older</td>
</tr>
<tr>
<td>Children’s Home Inventory for Listening Difficulties (CHILD)—Parent Version</td>
<td>3–12 years</td>
</tr>
<tr>
<td>Children’s Home Inventory for Listening Difficulties (CHILD)—Self-Reporting</td>
<td>8–12 years</td>
</tr>
<tr>
<td>Developmental Index of Audition and Listening (DIAL)</td>
<td>Birth–22 years</td>
</tr>
<tr>
<td>Early Listening Function (ELF)</td>
<td>4 months–3 years</td>
</tr>
<tr>
<td>Fisher’s Auditory Problems Checklist</td>
<td>5–12 years</td>
</tr>
<tr>
<td>Listening Inventory for Education (LIFE)—Student Appraisal</td>
<td>Grades 1–12</td>
</tr>
<tr>
<td>Listening Inventory for Education (LIFE)—Teacher Appraisal</td>
<td>Grades 1–12</td>
</tr>
<tr>
<td>Scale of Auditory Behaviors (SAB)</td>
<td>8.9–10.11 years</td>
</tr>
<tr>
<td>Screening Instrument for Targeting Educational Risk (SIFTER)—Preschool</td>
<td>3 years–kindergarten</td>
</tr>
<tr>
<td>Screening Instrument for Targeting Educational Risk (SIFTER)—Elementary</td>
<td>Grades 1–8</td>
</tr>
<tr>
<td>Screening Instrument for Targeting Educational Risk (SIFTER)—Secondary</td>
<td>Grades 9–12</td>
</tr>
</tbody>
</table>

dichotic testing. When an auditory signal enters the right ear during dichotic testing, the signal travels the dominant contralateral pathway and crosses directly to the language-dominant left hemisphere, where it is perceived. In turn, when a linguistic signal is presented to the left ear, it crosses to the right hemisphere, which then must transmit the signal through the corpus callosum to the left hemisphere for comprehension.

In dichotic listening tests, there will often be a higher percentage of correct responses in the right ear versus the left ear (Jancke, 2002). This right ear advantage (REA) minimizes around adolescence when myelination increases in the corpus callosum, making it more efficient and speedier. A significant REA in children—greater than normative data—may suggest a delay in maturation of the CANS, possibly within the corpus callosum. For these cases it is essential to monitor development of the CANS with annual testing for dichotic skills.

If test scores do not improve in the left ear with age, a disorder is suspected and further neurological testing is warranted. In turn, a left ear advantage (LEA) may reflect right hemisphere dominance or mixed right and left hemisphere governance for language (Keith & Anderson, 2007). Moncrieff (2011; Moncrieff, Keith, Abramson, & Swann, 2016) coined the term *amblyaudia* to represent this atypical dominance in ear advantage. In addition, Obrzut, Boliek, and Obrzut (1986) found that when children were directed to repeat the right or left ear first on dichotic tasks, those participants with a language and/or learning disability revealed an abnormal REA for right-ear-directed tasks and an LEA for left-ear-directed tasks. In these directed ear dichotic tasks, children who were not identified with a disability scored within the expected “normal” range for an REA. For individuals that reflect an LEA in dichotic listening tasks, continued testing by a multidisciplinary team is necessary due to suspicion of other global problems.
Children who exhibit abnormal scores on dichotic listening tests may be at risk for difficulty interpreting speech in the presence of other competing messages. For example, listening to two speakers at one time is extremely problematic, a situation that children are exposed to multiple times throughout the day. More difficulty may also be noted in group discussions where the individual must divide auditory attention and comprehend multiple signals (Parthasarathy, 2006). When listening to multiple speakers, we have two choices—to block out one signal while focusing on another signal (binaural separation) or to listen to both signals simultaneously and interpret as much information as possible (binaural integration). Functionally, either of these skills is very taxing for a child who has shown poor performance on dichotic listening tasks.

**Temporal Processing/Sequencing**

Temporal is defined as time based, and that is precisely how it relates to tests for AP. Behavioral tests for temporal processing/sequencing assess the ability to recognize the timing aspects of acoustic stimuli (see Table 19.1). This is an important function for the processing of auditory signals, especially for the interpretation of speech. Intact and accurate temporal processing/sequencing is critical for the perception of rapidly altering speech sounds. Similarly, sufficient temporal skills are needed for the interpretation of prosodic aspects of speech (Johnson, Bellis, & Billiet, 2007). Steinbrink, Zimmer, Lachmann, Dirichs, & Kammer (2014) completed a longitudinal study investigating auditory and visual temporal processing in children ranging from first to second grade. They found that rapid auditory processing abilities measured in auditory temporal order thresholds (TOTs) were highly predictive of reading and spelling aptitudes, while visual TOTs were not. It was concluded that the ability to rapidly process auditory information is a key influence in the development of early literacy skills.

Gap detection tests are generally used to assess temporal processing, the ability to recognize and distinguish auditory events over time (Shinn, 2007). Tests for gap detection assess an individual’s ability to detect small intervals of time between two consecutive auditory stimuli. As an example, the Random Gap Detection Test (RGDT) requires an individual to indicate the lowest millisecond (msec) interval in which she or he is able to detect the presence of two similar tonal or click stimuli (Keith, 2000). Gap intervals for stimuli are varied from 0 to 40 msec. Individuals are asked to raise one finger if they hear one stimulus or two fingers if they perceive two stimuli. The Gaps-In-Noise (GIN) test is similar; however, the examinee is presented with a series of 6-second segments of a broadband noise (Musiek et al., 2005). Within these segments of noise, a silent interval or intervals may be present. The silent gap intervals vary from 2 to 20 msec. Again, the examiner records responses and calculates the shortest gap duration detected by the listener.

Temporal sequencing tests, also referred to as temporal ordering, involve the sequential discrimination of multiple auditory signals over time (ASHA, 2005). Temporal ordering requires efficient communication between the right and left hemispheres, thus making temporal sequencing/patterning tests sensitive to neuromaturation and dysfunction of the interhemispheric pathways (Musiek, Pinheiro, & Wilson, 1980). Two primary tests for temporal sequencing involve frequency recognition and duration recognition. The Frequency Pattern test consists of two frequencies (a high- and low-frequency tone) presented in three or four tonal patterns (Musiek, 1994; Schow et al., 2006). The listener is instructed to label the sequence of the tones and repeat the arrangement in the same order (e.g., high-low-high, low-low-high, high-low-low-high; low-high-low-high, etc.). The Duration Pattern Test (Pinheiro & Musiek, 1985) is structured in a similar manner as the Frequency Pattern test. Listeners are asked to label patterns of sounds, but instead of varying the frequencies, the duration of the stimuli fluctuates between two lengths (e.g., long-long-short,
short-long-short, etc.). However, normative data are limited on children for most duration pattern tests.

Right hemisphere superiority is seen for such functions as the processing of prosodic features of speech, the analysis of facial expressions, and artistic talents such as musical abilities (Ross & Monnot, 2008), whereas interpretation of language is predominantly a role of the left hemisphere in right-handed individuals (Taylor & Taylor, 1990). Interhemispheric dysfunction may be reflected in poor performance on frequency and duration pattern tests. Problems with discrimination of speech, especially if it is rapid or presented in long segments with no breaks, may be observed in children who perform poorly on temporal processing tests. In addition, difficulty interpreting prosodic features of speech and trouble with gestalt may be observed (Bellis, 2003).

**Low-Redundancy Speech**

Low-redundancy speech tasks involve testing where the natural redundancy of speech is compromised by noise or poor signal quality. The ability to interpret degraded speech using auditory closure skills is a problem found in some listeners who experience AP difficulties (Geffner & Ross-Swain, 2007). In order to make closure, a listener must be familiar with the speech signal and be able to fill in missing elements when speech is not clear. There are several means for assessing a listener’s performance with degraded acoustic signals. The first is the most common method and employs identification of a speech signal while it is embedded in noise (AAA, 2010). Speech-in-noise tests, also referred to as auditory figure-ground tests, should be interpreted cautiously when used within the APD test battery. Speech-in-noise tests are known for their lack of sensitivity when diagnosing an APD. Other cognitive and attention influences may affect performance on speech-in-noise tasks. However, these tests are very useful in providing a description of how well an individual functions auditorily in excessive noise. This can be very valuable when developing a functional auditory profile for a child in the classroom. Speech-in-noise tests may be presented monaurally or bilaterally and require the listener to repeat an auditory signal in the presence of a competing message. Signal-to-noise ratios vary according to the criterion of the test, as do the stimuli (e.g., words versus sentences) and the type of competing noise (e.g., background noise versus speech competition). Varieties of tests normed for children are available and can provide insight on functional auditory abilities (see Table 19.1.)

A second method for assessing low-redundancy speech uses low-passed filter speech tests in which the speech signal is filtered, removing high-frequency spectral information. Several low-pass filter tests have been normed with cut-off filters at 500 Hz, 750 Hz, and 1000 Hz (Bellis, 2003; Keith, 2009a, 2009b; Wilson & Mueller, 1984); see Table 19.1. A list of low-pass filtered words are presented monaurally and listeners are required to repeat what they have heard. Low-pass filtered speech tests are associated with the ability to accurately make auditory closure when confronted with a poor acoustic speech signal.

Another procedure for evaluating auditory closure modifies temporal features of the speech signal. Time-compressed speech tests are presented at a rapid pace, without changing the frequency and intensity of the signal (Krishnamurti, 2007). Time-compressed speech tests are described by compression ratios; the percentage that the original stimulus is condensed with greater values equaling higher compressions. Stimuli can range from words to sentences. Normative data are available on several time-compressed assessment tools (see Table 19.1). Poor performance on time-compressed tests indicates decreased functional capabilities for processing rapid changes in acoustic stimuli, particularly fast speech.

Children who perform poorly on low-redundancy speech tasks may miss pieces of auditory information when the signal is distorted, indistinct, and/or degraded by noise. Although tests for low redundancy offer a questionable diagnosis for a true auditory sensory processing deficit, valuable information is given on auditory–cognitive abilities. This can be very useful when explaining poor listening skills in the classroom.
Binaural Interaction

Tests for binaural interaction reflect how auditory input works together from both ears at the level of the brainstem (see Table 19.1). These tests are very sensitive to intensity and timing differences between ears and are related to the localization and lateralization of sound (AAA, 2010). To date, there is no commercial test available that provides information concerning whether a listener has “normal” or “abnormal” abilities to accurately localize or lateralize to sound. There are tests that provide insight into the integrity of the lower brainstem, such as Masking Level Difference (Lynn, Gilroy, Taylor, & Leiser, 1981); however, these tests may not specifically provide a profile of localization/lateralization skills.

There are binaural interaction tests designed to measure binaural fusion of two signals presented simultaneously or interchangeably to both ears. For simultaneous signals, high-frequency information of a word is passed to one ear, while the low-frequency component is passed to the other ear. If the listener can adequately fuse the information, she or he is instructed to repeat the word that she or he hears. Binaural fusion tests also include tasks in which the listener hears rapidly alternating phonemes of a word or alternating words in sentences between ears and is asked to repeat the whole word or the entire sentence. However, these tests have been effective only in identifying conspicuous pathologies within the brainstem (Bamiou, 2007). Because of the lack of sensitivity for tests of binaural fusion, an audiologist may not include this type of evaluation tool within the APD test battery. However, there is growing research in this area, and new measures are being developed that examine binaural interaction functions. One such tool, the Listening in Spatialized Noise-Sentences Test (LiSN-S; Cameron et al., 2009) was developed to measure how well the listener uses directional cues (spatial advantages) to interpret speech in noise. An individual is asked to repeat a target speech signal while noise is presented from different locations.

A child who performs poorly on tests of binaural interaction may possess problems comprehending speech in the presence of background noise. This is due to the inability to segregate the speech signal when there is a competing sound source (Parthasarathy, 2006). Thus, listening proficiency for sound localization and auditory performance in background noise is affected. If a child cannot quickly locate the teacher’s voice in the room and has trouble understanding the teacher’s message from the noise in the classroom, the opportunity for learning is compromised.

Auditory Discrimination

Discrimination of speech sounds involves the ability to identify the frequency, intensity, and duration of phonemes (AAA, 2010). Auditory discrimination would appear to be a very integral part of the AP battery because perception of speech is necessary for the development of speech, language, and a host of other cognitive abilities. When a child cannot discriminate between sounds, especially those that have similar acoustic features, he or she will often misinterpret the message. However, deficits in auditory discrimination may show up on a number of behavioral AP tests due to the multiple auditory skills needed for the interpretation of speech. In addition, auditory discrimination is an auditory cognitive function and is difficult to separate from a true auditory sensory pathology. Due to this, it is better for the speech-language pathologist to investigate behavioral skills related to phonological/phonemic awareness to get a profile of a child’s ability to identify and manipulate sounds.

Electrophysiological Measures

Research has identified true auditory sensory deficits along the central auditory nervous system through the use of electrophysiological measures (Kraus et al., 1996); however, these tests require intricate and expensive equipment that is not always readily available at all audiologic facilities. Electrophysiological measures currently cannot replace the behavioral test battery for APD; however, in
conjunction with behavioral tests, they provide valuable information about the physiology and integrity of the CANS. Positive changes between pre- and postauditory training recordings are an important, effective way to objectively monitor the progress of an auditory training program. Continued research of electrophysiological responses in children with APD will further our understanding of auditory processing and the underlying auditory mechanisms that may be responsible for APD.

**Interpretation**

The results of the APD assessment should indicate whether an APD is present. The diagnosis of APD is based on reviewing all of the test results in the battery to determine whether there is a pattern of performance across different tests of auditory processing, possible interaural differences (ear weakness), and specific auditory processing deficits or weaknesses. Because APD is a heterogeneous disorder, a description of the auditory weaknesses or deficits should be detailed in order to implement a deficit-specific auditory rehabilitation plan.

One approach to test interpretation and auditory rehabilitation is to use models or profiles to further describe APD deficits and associated underlying neurophysiological site(s) of dysfunction. It is important to note that although these models are widely accepted, they have not undergone peer review.

**Models of APD**

**Bellis/Ferre Model**

The Bellis/Ferre model (Bellis, 2003; Bellis & Ferre, 1999) is one popular model that includes three primary subprofiles—Auditory Decoding Deficit, Prosodic Deficit, and Integration Deficit—and two secondary profiles—Associative Deficit and Output Organization (see Table 19.2). (For a detailed review, the reader is referred to Bellis [2003].)

<table>
<thead>
<tr>
<th>TABLE 19.2 Bellis/Ferre Profiles of (C)APD and Associated Deficits</th>
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<tr>
<td><strong>Primary Profile</strong></td>
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Auditory Decoding Deficit Profile is characterized by auditory discrimination deficits and difficulty listening in noise. Children with this profile may behave similarly to a child with a hearing loss. This child will often have difficulty with reading and spelling and weak phonological skills. Performance on tests of monaural low-redundancy speech will be abnormal. The Prosodic Deficit Profile describes deficits in temporal processing skills with abnormal performance in auditory pattern and temporal ordering tasks. Individuals with these deficits will have difficulty understanding the meaning of verbal messages because of difficulty with stress, rhythm, and intonation patterns. The Integration Deficit Profile is characterized by deficits in the ability to perform tasks requiring multisensory communication, such as incorporating both auditory and visual information simultaneously. The individual will have difficulty with tasks that require information processing from both the right and left hemispheres. Individuals with this profile will perform poorly on binaural integration tasks, dichotic listening tests, and linguistic labeling of temporals.

Buffalo Model

The Buffalo model of APD (Katz, 1992) is another popular model and is strongly based on the individual’s performance on the Staggered Spondaic Word Test. This model includes four categories: Decoding, Tolerance-Fading Memory, Organization, and Integration. The Decoding subtype describes individuals with difficulty synthesizing small parts of auditory information into larger parts. These individuals tend to respond slowly and have difficulty with spelling and reading. Remediation will focus on phonemic awareness skills. The Tolerance-Fading Memory subtype is characterized by short-term auditory memory deficits and difficulty listening to speech in poor acoustic environments. Remediation will incorporate speech-in-noise training and auditory memory strategies. The Organization subtype is characterized by inability to organize auditory information. An individual with this subtype will have difficulty retelling the sequence of a story. Speech-language intervention to target sequencing is recommended. The Integration subtype is characterized by inability to integrate multisensory information, such as auditory and other modalities of information.

It is important to note that an individual may not fit into one particular profile and may have characteristics of more than one profile or subtype. For this reason, some clinicians will focus rehabilitation efforts on the specific areas of auditory weakness.

Process-Based Auditory Training Rehabilitation

Clinicians may use a process-based method to interpret the AP testing results. This method identifies specific auditory deficits and weaknesses of auditory processing including such behaviors as temporal spectral and binaural processing, discrimination of speech in noise, and deficits in interhemispheric transfer of auditory information. Examples of interventions for process-based auditory remediation are shown in Table 19.3.

Auditory Training

Auditory training (AT) is described as therapy that improves auditory perception through auditory listening exercises (Musiek, Chermak, & Weihing, 2007). By addressing AT, auditory and nonauditory areas of the brain are engaged. This includes areas involved in attention, executive control, working memory, language processing, and motor planning. Auditory training is important for any child who has difficulty processing auditory information, whether it is due to a peripheral or central disorder. AT takes advantage of the brain’s lifelong capacity for plasticity and adaptive reorganization, which may be at least partially reversible through a deficit-specific training program (Musiek et al., 2007). Auditory training programs strengthen specific auditory skills, and programs may be formal or informal and active or passive. These programs need to match the auditory deficit that is observed and documented. Passive music programs have
become quite controversial in recent years. There is a lack of data to support such auditory integration treatments (ASHA, 2004), so they will not be discussed in this chapter. Active programs require participation from the patient and are probably more effective than passive programs (Bellis, 2003).

**Features for Effective AT**

Current literature reflects that AT training may be most effective in the early stages of therapy (Weihing, Chernak, & Musiek, 2015). As time passes, learning typically decreases and gains become smaller (Hawkey, Amitay & Moore, 2004). As a result, AT should be dispersed in frequent, shorter sessions in the initial therapy phases. Duration of AT may be most beneficial in a 6 to 8-week period if frequency is maximized. Once maximum gains have stabilized and have been documented, intermittent review sessions are helpful in maintaining skill levels obtained.

When implementing AT, it is most imperative that the child have access to auditory information and is able to hear and listen at a comfortable listening level. An assistive listening device such as remote microphone technology can be utilized to ensure audibility. If a child cannot hear and interpret auditory signals presented during AT, he or she will not benefit from the intervention. If the child utilizes assistive technology, a listening check should be performed before every session to confirm the device is working properly. Also, environmental conditions should be ideal for optimal listening. Ambient noise levels should be at a minimum, with limited auditory distractions.

As with any intervention, AT tasks should be implemented in a hierarchy of difficulty based on the child’s performance level. Weihing and colleagues (2015) recommend a success-to-failure criterion ratio of 70-30, with a 70% achievement level and no more than a 30% failure rate for all tasks addressed during therapy. This measure helps to monitor task complexity and ensure that the child is challenged, while helping to maintain motivation. Children can lose focus if a task at hand is too difficult. In addition, little improvement may be seen since there is limited auditory stimulation.

In order to sustain motivation, Weihing et al. (2015) emphasize providing a fundamental understanding of the importance of the listening activities to the child. The child should be able to explain what type of skills he or she is working on and how mastering these skills could help with his or her social and academic performance. Particularly school-age children may be required to partake in therapeutic activities that they do not understand. By keeping children...
informed of possible consequences, they will share ownership and be inspired by the progress they make.

**Monaural Low-Redundancy Training**

*Monaural low-redundancy training* will help individuals who have difficulty hearing in background noise, understanding rapidly connected speech, or hearing when the auditory signal is not optimal. Clinicians may introduce background noise during therapy sessions; auditory closure activities and vocabulary building activities are often used in training.

**Dichotic Auditory Training**

*Dichotic auditory training* is defined as therapy that addresses the ability of a listener to transfer information across the corpus callosum, from the right to left hemisphere and back. The purpose of DAT is to stimulate interhemispheric transfer and improve communication between the right and left hemispheres.

Dichotic auditory training is an innovative therapy for the remediation of the compromised central auditory pathway (Musiek, Chermak, & Weihing, 2007). This is accomplished via dichotic listening tasks by decreasing the signal intensity of the unimpaired pathway and slowly increasing the intensity level over time, as the weaker, impaired pathway grows stronger. This is also referred to as the dichotic interaural intensity difference (DIID; Musiek et al., 2007) and dichotic listening training. Dichotic auditory training differs from traditional language therapy in which the acoustic signal (recorded speech, therapist's voice, etc.) is presented binaurally. By contrast, dichotic listening training purports to specifically target the deficit ear and activate brain regions that receive auditory sensory input on the deficit side. Previous investigations have shown behavioral and electrophysiological evidence of improvement of the central auditory nervous system after dichotic listening training (Hurley & Billiet, 2008; Moncrieff & Wertz, 2008; Musiek, Baran, & Shinn, 2004).

There are two primary training tasks involved in DAT which include binaural separation tasks and binaural integration tasks. Both utilize auditory stimuli of digits, words, sentences, discourse, consonants-vowels (CVs), vowels-consonants (VCs), consonants-vowels-consonants (CVCs), and vowels-consonants-vowels (VCVs). As discussed earlier, binaural separation requires an individual to repeat back auditory information presented to the target ear, while ignoring a concurrent competing auditory signal in the opposite ear. For binaural integration, conflicting auditory signals presented simultaneously in both ears are to be repeated. To add more cognitive demand, a specific order may be required when repeating the stimuli, such as the stimulus in the right ear is to be repeated first and then the left. Dichotic auditory training exercises are available commercially; however, dichotic training can also be accomplished by using recorded materials or live voice and can be implemented in most therapy settings. An iPod, portable CD player, and/or personal amplifier system can be manipulated to present target stimuli. For example, words presented by the clinician are directed to the target ear via an earphone through a personal microphone system. At the same time a competing signal is routed to the opposite ear via an earphone from another player device. The competing signal can be a prerecorded four talker babble, a story, or some type of background noise. The child is asked to repeat what she or he hears in the target ear. Complexity can be increased by having the child follow directions, complete closure activities, or answer comprehension questions. The child can also listen to a story in the target ear, while a competing signal is directed in the opposite ear. Stories can be prerecorded and presented by an iPod, portable CD player, etc. A “Y” jack will be needed for the audio device so the clinician can also listen and follow the target signal. At various points the stimulus is stopped and comprehension questions are asked or the student may be required to provide a summary. The difficulty of the required task is matched to the performance level of the child. Complexity is also
augmented by increasing the intensity of the competing signal over time.

**Temporal Processing Training**

Training for temporal processing deficits may include formal or informal activities. The Fast ForWord family of software is based on successful temporal processing training. Other training methods may include using nonspeech sound, involving “same/different” judgments of tones, or narrow or broadband sounds that differ in frequency and/or temporal gaps. Listeners can also imitate the rhythm of a series of claps or tones (such as notes on a keyboard) of increasing complexity and length.

**Designing the Remediation Plan for APD**

Treatment of APD generally focuses on three areas: (1) environmental changes to ease communication difficulties, (2) introducing compensatory skills and strategies for the disorder, and (3) remediation of the auditory deficit (ASHA, 2005). These include bottom-up skills that focus on enhancement of the auditory signal and training to utilize the auditory message, and top-down skills that teach strategies for how to utilize the auditory signal more efficiently (ASHA, 2005). The remediation plan should reflect collaboration among the family, professionals, and even the student him- or herself. It may be manifested in an Individualized Education Plan, Section 504 Plan, or through Response to Intervention approach. No matter what intervention protocol is used, APD remediation should relate to Common Core Standards and the improvement of academic performance.

**Environmental Modifications**

Listening and learning can be adversely affected by the listening environment (Crandell & Smaldino, 2004). It is estimated that children spend approximately 50% of classroom time hearing and/or listening to instruction from their teacher (Berg, 1987) and approximately 45% of their time outside school hours involved in social activities requiring them to listen (Hunsaker, 1990). Creating an optimal acoustic environment for listening by making environmental/classroom modifications is important so that children with APD will have access to auditory information.

An assessment of the auditory environment may include examination of acoustic factors such as background noise, reverberation, and distance from the signal, as well as nonacoustic factors such as lighting and supplemental visual information (Crandell & Smaldino, 2004). Technology to enhance the signal-to-noise ratio may be beneficial to some individuals with APD, but may only be appropriate if the individual can adjust the unit. A general recommendation for a frequency-modulation (FM) system is not appropriate for all individuals with APD and should be considered only after positive improvements are noted during a trial period.

Environmental/classroom modifications may also include something as simple as preferential seating. The general term *preferential seating* is often referred to as placing the student in the front row. However, there is more to consider when identifying optimal seating for a student. It is important to make sure the student is seated away from noise sources (e.g. pencil sharpeners, doors) and in good visual view of the teacher/speaker. Positioning the student so that he or she has other students around him or her can provide good models when following directions. This will provide visual support to the student who has difficulty following auditory directions and allow him to use cues from her or his neighbors to fill in missing gaps of information.

**Compensatory Strategies**

Listening is the most used language art, and the one taught the least (Jalongo, 2006). Good listening skills can be taught. Compensatory strategies are top-down skills and are an important part of
teaching the child how to compensate for listening difficulties. These strategies teach techniques so an individual can become a better, active listener. Metalinguistic skills and metacognitive activities are top-down and equip the child to take responsibility for listening successes and failures.

Encouraging and instructing self-advocacy skills will help the child with an APD compensate for missed information in the classroom and in daily situations. The student should feel comfortable modifying conditions and situations in the environment that are not conducive to learning. Students should be encouraged to ask questions and request clarification when there is difficulty comprehending directions. Some students may need direct instruction on how to effectively ask for help and appropriately demonstrate good self-advocacy.

**Remediation and Direct Intervention**

Direct intervention incorporates a variation of strategies and skills to be addressed. This includes services for comorbid conditions, such as language, attention, academic difficulties, etc. This supports the need for a collaborative approach when addressing the needs of a child with an auditory processing disorder. However, one specific remediation strategy that is often disregarded is auditory training (AT). AT directly addresses deficiencies in auditory processing and has been shown to improve auditory skills in children with specific auditory difficulties (Weihing, Chermak & Musiek, 2015).

**Computer-Mediated Auditory Training Programs**

Computer-mediated auditory training programs are growing in popularity and have many advantages. They are convenient, they hold the interest of young children, there is a standardization of control of the stimulus, and the programs are adaptive. Thus, the stimulus or level may change based on the child’s correct or incorrect response. It is important to recognize the individual’s specific auditory deficit(s) and remember that no one single program will target every underlying auditory processing skill. New programs are introduced to the market continuously, so it is important for the clinician to be aware of new additions. Below is a brief description of some current programs available (see Table 19.4 for a list and sources).

**Formal Auditory Therapy**

Formal auditory training programs are usually conducted by an audiologist, speech-language therapist, or other educational specialist. Clinicians should consider the patient’s age, motivation, language ability, and ability to maintain attention throughout the therapy sessions. These factors should also be considered when choosing a training program. Therapy should be challenging, but not frustrating. Various tasks may be employed during sessions to prevent boredom.

**TABLE 19.4** Computer-Assisted Instruction

<table>
<thead>
<tr>
<th>Program</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>BrainTrain</td>
<td>BrainTrain, Inc.&lt;br&gt;<a href="http://www.braintrain.com">http://www.braintrain.com</a></td>
</tr>
<tr>
<td>CAPDOTS</td>
<td>The Listening Academy, Inc.&lt;br&gt;<a href="http://capdots.com">http://capdots.com</a></td>
</tr>
<tr>
<td>Fast ForWord</td>
<td>Scientific Learning&lt;br&gt;<a href="http://www.scilearn.com/products/fast-forward">http://www.scilearn.com/products/fast-forward</a></td>
</tr>
<tr>
<td>HearBuilders</td>
<td>Super Duper Publications&lt;br&gt;<a href="http://www.hearbuilder.com">http://www.hearbuilder.com</a></td>
</tr>
<tr>
<td>Laureate Learning</td>
<td>Laureate&lt;br&gt;<a href="http://www.laureatelearning.com">http://www.laureatelearning.com</a></td>
</tr>
<tr>
<td>Systems</td>
<td></td>
</tr>
<tr>
<td>Sound Auditory</td>
<td>Plural Publishing&lt;br&gt;<a href="http://pluralpublishing.com/publication_sat">http://pluralpublishing.com/publication_sat</a></td>
</tr>
<tr>
<td>Training</td>
<td></td>
</tr>
</tbody>
</table>
Acoustic Pioneer

Another web-based program specifically designed for individuals with auditory processing concerns is Acoustic Pioneer. Acoustic Pioneer incorporates a diagnostic component along with direct intervention to address temporal processing, non-linguistic auditory memory, non-linguistic dichotic ability, rapid tonal processing, linguistic auditory memory, linguistic dichotic ability, time-compressed degraded speech, and speech-in-noise. Activities to address these areas are presented in animated games and increase in complexity as the individual progresses.

BrainTrain

BrainTrain is another software program useful in aiding underlying language-processing skills, such as attention, sequencing, processing speed, and memory. Efficacy studies of this product have been limited to children with ADHD. This program is designed for patients age 6 years to adult.

CAPDOTS

CAPDOTS (The Listening Academy) is an online auditory training program that focuses on dichotic training. CAPDOTS Integrated emphasizes exercises to improve binaural integration deficits. For these tasks, varied information presented to each hear must be interpreted and repeated. CAPDOTS Selected incorporates exercises to improve binaural separation skill, which require interpreting information presented to one ear while disregarding auditory input into the opposite ear. Training can be started in children as young as 5 years of age.

Earobics

The Earobics family of software products is another popular program for improving phonemic awareness, auditory processing, and phonics, as well as cognitive and language skills that may benefit auditory and listening comprehension. Earobics is available for home, clinic, and school use. It is available in three levels—prekindergarten, school age, and adolescents and adults.

Fast ForWord

Fast ForWord (FFW) is one popular software program based on the underlying temporal processing research of Tallal et al. (1996) and Merzenich et al. (1996). The Fast ForWord program is designed to develop temporal and acoustic skills to detect rapid transitions of speech. The exercises in the Fast ForWord program use acoustically modified speech. It is important to note an individual may not fit into one particular profile and may have characteristics of more than one profile or subtype. For this reason, some clinicians will focus rehabilitation efforts on the specific areas of auditory weakness.

In the beginning of the program, the exercises prolong and emphasize the sounds and are easier to distinguish. As the listener progresses, speech sounds approach the rate of normal speech. As the listener improves, the exercises become more challenging, and the participant develops enhanced language awareness and comprehension.

HearBuilders

HearBuilders incorporates multilevel activities centered around specific auditory language objectives for following directions, phonological awareness, auditory memory, and sequencing. Tasks increase in complexity from visual with auditory to auditory alone. The program is appropriate for pre-K through eighth grade.

Laureate Learning Systems

The Laureate Learning Systems include programs that address language-processing skills. The programs contain exercises for preverbal children up to adults. Exercises include categorization and syntax training, auditory discrimination, reading, and spelling.

LiSN and Learn

The LiSN and Learn computer-based program is specifically designed to help improve the perception of speech in the presence of background noise. A three-dimensional auditory environment is
produced under headphones where speech is spatially separated in noise. The tasks are presented in a game-like format where the child identifies a target word from a sentence.

**Sound Auditory Training**

Sound auditory training (SAT) is an auditory training program designed to address a variety of auditory skills. Preformatted auditory tasks train in the areas of intensity, frequency, and temporal discrimination, identification, and recognition, gap detection and identification, frequency and duration pattern recognition, binaural interaction (500 Hz tone or speech), speech recognition in noise, and dichotic listening. It is specifically designed for children and adults with auditory processing disorders.

**Other Programs**

Several other computer-mediated programs have been developed for individuals with hearing loss. These programs are appropriate for a wide variety of ages, from preschoolers through adults, and include exercises in sound identification, auditory discrimination, and speech-in-noise training.

New software programs targeting AP skills are continuously introduced into the market. Clinicians need to routinely search for new product launches to remain current.

**Informal Auditory Therapy**

*Informal auditory therapy* activities may be done at home and are recommended to supplement formal auditory training. Engaging a young child at risk for APD in auditory training or auditory enrichment may involve everyday routine activities. Reading to children is one very important auditory training activity. A child who listens to a story and then answers questions about the story, or retells the story, is practicing active listening and improving his or her listening skills.

There are numerous reports of superior auditory processing ability in musicians. Music and speech share many of the same acoustical properties, such as pitch, timing, and timbre, to convey meaning. Musicians have a superior ability to hear in background noise, and have better temporal, timbre, and pitch discrimination abilities. Kraus and Chandrasekaran (2010) reviewed the benefits of formal music training as an enjoyable auditory activity that sharpens one’s sensitivity to pitch, timing, and timbre, and as a result aids the capacity to discern emotional intonation in speech and to learn native and foreign languages.

Another suggestion for informal auditory therapy is activities such as computer games, board games, or video games. Ferre (2002) provided a review of board games and activities targeting specific auditory processing skills (see Table 19.3). Dowell, Milligan, Davis, and Hurley (2011) reviewed current video games on the market to augment formal therapy. By incorporating skill development into everyday activities, auditory remediation may improve these deficit-specific areas. The use of popular, interactive games may be useful and convenient for audiologists, speech-language pathologists, early interventionists, or parents who wish to engage listening and auditory processing skills during play.

**Speech Language Intervention**

It is understandable that SLPs have many questions on how to appropriately provide intervention for children diagnoses with an APD. Even though a SLP may have limited training, he or she is often responsible for interpreting results and helping to develop an education plan to address the individual needs of students with APDs. When developing a plan, it is important to be aware that there is no one protocol that works for every individual with an APD. This is why the SLP needs to complete a comprehensive speech and language evaluation to decipher if there are any associated deficits in communication skills. However, investigating primary language skills linked to syntax, semantics, pragmatics, and morphology may not be sufficient.
An in-depth language profile may reveal more problematic areas. It is known that children with hearing loss struggle with abstract/higher level language, critical-thinking, and metalinguistic skills. A child who experiences a breakdown in auditory processing, whether it is caused by a peripheral or central etiology, will miss the redundancy needed to acquire proficient speech and/or language. Subsequently, communication skills that are often instinctively learned, must be directly trained. With that being said, Common Core State Standards have an emphasis on language arts. This comprises reading literature, reading information text, reading foundation skills, writing, language, and speaking and listening. These are all potential problematic areas that may be associated with an APD. IEP goals are most beneficial when they are aligned with and chosen to facilitate student attainment of these standards. Therefore, it may be most advantageous for the SLP to focus intervention on the following areas:

**Development of Listening Strategies:** assisting in the retention of complex messages using chunking (breaking long messages into smaller component parts and grouping like concepts together), verbal rehearsal (repetition and reauditorization of a message), and paraphrasing (restating the message in his/her own words). Example of behavioral objective: Given a three-step instruction, the student will paraphrase the instruction in his/her own words, including each relevant step.

**Development of Metalinguistic Abilities:** building language awareness and the ability to think about language. This involves training in the rules of language by addressing phonological awareness, narrative abilities and expository text, and scaffolding. Example of behavioral objective: The student will track and identify with colored squares changes in phonemes for nonsense words.

**Developing Metacognitive Abilities:** increasing the ability to reflect or think about thinking. Example of behavioral objective: Given a scenario of a communication breakdown, the student will explain two repair strategies to improve the message.

**Developing Self-Advocacy:** helping the student modify conditions in the environment that are not conducive to learning. Providing direct instruction on how to effectively ask for help and appropriately demonstrate good self-advocacy. Example of behavioral objective: Given a directive, the student will identify missing information needed in order to successfully complete the task.

**Conclusion: Working Together**

Despite the controversy over auditory processing disorders, a cooperative team involving the speech-language pathologist and the audiologist is essential for addressing auditory skill deficits in children. Both the AUD and the SLP play an integral part in the diagnosis and treatment of children with (central) auditory–cognitive processing deficits. An AUD can provide a unique perspective as to why a child may not interpret auditory information accurately. In return, the SLP offers insight into how language skills are affected by the breakdown in auditory-related skills. There are numerous disorders for which the true underlying etiology is unknown; however, this has not stopped our professions from treating behavioral deficits reflected by a disorder. It is time for the separate disciplines to work together to develop individualized and efficient intervention plans that meet the needs of children who have difficulty with the interpretation and comprehension of auditory information.
SUMMARY

Despite the varying information in the literature concerning the etiology of an APD, it is commonly described as an auditory diagnosis resulting from various dysfunctions of neural representation of auditory stimuli in the central auditory nervous system. This can manifest as a heterogeneous group of auditory deficits such as poor auditory discrimination for speech, decreased auditory attention, and difficulty comprehending rapid speech and/or speech in noise. A diagnosis of APD cannot be made from one test, but rather must be made from looking at a pattern of performances across a test battery and is best identified while working in collaboration with other professionals as a multidisciplinary team. Collaboration among the audiologist, speech-language pathologist, and other relevant professionals will help to ensure the most accurate diagnosis and lead to a well-designed remediation plan that includes (1) environmental changes to ease communication difficulties, (2) compensatory skills and strategies to alleviate complications associated with the disorder, and (3) remediation of the auditory deficit (ASHA, 2005). These collaborative treatment plans may include bottom-up and top-down formal and informal activities and should be deficit specific to address the needs of the child.

DISCUSSION QUESTIONS

1. Discuss how the collaborative model may be beneficial in the diagnosis and treatment of APD.
2. Discuss other conditions that may coexist with APD. How can these be distinguished?
3. Which auditory processes do dichotic speech tasks evaluate?
4. Discuss three temporal processing tests. Why is temporal processing important for understanding speech?
5. Briefly discuss methods used to reduce the redundancy of speech for APD assessment.
6. Discuss the limitations of electroacoustic and electrophysiological testing in the APD battery.
7. Briefly list behavioral, academic, and management approaches for the following subprofiles of APD:
   - Auditory decoding deficit
   - Prosodic deficit
   - Integration deficit
8. What are three main categories of APD treatment?
9. What are the common strategies for implementing an effective AT program?
10. What are three advantages of computer-mediated auditory training programs?
11. What are some examples of informal auditory training programs?

REFERENCES


Chapter 20

Acute, Subacute, and Nursing Home/Long-Term Care Facilities

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Key Terms

Acute care
Americans with Disabilities Act (ADA)
Aural rehabilitation
Consulting audiologist
Educational model

Feedback
Five stages of grief model
Hearing Handicap Inventory for the Elderly
In-service training
Medical model

Minimum Data Set for Nursing Home Residents Assessment and Care Screening Tool (MDS)
Omnibus Budget Reconciliation Act
Subacute care
Veterans Affairs facility

Objectives

• Summarize the variety of services and responsibilities required of the speech-language pathologist caring for patients with hearing loss in acute, subacute, and nursing home/long-term care facilities.
• Define the role of the speech-language pathologist when working with an individual with hearing loss in an acute versus subacute setting.
• Understand and describe the difference between the medical and educational model of service provision.
• Discuss the different tools used to assess hearing and auditory communication status in the subacute and nursing home/long-term care settings.
• Identify and describe the hearing aid issues and considerations for the patient in a nursing home/long-term care facility.
• Explain and discuss models of aural rehabilitation for adults.
Introduction

One of the most exciting aspects of being a speech-language pathologist (SLP) is the wide variety of settings available to the professional. Although the majority of SLPs will find themselves employed in school systems (Lubinski, 2013) many will also seek employment in subacute facilities, rehabilitation centers, and long-term care facilities. Regardless of setting, eventually the SLP will find him- or herself working with someone who is hard of hearing. The purpose of this chapter is to enable the speech-language pathologist to manage the resources available when working in such facilities, in the best interest of their patient with hearing loss.

Acute Care

Acute care settings deal with medically complex individuals; patients in this type of setting are usually treated for a sudden episode or illness. SLPs in this setting provide evaluation and treatment for a variety of disorders, which may include, but not be limited to, swallowing, and speech and language deficits resulting from strokes, head injury, respiratory, and other issues. Additionally, according to the American Speech-Language-Hearing Association (ASHA, n.d., para. 2), the top five primary medical diagnoses of acute care patients are cerebrovascular accident (CVA) or stroke, head injury, hemorrhage/injury, respiratory illnesses, and central nervous system (CNS) disease. Each of these disorders can cause and/or be associated with impaired auditory system function. Therefore, before the SLP does a speech-language evaluation on an acute care patient with a communication disorder of any type, confirming the patient’s hearing status is a key component to obtaining accurate speech and language evaluation results.

In this section we will discuss different aspects of providing services in an acute care setting to patients who may experience hearing loss either comorbidly or as a direct result of the acute medical illness for which they are being treated.

The Medical Model of Health Care

In the United States and in many countries around the world, acute healthcare facilities provide care to their patients based on a medical model of service delivery. This model depends on an interdisciplinary group of trained medical professionals and allied health professionals working with a single patient and varies significantly from an educational model of service delivery. See Table 20.1.

In a medical model, the interdisciplinary team is led by a primary physician who manages the overall care of the patient forming a team based on the needs of the patient. In this healthcare model, written requests for consultation by members of this team, otherwise known as doctor’s orders, are required for all preventative, curative, consultate and rehabilitation services. No care can be provided to a patient without orders from the primary care physician (Zenzano et al., 2011).

As a speech-language pathologist working in an acute care facility, typically, your department will receive a written form (order) to provide consultation, evaluation, and rehabilitation within your scope of practice to the patient under the physician’s care. This written process is carefully executed based on the liability of patient care and malpractice set forth by each hospital facility. In this employment setting, chances are that you will find yourself working side by side with one or more audiologist(s) in the same department or facility. Consulting with this individual on patient care becomes a routine part of the SLPs day. If there is no full-time or part-time audiologist on staff at the hospital, find out who the consulting audiologist of record is. Alternatively, if the patient has been identified as being hard of hearing or deaf, find out who the managing audiologist is and consult with that professional as part of the interdisciplinary model of care.

Consulting Audiologists

In many rural healthcare facilities, audiologists may be hired as consultants rather than full-time employees of the healthcare facility. In this scenario,
Collaboration is the key that unlocks services to children who may have medical needs that may also manifest themselves in the educational realm. However, it may seem that physicians and the school-based professionals are speaking two different languages, both with the interest of the patient/client at heart. The following is an analysis of the major differences between these two models. Gaining an understanding of how each part of the process varies will enable professionals to request the appropriate service from the appropriate specialist using the appropriate procedural language. The result is more efficient and effective service provision.

### Table 20.1 Medical Versus Educational Model of Service Provision

<table>
<thead>
<tr>
<th>Component of Service Provision</th>
<th>Medical Model</th>
<th>Educational Model (for Special Education and Related Services)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Testing terminology and timelines</td>
<td>Testing of disease or disorder and the process thereof is managed by the Primary Care Physician (PCP) or managing medical provider. Re-evaluation or revision of diagnosis is only done if and when symptoms change.</td>
<td>Testing for a “suspected disabling condition” is accomplished at the time of the initial referral for special education and related services and then revisited once every 3 years at a “re-evaluation planning meeting.” (<a href="https://www2.ed.gov/policy/speced/guid/idea/modelform-safeguards.pdf">https://www2.ed.gov/policy/speced/guid/idea/modelform-safeguards.pdf</a>)</td>
</tr>
<tr>
<td>Testing may include (but is not limited to)</td>
<td>A battery of examinations and evaluations to arrive at the medical diagnosis. What testing and how many tests are done is a decision made solely at the discretion of the PCP, managing medical provider or specialist.</td>
<td>Social assessment, psychoeducational assessment, learning evaluation, speech and language evaluation, audiological evaluation, occupation and/or physical therapy evaluation, behavioral evaluation, pediatric neurological evaluation, teacher evaluations. The evaluations chosen are based upon a procedural meeting held by the school-based child study team.</td>
</tr>
<tr>
<td>Outside assessments</td>
<td>Completed at the discretion of the PCP or managing medical provider based on the suspected diagnosis.</td>
<td>May be introduced to the child study team, but the team is not obligated to accept an assessment or its recommendations. This includes information provided to the school by the child’s managing medical provider.</td>
</tr>
<tr>
<td>Services provided through</td>
<td>A treatment plan managed by the PCP, managing medical provider, or medical specialist.</td>
<td>The development of an individual education program (IEP) by a team of educational specialists, classroom staff, and the parent.</td>
</tr>
<tr>
<td>Eligibility for school based services</td>
<td>A medical diagnosis does not automatically make a child eligible for service provision in the educational setting.</td>
<td>A child is found “eligible for special education and related services” based on the results of the evaluations completed by the school based child study team using the terminology of 1 of the 13 classifying conditions. (<a href="http://idea.ed.gov/">http://idea.ed.gov/</a>)</td>
</tr>
<tr>
<td>For school-based services to be provided</td>
<td>Contact needs to be made with a school based Student Support Team (SST) who is then charged to prove: “A physical or mental impairment which substantially limits one or more major life activities.” (<a href="https://www.ada.gov/">https://www.ada.gov/</a>)</td>
<td>IEP Team must determine: “Manifestation of the disability in the educational setting.” (<a href="http://idea.ed.gov/">http://idea.ed.gov/</a>)</td>
</tr>
<tr>
<td>Focus of related services</td>
<td>Among other related services, occupational, physical, and speech therapies may have a broader focus on the individual’s whole environment.</td>
<td>Some services, such as occupational and physical therapies may be limited to skills that are educationally relevant and relate to a child’s learning activities only.</td>
</tr>
</tbody>
</table>

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as the on-staff speech-language pathologist you may find yourself providing audiologic screening services, hearing aid maintenance, and the like based on your scope of practice (refer to ASHA, 2016 for further details on the SLP scope of practice). In this setting you may be required to meet with the audiologist when that professional is on schedule for his or her assigned day(s) of consultation to the facility. In this case, it may be important (and useful) to establish a mutually agreeable time with that individual to review cases and update the audiologist on any new cases that have been admitted and any services that you have provided or may need to be prepared to provide in their absence. As acute care facilities attempt to keep a patient’s stay as brief as possible, you may be asked to provide services that are not within your scope of practice at the urging of the facility in the absence of the consulting audiologist. It is therefore of utmost importance, when working in a medical facility with an audiologist on a consulting basis, that strict procedures are in place regarding each professional’s responsibility to the patient with hearing loss. Having these policies and procedures in place and in writing is to the benefit of everyone involved with the appropriate care of the patient.

**Specialty Clinics**

Acute care facilities that specialize in a specific disability, such as pediatric cochlear implants, cleft palate, or Down syndrome, may have established specialty clinics. When patients are seen in specialty clinics, a multidisciplinary team of medical and allied health professionals is gathered for a period of time. Typically, clinics are run for a half day, either morning or afternoon, on a delineated day of the week or month (e.g., the third Tuesday of the month) when all patients are scheduled to arrive at a single time and are cycled through the specialty areas addressing the multiple needs of the patient. Because of the multiple conditions of the patient, hearing screenings may be a responsibility assigned to the speech-language pathologist as part of a comprehensive speech and language evaluation of the patient. The SLP should find out what the established protocol is for the screening and for referring a patient for a complete audiologic evaluation, should a patient fail the screening procedure. In the event that the SLP requests a complete audiological evaluation, the SLP should then discuss with the multidisciplinary team that a speech and language evaluation should be postponed until hearing thresholds are established. Many hospitals running specialty clinics will have scheduled multidisciplinary team meetings following a clinic or at another scheduled time. This is the SLP opportunity to discuss the hearing concerns and recommendations for referral to an audiologist. If such meetings are not part of the particular hospital’s clinic policy, then the SLP should find out what the hospital’s system is for information sharing of this nature and the procedure for referring patients to the audiologist when a problem is suspected.

**Veterans Affairs (VA) Hospitals**

The U.S. Department of Veterans Affairs, also known as the VA, administers more than 1,700 hospitals, clinics, community living centers, domiciliary care centers, and readjustment counseling centers across the country. These facilities make up the largest integrated healthcare system in the United States. Services of the VA include a variety of medical and allied health benefits that are available to members of the armed services, veterans, their immediate families, and their survivors. Speech-language pathologists working in a Veterans Affairs facility will discover that audiologists are also widely employed by the VA to provide a range of services including the evaluation of hearing sensitivity, hearing aid dispensing, and aural rehabilitation services for military and veteran personnel as well as their families. As with acute and subacute facilities, the SLP is encouraged to seek out the audiology department within the VA facility of employment, understanding that he or she may not be associated with the department of speech-language pathology, but rather with the otolaryngology department of the hospital.
The following summarizes the long-term relationship between the VA and audiologists:

- The first VA audiology clinic opened in 1946 in New York.
- The VA is one of the largest employers of audiologists in the country.
- The VA provides routine grant opportunities for research in the field of audiology.
- The first recorded materials for speech audiometry came from the Mountain Home VA Hospital in Tennessee (Jerger, n.d.).

Readers are encouraged to go the U.S. Department of Veterans Affairs at http://www.va.gov for additional information on healthcare settings and services available for patients who have served in the U.S. military.

**Subacute Care**

The definition of subacute care, as developed by several organizations [e.g., the American Health Care Association (AHCA), the Joint Commission, and the Association of Hospital-Based Skilled Nursing Facilities], states that subacute care is comprehensive inpatient care designed for someone who has an acute illness, injury, or exacerbation of a disease process. It is a goal-oriented treatment immediately after, or instead of, acute hospitalization (Kuchar, 2006). Patients are sent to the subacute facility once they have been stabilized in the medical facility (e.g., hospital), and no longer meet the criteria for that acute care setting. The subacute settings cover a wide range of services and may specialize in a specific type of care, either long term or rehabilitative in nature. The level of care provided in subacute units is generally for higher acuity conditions than care provided in long-term care units, but of lower acuity than in acute care hospital units (Kiresuk, 2010). The services are comprehensive and goal oriented, and many facilities may choose to use an interdisciplinary approach. These authors have found the collaborative approach to be most successful in our practice as communication disorders service providers.

The length of stay for a patient in subacute care depends on the individual patient’s needs; however, it is likely to be longer, and in some cases considerably so, than the acute phase of care. As such, the speech-language pathologist will have more extensive contact with the patient, and have a greater variety of therapeutic experiences with them. The needs of the SLP in terms of understanding the nature, severity, impact of hearing loss, and hearing aids/assistive devices will be that much greater in this setting as well. Therefore, it is imperative that the SLP establishes whether there is an audiologist who consults with the particular subacute facility for the hearing health care of the patients while in residence. There may be a regularly scheduled day that the audiologist is there to see all patients referred for services. This person may be on call as needed and, as the SLP, you may be the point person to identify and contact the audiologist when services are needed. The process for doing so must be clearly identified and, even better, documented in writing between the facility and the speech-language pathologist. Regardless, you must familiarize yourself with the policy of the facility. Likewise, a hearing aid dispenser may also be contracted to service the facility in a similar fashion. Again, good communication is the key to working with these individuals as partners in patient care. Also, note that the audiologist and the hearing aid dispenser may or in some cases may not be the same professional. Many hospitals are affiliated with specific subacute facilities for the continuity of care for their patients. It is wise to make sure that you are aware of the facility’s hospital affiliation(s), and the acceptable process of communication with that facility.

**The Case History**

If an established protocol for a relationship with the sending facility exists, this will enable you, as the speech-language pathologist on staff, to consult with the physician/specialist who may be familiar with the patient. If such a model of consultation is not available, then the patient’s records should be thoroughly reviewed. Always begin with a thorough case history. In such a facility you may
encounter several stumbling blocks to a comprehensive case history, including records not being transferred properly with the patient, records being delayed but pressure to begin therapy being applied to you, the absence of family who can provide accurate information, the presence of a family member who is providing inaccurate information, and/or a patient who is unable, due to her or his medical condition, to provide an accurate self-report.

Case History Information Related to Hearing Loss

In many instances, when working in subacute care facilities, a significant emotional component regarding the overall status of the admitted patient may exist. Actual versus perceived medical condition, the family’s emotional bond with the patient, their desire to see the patient return to full health and function, overall quality of life, and the reality of their loved one’s prognosis, may all be factors that will stand in the way of an accurate case history (Adams-Wendling & Pimple, 2008). The patient and/or family and loved ones’ reactions to some of the significant life changes that precipitate entry into the acute or subacute setting can resemble the stages that individuals have been observed to experience when faced with the prospects of death and dying (Long, 2011).

Dr. Elisabeth Kübler-Ross is well known for her methodology in the support and counseling of personal tragedy and grieving associated with death and dying. She also dramatically improved the understanding and counseling practices related to bereavement and hospice care. Her influential book, On Death and Dying (1969), mapped out a five-stage framework, known as the five stages of grief model, to explain the experience of dying patients, which progress through denial, anger, bargaining for time, depression, and acceptance (Kübler-Ross, 1969). These stages are also observed in people and family members experiencing personal change and emotional upset resulting from factors other than death and bereavement.

This makes Kübler-Ross’s model worth including when discussing the varied emotions the speech-language pathologist will encounter when working with both the patient and family members in acute and subacute care facilities. The model helps remind us that a person’s perspective may be different from our own. Getting through this emotional component of patient care will allow the SLP to better understand the patient’s needs as a whole, understanding that family support is an important part of patient care as well.

Several key points may assist you in focusing case history questions that will allow you to proceed ethically with the care of your patient with hearing loss. First and foremost, you must know their diagnosis. What has led them to the facility? Was the event a stroke, car accident, or some other trauma? Even if the admitting diagnosis is not related to a hearing loss, it is most worthy of investigation. Often, a medical condition or diagnosis may not seem to be related to the auditory system, but there are conditions that can actually cause or exacerbate an existing hearing loss, and there also may be comorbidities. Again, your patient may or may not be the best historian. If the availability of records is limited, or if the family or the patient cannot be a reliable informant, try to answer the following questions:

- What is the patient’s diagnosis?
- Is there a secondary or tertiary diagnosis?
- How long did the patient reside in an acute care facility?
- Is there anything in the chart that may be a red flag for hearing loss: notes from the physician that indicate the patient did not appear to comprehend instructions, nurse’s notes indicating that the patient was speaking in a loud voice or patient was listening to the television too loud?
- Is there a pharmacological potential for hearing loss that may or may not have been discussed with the patient?
- Is the patient complaining of tinnitus?
• Do you see hearing aids? Remember, they may *not* be in the patient’s ears; they may be with his or her belongings, or on an inventory list upon transfer from the acute care facility. Many times family members will take the hearing aids home, worried that they will be lost in the transition to a subacute facility. Do not assume that if a patient has hearing aids they will be in his or her ears.

**Hard-of-Hearing Patients in Subacute Care**

Beyond the legal rights of patient care and the *Americans with Disabilities Act* (ADA) laws of access, the speech-language pathologist may find him- or herself in a place of advocacy for appropriate communication between facility staff and the patient. One example may be creating and posting an advisement regarding hearing loss by a patient’s bed or on the door of the patient’s room to aid in communication.

In-service training, grand rounds, and patient review panels are examples of other avenues by which the SLP can advocate for the hard-of-hearing patient. Other responsibilities may include counseling with the family members regarding follow-up for obtaining appropriate hearing evaluation/hearing aid purchase, tolerance when communicating with the family member, and/or encouragement for routine hearing aid use. Realistic expectations should also be set for the family regarding the benefit of amplification.

**The Deaf Patient in Subacute Care**

Rights of communication access become of paramount concern with the deaf patient in any medical facility. The denial of the ADA rights of access have led to many civil rights lawsuits across the United States between the deaf patient and healthcare facility. In reviewing the ADA rights, attention should be drawn to the word *obligated* in terms of providing interpreting services for the deaf patient and deaf family members as well. The purpose of this terminology is clear. Effective communication and a clear understanding of symptoms, medical diagnosis, and follow-up care are paramount to a patient’s care. Failure to provide effective communication can result in misdiagnosis, delay in treatment, or even worse (i.e., inappropriate treatment). Again, the SLP may find him- or herself in a position of being an advocate or facilitator of such services throughout their facility of employment.

**Universal Sign for Deafness**

[Figure 20.1] shows the universal advisement sign for deafness. Posting of this sign on a patient’s door or above the bed, with further directions on the ADA rights of communication (see previous section), may be beneficial to the prevention of facility liability.

**Nursing Homes and Long-Term Care Facilities**

The ASHA, Ad Hoc Committee of Audiology Service Delivery in Home Care and Institutional Settings, has published “Guidelines for Audiology Service Delivery in Nursing Homes” (ASHA, 1997). The document provides specific practice procedure recommendations for audiologists working in such facilities, but can also be used as a guideline for the...
speech-language pathologist servicing the hard-of-hearing or deaf patient. The SLP should function only within his or her own scope of practice when providing services for the hard-of-hearing and deaf patients in such facilities.

**Defining and Identifying Staff**

Seeking out the appropriate professionals for providing care to the hard-of-hearing or deaf patient will be paramount to the success of patient care. Is there an audiologist on staff? Is that individual full time, part time, or available only on a consultative basis? Are the audiologist’s services defined by the facility through a job description or an internal scope of practice?

Many long-term care facilities will also employ or have a working relationship with a local hearing aid dispenser. Whether licensed and credentialed as an audiologist or hearing aid professional will depend on the individual state regulations, which vary greatly from state to state. This person may or may not be the audiologist providing evaluation and follow-up care to the hard-of-hearing or deaf patient within the facility. Some facilities may use audiology technicians in lieu of a certified audiologist, in which case the speech-language pathologist may want to identify who the supervising audiologist is, and communicate with that person as well. Other facilities may employ no one at all, relying on the patient’s family to provide such care. It is important that the SLP determine the extent of service provision and work with the professionals in this area or make appropriate recommendations for the establishment of audiology services within the facility.

**Minimum Data Set for Nursing Home Residents Assessment and Care Screening Tool (MDS)**

The Omnibus Budget Reconciliation Act of 1987 (OBRA) requires all nursing homes receiving federal funding to assess each new patient using the Minimum Data Set for Nursing Home Residents Assessment and Care Screening Tool (MDS). The MDS is part of the U.S. federally mandated process for clinical assessment that is to be administered to all nursing home patients in Medicare and Medicaid certified nursing homes within the first 14 days of admission. It covers a wide range of functional areas from behavior to special needs, including hearing acuity and hearing aid use (ASHA, 1997). The results of the MDS will drive the patient care program of the nursing home facility, which may include further evaluations involving the services of an audiologist.

**Hearing Screening Tools**

OBRA further addresses screening procedures for patients within the nursing home facility, including that of a hearing screening. As an audiologist, the term *screening* naturally refers to the use of calibrated electronic technology used to assess auditory thresholds. However, there are other tools, used inside and/or outside the field of audiology, that are used to help determine hearing and communication status and the need for further referral and interventions.

**Audiometric Screening**

If your information gathering, thus far, suggests that an audiometric screening has not been done, or cannot be located, then it is recommended that it be performed. Some of the audiometric screening devices that may be available and used to assess hearing acuity include audioscopes, otoacoustic emission screeners, and the traditional screening audiometer. These pieces of equipment may be available within the facility to more accurately assess auditory acuity versus perceived hearing status, and is within the SLP’s scope of practice to perform.

**Questionnaires**

In addition to the audiometric type of screening, other methods and tools, such as questionnaires and behavioral observation checklists, help determine hearing status and its concomitant impact on communication. These inventories rely on self-assessment and quality-of-life questions using the patient’s or family’s viewpoint of communication.
status (Lichtenstein, Bess, & Logan, 1988). An example of this type of measure is the *Hearing Handicap Inventory for the Elderly* (Ventry & Weinstein, 1982). This tool is a 25-item questionnaire that measures an individual's perceived activity limitation and participation restriction as a result of the hearing loss. Ventry and Weinstein also developed a screening version of this tool (1983), the Hearing Handicap Inventory for the Elderly–Screener version (HHIE-S), which is shown in Figure 20.2. This abbreviated version contains 10 questions, and can be easily and quickly administered to a patient.

As described by Thoren, Andersson, and Lunner (2012), there are other paper and pencil

<table>
<thead>
<tr>
<th>ITEM</th>
<th>YES (4 pts)</th>
<th>SOMETIMES (2 pts)</th>
<th>NO (0 pts)</th>
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<tbody>
<tr>
<td>Does a hearing problem cause you to feel embarrassed when you meet new people?</td>
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<tr>
<td>Does a hearing problem cause you to feel frustrated when talking to members of your family?</td>
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<tr>
<td>Do you have difficulty hearing when someone speaks in a whisper?</td>
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<tr>
<td>Do you feel handicapped by a hearing problem?</td>
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<tr>
<td>Does a hearing problem cause you difficulty when visiting friends, relatives, or neighbors?</td>
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<tr>
<td>Does a hearing problem cause you to attend religious services less often than you would like?</td>
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<td>Does a hearing problem cause you to have arguments with family members?</td>
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<td>Does a hearing problem cause you difficulty when listening to TV or radio?</td>
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<td>Do you feel that any difficulty with your hearing limits or hampers your personal or social life?</td>
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<tr>
<td>Does a hearing problem cause you difficulty when in a restaurant with relatives or friends?</td>
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</tbody>
</table>

**RAW SCORE** (sum of the points assigned each of the items)

**INTERPRETING THE RAW SCORE**

- **0 to 8** = 13% probability of hearing impairment (no handicap/no referral)
- **10 to 24** = 50% probability of hearing impairment (mild-moderate handicap/refer)
- **26 to 40** = 84% probability of hearing impairment (severe handicap/refer)

questionnaires that can be successfully used in this population; some of them address the patient’s functional abilities with her or his hearing aids (or other device) in place, such as the International Outcome Inventory for Hearing Aids (IOI-HA), which is a seven-item questionnaire that measures the benefit of hearing aids (Cox & Alexander, 2001; Cox, Alexander, & Beyer, 2003; Cox et al., 2000), and the Satisfaction with Amplification in Daily Life (SADL) (Cox & Alexander, 2001), which is a 15-item questionnaire that measures the benefits and positive effects of hearing aids on a seven-point scale.

Whispered Voice Screening Test

Another screening tool used is the Whispered Voice Screening Test (Swan & Browning, 1985). In this screening, the examiner stands 2 feet away from and behind the patient, in order to remove the ability to speech read, and whispers into the test ear; at the same time, the examiner instructs the patient to occlude (using a finger) and simultaneously gently rub the nontest ear, in an attempt to mask the nontest ear. A random set of three numbers or letters is then verbally presented, with the direction to repeat what the examiner has said. Despite the fact that it may be difficult to compare results of this test from examiner to examiner, within the same examiner it has been found to be a valid and reliable screen for hearing loss (Bagai, Thavendiranathan, & Detsky, 2006). It is the opinion of these authors however, that such tests should be used and interpreted with extreme caution and should not take the place of conventional audiometric methods of screening.

Hearing Aid Care in the Nursing Home

One of the greatest challenges the speech-language pathologist will face in a nursing home facility when caring for the hard-of-hearing patient is designing a plan for hearing aid use, care, safety, maintenance, and accountability. A care plan can be incorporated into therapy goals and can employ the participation of the patient, nursing services, family members, and housekeeping. What follows is a brief, non-exhaustive list of issues that should be considered when designing a care plan:

- **Patient’s view of amplification:** Is the patient amenable to using the hearing aid(s)? What is the word discrimination ability of the patient? Are the hearing aids just making poor word discrimination louder? Remember, hearing aids make things louder, not always clearer. They cannot always correct the distortional aspect of a sensorineural hearing loss.

- **Hearing aid manipulation:** Can the patient manipulate the hearing aid? Does the patient know how it operates? Are the family members knowledgeable about the care and manipulation of the device(s) as well? The speech-language pathologist often has more regular contact with the patient than do the audiologist and/or hearing aid dispenser and therefore must become educated regarding care, manipulation, and functionality of each patient’s hearing aid(s). The SLP would be well served to contact the audiologist, hearing aid dispenser, and also a representative from the hearing aid technology manufacturer for any necessary guidance.

- **When hearing aids aren’t used for listening:** Is the patient spending most of the time sleeping in his or her room? Remember, feedback (a high-pitched electronic whistle) occurs when the seal between the ear and the hearing aid is broken and amplified sound leaks out of the ear and is reamplified. When a patient lies on his or her side and is wearing a hearing aid, the pinna is pushed back, creating this situation. Frequently, in a partially sleeping state, the hearing aid may be removed and placed on a side table or on the bed sheet.

- **Who is responsible for the hearing aid batteries?** As with small children, caution should be used with hearing aid batteries in patients with waning cognitive status. Hearing aid batteries can be mistaken for medication and ingested, causing significant internal
damage. Should consideration be given to tamper-resistant battery doors on the devices (Cohen-Mansfield & Taylor, 2004)?

• Vanity thy name is hearing aid: Socially interactive patients who want to use their hearing aids also insist on looking their best. Hairspray is an arch enemy of a hearing aid, clogging the microphone, on/off switch, and volume control wheel of the device. Instructing the patient to put on jewelry and hearing aids after completing a hair care routine will extend the life of the hearing aid.

• Cerumen management: Cerumen, or ear wax, is another arch enemy of the hearing aid. During the aging process, ear wax tends to get drier and harder. In addition to clogging up the small components of the hearing aid, the hearing aid’s mere presence in the ear disturbs the body’s natural process for moving the wax out of the ear canal. The growth of hair in the ear also contributes to the impaction of cerumen in the elderly patient. Although the saying, “Never stick anything smaller than your elbow in your ear” holds true, the elderly patient always seems to find small thin objects to use in an attempt to remove ear wax.

• Consider other devices for terminal patients: Small portable devices, frequently called pocket talkers, are available at local electronic stores and are an affordable alternative to hearing aids for improving the quality of life for terminally ill patients. These devices function as a small amplifier, and are the size of an MP4 or old transistor radio. Earphones are attached via an earphone jack and the volume is controlled manually. Such devices can be used to communicate pertinent information to a patient and then can be removed for the comfort of the patient when not in use. Figure 20.3 shows an example of a Pocket Talker Pro.

• What is the plan for follow-up? Routine hearing evaluations will indicate if there has been a change in auditory status that may or may not require reprogramming of the hearing aid(s). Cerumen management may have to be done on a routine basis to prevent issues of occlusion or interference with amplification usage. Whatever the case, a clear, routine plan for follow-up audiologic testing, medical management, and hearing aid maintenance should be discussed with the patient and the family.

Aural Rehabilitation Groups

The speech-language pathologist may be requested, or required, to facilitate therapy groups for hard-of-hearing patients within the nursing home facility. These groups might center on self-advocacy for the hard-of-hearing patient, hearing aid care, listening strategies with and without hearing aids, reading the audiogram, and understanding the nature of hearing loss. Specifics on running such a group will depend on the needs of the patients and their individual goals for therapy. There may also be local community resources such as the Hearing Loss Association of America (HLAA; available online at http://www.hearingloss.org), formerly known as Self Help for the Hard of Hearing (SHHH), which facilitate such services or work in conjunction with the SLP servicing the patients. State agencies for the deaf and hard of hearing are also a useful resource. Frequently, publications from such agencies will
provide information regarding support groups and interpreter services or social activities throughout the area.

**Aural rehabilitation** groups are also an excellent avenue to involve family members in the hearing health care of the nursing home patient. Information packets describing many of the care and maintenance issues can be disseminated at such meetings. Realistic goals and expectations can also be discussed in general terms, easing some of the frustration that the family members may be having in communicating with the patient. When issues such as these are discussed in group settings, there is less of a chance of confrontational issues coming up that may cloud the ability of the family to understand the nature of the patient’s hearing loss and communication needs.

When providing such services, there are several decision-making framework tools that may assist the speech-language pathologist in designing and implementing services to a patient and their families or as a group activity. One model involves the guidelines of CARE and CORE. The first is for the assessment of hearing loss (CORE) and the other is for the management of hearing loss (CARE). CORE stands for communication status, overall participation variables, related personal factors, and environmental factors while CARE stands for counseling and psychosocial aspects, audibility or amplification aspects, remediation of communication activity, and environmental participation (Schow & Nerbonne, 2007). Tools such as the Abbreviated Profile of Hearing Aid Benefit (APHAB; Cox & Alexander, 1995), available at http://www.hearingutah.com/Aphab.pdf can also provide useful information to drive therapeutic goals. The SLP should always take into consideration both the audiological results themselves as well as the perception of an individual’s hearing loss when writing intervention goals for a specific patient, group, or family (ASHA, 1998).

**In-Service Training**

Perhaps the most valuable asset you will have in the nursing home is the other staff members with whom you will work. Training those staff members as the professional they will look toward to managing the needs of a deaf or hard-of-hearing patient can be a rewarding time for all involved. Nurses, nurses’ aides, environmental engineers, and the staff responsible for linens and laundry will play a crucial role in the overall well-being and quality of life of the hard-of-hearing patient in a nursing home facility. **In-service training** refers to those times staff members gather to gain further functional understanding of a specific topic. In nursing homes or long-term care facilities, this may present a specific challenge with these staff members; the SLP must make every effort to put aside the vocabulary of the field and break down the terminology to a level that can be understood by lay personnel. As professionals in the disciplines of audiology and speech-language pathology, we gain comfort in our terminology; however, discussing a “postauricular hearing aid fitting appropriately around the pinna” may cause the audience to lose attention to the material being taught. “This is a typical behind-the-ear hearing aid, and it is made to fit comfortably around this part of the ear” may be more user-friendly language that can be understood by all. Showing a simple video on how the ear works may also be beneficial. A good rule of thumb is to practice any presentation on family members not trained in the field to determine if the instructional level of content is appropriate for your audience.

In-service training allows the SLP to assist in staff team building, which benefits not only the atmosphere of the workspace, but also the attitude of patient care. Make sure that the material being covered is applicable to the current environment of the facility (i.e., don’t train the staff on communicating with deaf residents if there isn’t currently a deaf resident in the home). Keep training light-hearted and fun. Whenever possible, make training hands on, with lots of interactive exercises. Even the title of the training is important to spark an interest in the topic at hand (McLagan, 1978). “How to Spot a Hearing Aid in a Laundry Cart,” “Do You Hear What I Hear?” and “It’s Not that I Didn’t Hear You, I Was Ignoring You,” are just some ideas of catchy
titles that may motivate someone to attend your workshop.

We have all participated in continuing education forums and been asked to fill out a questionnaire before leaving. Have you ever wondered why? Judging the value and ultimate results of in-service instruction is also an important part of the training process. Feedback from the trainees is important for judging their understanding of materials, their attitude about the subject matter, and how receptive they will be in changing their current work behaviors. Feedback regarding the trainer’s ability to instruct and hold their interest, and the trainees’ desire to be trained further on similar topics, will allow the facility administration to plan for future trainings (Dopyera & Lay-Dopyera, 1980). Most important, the goal of your training should be ongoing, not a one-shot deal, to better educate your coworkers on effectively communicating with the deaf and hard-of-hearing patient.

**Summary**

The speech-language pathologist providing therapeutic interventions to hard-of-hearing and deaf patients in an acute, subacute, or nursing home setting will face a wide variety of challenges; they may range from identifying the patient’s auditory diagnosis to in-service education for all staff in a given facility. This chapter provides some guidance and suggestions for the practicing clinician for managing these challenging situations. Although some of these matters may at first seem intimidating, remember that your goal is to practice as a member of an interprofessional collaborative team. The mutual sharing and collaboration among the speech-language pathologist, audiologist, hearing aid dispenser, and other involved healthcare professionals is in the best interest for optimal patient outcome.

The reader is encouraged to explore some of the resources provided in this chapter, and to seek out your “friendly neighborhood audiologist” with any questions or problems that may be better solved with the collaborative approach.

**Discussion Questions**

1. Describe the medical model of healthcare provision. How might this differ from an educational model?
2. What is the difference between a consulting audiologist and a staff audiologist? List three ways you could easily locate these professionals.
3. How has Veterans Affairs played an important role in the development of audiology services in the United States?
4. List three factors that might stand in the way of providing services to a hard-of-hearing patient in a subacute facility. How would you remedy each situation?
5. You have been assigned to a 75-year-old resident with hearing aids in the nursing home. Design either (1) a hearing loss advisement poster to place at the door of the patient’s room, or (2) an outline for an in-service training for the nursing home staff.
6. Identify a local hearing loss resource or support group in your area. What services do they provide? Do they have regular meetings? Obtain a copy of a publication or newsletter from this agency.
References


Glossary

**Acceleration**: The speed (distance traveled per unit of time) of an object per unit of time, which is represented mathematically as length divided by time.

**Acoustic neuroma**: An uncommon and noncancerous tumor that grows on the auditory nerve.

**Acoustic reflex decay (ARD)**: Measures how long and how well the acoustic reflex is capable of sustaining itself. In the normal system, the acoustic reflex should be able to maintain its contraction for a period of time before it drops off; however, the auditory system whose reflex falls off too quickly is abnormal.

**Acoustic reflex threshold (ART)**: The acoustic threshold at which the muscles of the middle ear contract in response to a high-intensity sound.

**Acoustic (stapedial) reflex**: Involuntary contractions of the middle ear muscles, the stapedius (primarily) and the tensor tympani, which occur in response to high-intensity sound.

**Acoustics**: The study of sound; a branch of physics.

**Acquired hearing loss**: A hearing loss that is the result of an illness, disease, or disorder that was not present at birth.

**Acute care**: Refers to a medical setting where patients are treated for a sudden episode or illness. A hospital stay in an acute care facility is typically brief, only until a patient is considered medically stable.

**Adaptive digital modulation (DM) FM technology**: Digital sound delivery of an FM signal transmission. Such signal processing allows for a clearer and more robust transmission of a sound source as compared to older analog transmission technology. See also digital modulation technology.

**Air–bone gap**: The difference between the air conduction thresholds and the bone conduction thresholds, which reflects a conductive component of a hearing loss.

**Air conduction**: The normal means of sound transmission to our ears in day-to-day situations. Sound transmitted through air reaches the outer ear and travels through the middle ear to the organ of hearing in the inner ear and then is sent along the central auditory pathway to the brain for interpretation.

**Air conduction pathway**: The typical route that air conducted sound takes as it travels through the auditory system. This begins at the outer ear, continues through the middle ear, inner ear, the eighth cranial nerve, and eventually arrives at the auditory reception areas in the brain.

**Amblyaudia**: A term coined by Moncrieff & Wertz (2011). Represents the atypical dominance in ear advantage, in which a left-ear advantage may reflect right-hemisphere dominance or mixed right- and left-hemisphere governance for language (Keith & Anderson, 2007).

**American Sign Language**: A visual language system of communication that is based on hand shapes, hand movements, and gestures relative to their placement on the body.

**Americans with Disabilities Act**: A federal civil rights law that protects individuals with disabilities, intended to prohibit discrimination in a broad range of contexts.

**Anotia**: Complete absence of the pinna.

**Assistive listening device (ALD)**: Devices that help an individual with hearing loss or disorders of auditory attention to more effectively communicate and participate in communication situations. These devices help an individual hear and understand what is being said more clearly, thus allowing access to sound and speech for personal communication, group situations, vocational and educational situations, and recreational situations. Examples of assistive listening devices include FM amplification systems, induction loop systems, and infrared systems.

**Asymmetrical hearing loss**: A significant variation in a person's hearing sensitivity from one ear to the other. This could be a unilateral hearing loss or a different degree of loss in one ear versus the other.
**Atresia**: A malformation of or misshaped pinna, which may also include the malformation or absence of an external auditory canal.

**Attention-deficit/hyperactivity disorder (ADHD)**: A chronic condition that may be a combination of difficulties including sustained attention, hyperactivity, and impulsivity.

**Attenuator**: The electronic component of an audiometer that controls the intensity or loudness of the sound source in decibels.

**Audiogram**: Graphic depiction of a person's hearing sensitivity; when pure tone thresholds are obtained, they are charted on this grid. The frequency is in Hertz (Hz) on the x-axis, and intensity in the decibel scale of hearing level (dB HL) is on the y-axis. Frequencies are in full octaves ranging from 125 Hz to 8000 Hz, and intensity is marked from –10 dB HL to 120 dB HL.

**Audiometric zero**: The decibel level that is denoted as a solid black line on the audiogram and corresponds to 0 dB HL; this represents average normal hearing acuity. However, 0 dB HL may not be the lowest level that a person with superior hearing can detect.

**Auditory access**: Ensuring that each child who is deaf or hard of hearing has optimal access to the speech signal through appropriate advanced hearing technology. This includes access to and consistent wearing of appropriate individual hearing instruments, monitoring the child's auditory learning through the hearing device(s), appropriate ongoing audiological management, and sufficient auditory input of language.

**Auditory brainstem response study (ABR)**: Indirect measure of hearing that tests the neurological response to an auditory stimulus at the level of the brainstem.

**Auditory discrimination**: The ability to differentiate between words that differ in phonemic content.

**Auditory disorder**: An abnormality of the anatomical structures of the auditory system, with or without a concomitant auditory impairment.

**Auditory environment**: The child's listening situation at home and at school. An optimal auditory environment incorporates reducing background noise, moving closer to the speaker, and being on the same level when speaking to the child.

**Auditory habilitation**: The teaching of auditory skills where those skills do not currently exist.

**Auditory impairment**: The loss of function of the auditory system.

**Auditory labyrinth**: Also known as the cochlea; the sensory end organ of hearing. The cochlea is a fluid-filled space within the temporal bone and is a snail-shaped spiral canal, with three chambers and inner and outer hair cells that help to analyze frequency and intensity of incoming sound signals.

**Auditory masking**: When the introduction of one sound prevents the perception of another sound. In audiometric testing, it refers to the process whereby sound is introduced into the "nontest" ear to prevent the test sound from reaching that ear and, thus, being heard by that ear instead of the "test ear."

**Auditory processing (AP)**: The ability to efficiently and effectively process information that enters through the peripheral auditory system.

**Auditory processing disorder (APD)**: A disorder in the efficient and effective processing of auditory information for the purpose of daily communication.

**Auditory steady-state response (ASSR) study**: Indirect assessment of hearing that yields electrophysiological results from the same general anatomical sites as ABR, but uses different stimulus; useful when distinction of a severe versus profound hearing loss is sought.

**Auditory threshold**: The lowest hearing level at which a person responds in at least one-half (50%) of a series of ascending trials (ASHA, 2005).

**Auditory training (AT)**: Therapy that seeks to improve auditory perception through auditory listening exercises.

**Auditory training device**: A device available for individuals with hearing loss to assist with auditory therapy. The specific type used is based on a number of variables, including type of hearing aid and preferred methodology adopted by the school or facility.

**Aural habilitation**: Initial processes of therapeutic intervention to help children born with hearing loss, which begin at the start of early language development. Decisions about amplification, types of therapy and communication method, etc. can be decided at a younger age, which greatly benefits the infant as well as the family and are also considered to be part of the aural habilitation process.

**Aural rehabilitation**: The process of helping those affected by acquired hearing loss who have already attained language and require restoration of these skills. This includes evaluation of hearing, diagnosis and
effects of hearing loss, recommendation and selection of amplification devices, consideration of the type of rehabilitation setting, and counseling of patient and families about the impact of hearing loss and the need for rehabilitation.

**Autism spectrum disorder:** A developmental disorder characterized by difficulties in social interactions, receptive and expressive language skills, and may or may not be accompanied by repetitive physical behaviors (self-stimulation).

**Autoimmune inner ear disease:** A poorly understood form of sensorineural hearing loss.

**Automated auditory brainstem response (AABR) screening:** An electrophysiologic screening tool that can infer the presence of hearing loss by measuring auditory brainstem integrity.

**Autosomal dominant:** A genetic condition that is passed directly from parent to child.

**Autosomal recessive:** A genetic condition that can be linked to a family member, although the condition may or may not manifest in said family member (this person is known as a carrier).

**Basilar membrane:** The structure on which the organ of Corti sits. The basilar membrane, along with other structures, form the “floor” of the cochlear duct.

**Behavioral observation audiometry (BOA):** A methodology used when attempting to subjectively test the hearing of a child with a developmental age of approximately 6 or 7 months.

**Behind-the-ear (BTE) hearing aid:** Hearing device that is worn over the top of the ear. The components are housed in the casing that sits on the pinna, and an ear hook is connected to the earmold, which is placed in the ear canal.

**Bel:** Unit of measurement used to describe human intensity differences. This is a relative measurement of intensity, which expresses the ratio of a measured sound intensity to a relative sound intensity.

**Bellis/Ferre Model:** A model of (C)APD that includes three subprofiles, or categories, of dysfunction: Auditory Decoding, Prosodic Deficit, and Integration Deficit, and two secondary profiles: Associative Deficit and Output Organization.

**Best practice:** A management philosophy that asserts that there is a technique, method, process, or activity that is more effective at delivering a particular outcome than any other technique, method, process, or activity.

**Bilaterally:** Pertaining to both ears.

**Bilingual-bimodal:** An educational methodology that incorporates American Sign Language (or other native sign language) and spoken English (or other spoken language), yielding communication through two languages and two modalities. Both languages have equal value and representation.

**Bimodal hearing amplification:** Using two different types of hearing technology between the ears.

**Binaural:** Of or pertaining to both ears together.

**Binaural integration:** The ability of the auditory system to assimilate information received by both ears simultaneously.

**Binaural interaction:** Tests that reflect how auditory input works together from both ears at the level of the brainstem. They are sensitive to intensity and timing differences between ears and are related to the localization and lateralization of sound. Children who perform poorly on tests of binaural interaction may possess problems comprehending speech in the presence of background noise because of the inability to segregate the speech signal when there is a competing sound source.

**Binaural separation:** The ability of the auditory system to separate information received by both ears simultaneously. Typically, in tests of binaural separation, the individual is asked to ignore information presented to one ear while attempting to accurately repeat information received by the other ear.

**Biological calibration:** A required, daily check of equipment to identify potential problems that may periodically arise that could affect the functioning of the equipment and the validity and reliability of the test results.

**Bone-anchored hearing aid (BAHA)/Bone-anchored hearing system (BAHS):** Involves surgically anchoring a “screw” into the skull behind the ear, to which an external device is connected, and directly stimulates the cochlea by bone conduction, which bypasses the outer and middle ears. This style of hearing aid is typically used with conductive hearing losses associated with atresia, and other such pathologies when a traditional hearing aid and earmold cannot be utilized.

**Bone conduction:** Sound transmitted through vibration of the skull, which directly stimulates the cochlea in the inner ear and then is sent along the central auditory pathway to the brain for interpretation.
Bone conduction pathway: The route that bone-conducted sound travels as it makes its way through the auditory system. Unlike the typical air conduction pathway, sound is transmitted to the auditory reception areas of the brain by way of vibration of the bones of the skull.

Boyle’s law: For a fixed volume of vibrating air molecules, increased concentration (density) of air particles results in increased air pressure. Pressure and volume of a gas are inversely proportional if kept at a constant temperature.

Broca’s area: Located in the inferior frontal gyrus where motor production of language is located and processing of sentence structure, grammar, and syntax is located.

Brownian motion: Random movement at high speeds, which results from the impact of molecules, found within a gas or liquid. This was named after Robert Brown, a Scottish botanist, who described this motion.

The Buffalo model: A model for the diagnosis of (central) auditory processing, which is strongly based on the individual’s performance on the Staggered Spondaic Word Test. This model includes four categories: Decoding, Tolerance Fading Memory, Integration, and Organization. An individual may not “fit” into one particular profile and may have characteristics of more than one profile or subtype; therefore, some clinicians will focus rehabilitation efforts on the specific areas of auditory weakness.

Captioned telephone (CapTel): A type of video telephone system that provides a display of a written text or caption of everything the caller says. This allows the user to hear and see what the speaker is saying.

Central auditory nervous system (CANS): Beginning at the cochlear nucleus and ending at the auditory reception centers of the brain, the portion of the auditory system that transmits what a person hears from their peripheral auditory system to the cerebral cortex for processing.

(Central) auditory processing disorders ([C]APD): (C)APD refers to difficulties in the perceptual processing of auditory information in the central nervous system and the neurobiologic activity that underlies that processing and gives rise to electrophysiologic auditory potentials. Although this may coexist with other disorders, it is not the result of these disorders (ASHA, 2005).

Cerumen: Earwax.

Child Find: A portion of federal special education laws that requires the local education agency (LEA) to seek out and identify children with disabilities, aged from birth to 21 years. Child Find programs primarily target at-risk early childhood groups by providing developmental screenings, which also include vision and hearing screening.

Cholesteatoma: An abnormal growth of skin and debris that forms behind the eardrum in the middle ear space.

Civil Rights of Institutionalized Persons Act (CRIPA): Enacted in 1997 for the purpose of protecting person’s rights of health and safety while residing in an institution.

Classroom acoustics: The properties of classroom environment that affect the ability to perceive sound. Classroom acoustics should always be considered when evaluating an academic environment for the use of hearing assistance technology.

Classroom audio distribution system (CADS): Equipment designed to provide an improved signal-to-noise ratio throughout a single room, whether a classroom or meeting hall.

Classroom listening assessment: An assessment performed as part of the evaluation process prior to fitting a student with hearing assistance technology.

Closed-set assessment: An assessment that has a fixed number of stimuli from which the child chooses the correct answer.

Cochlea: A fluid-filled space within the temporal bones that is a snail-shaped spiral canal. Within each membranous duct there are three fluid-filled chambers. The organ of Corti is within the cochlear duct, which contains the sensory cells of hearing on the basilar membrane. The inner and outer hair cells analyze frequency and intensity of incoming sound signals at the basilar membrane.

Cochlear implant (CI): This surgically implanted amplification device can enhance hearing and speech abilities for individuals with severe to profound hearing
loss. A cochlear implant system has an external speech processor and an internal implant, which is placed under the skin. A cochlear implant device has four parts: a microphone; a speech processor, which selects and arranges sounds picked up by the microphone; a transmitter and receiver/stimulator, which receives signals from the speech processor and converts them into electric impulses; and electrodes, which collect the impulses from the stimulator and send them to the brain.

**Collapsed canal:** The closing of the ear canal caused by the pressure applied by the earphone, which occurs in those with “very soft” tissue/cartilage; this condition prevents the test sounds from entering the ear and may negatively impact the test results.

**Comorbidity:** A condition occurring simultaneously with another, which may or may not have similar characteristics.

**Compensatory strategies:** Techniques that are either learned or naturally developed to overcome weaknesses manifested in a specific function or skill.

**Completely-in-canal (CIC) hearing aid:** Type of hearing aid style that is custom molded to fit the shape of the individual's ear, but is inserted deeper into the canal to be less noticeable than other in the ear (ITE) devices.

**Comprehension:** A part of the auditory skill development framework that includes the ability to demonstrate the use of information presented auditorily. Comprehension is the highest level of auditory skills development and the ultimate goal of therapeutic intervention.

**Condensation/compression:** In regards to sound waveforms, the displacement passed from molecule to molecule that creates areas of increased pressure and density.

**Conditioned play audiometry (CPA):** An evaluation technique that is designed to gain audiological test results by making the evaluation process into a game.

**Conductive hearing loss:** Hearing loss caused by an abnormality in the external or middle ear characterized by the reduction in the conduction of sound into the ear. Individuals with (purely) conductive hearing loss have normal sensorineural hearing.

**Congenital:** A condition that is present at birth. With reference to a congenital hearing loss, it may or may not be associated with a familial history.

**Conscious attention:** One's ability to volitionally attend to a signal or stimulus.

**Consulting audiologist:** Using a consultative model of service provision, audiologists may be hired on an as-needed basis rather than as full-time employees.

**Conventional hearing aid:** Personal listening device that provides frequency-based amplification to manage hearing loss.

**Cookie bite:** A common hearing loss pattern configuration that depicts the most impaired thresholds in the mid-frequency range, with recovery noted in both the lower and higher frequencies.

**Cued speech:** Spoken language/visual cue concept that utilizes eight hand shapes in four different positions. The positions are considered cues, which are all located around the speaker's face. The visual cues are incorporated because of the many different sounding vowels and consonants that appear the same when lip-reading. The visual cues help identify each sound for the child, and the use of amplification is encouraged.

**deaf:** Note use of lowercase “d”; refers to an individual whose hearing loss is so severe that they cannot use their sense of audition as a primary means of daily communication.

**Deafness:** As defined by IDEA, a hearing impairment that is so severe that the child is impaired in processing linguistic information through hearing, with or without amplification, which adversely affects a child's educational performance.

**Decibel (dB):** A ratio between the measured sound pressure and relative sound pressure, using logarithms. This is a useable unit of measurement for intensity of the range of human hearing.

**Decibel hearing level (dB HL):** This decibel reference level is used to audiometrically measure an individual's hearing level, and its reference varies with frequency according to minimum audibility curve.

**Decibel sensation level (dB SL):** The intensity level of stimulus presentation using the individual's threshold as reference. For example, a 30 dB SL sound for someone with a 20 dB HL threshold will result in a presentation level of 50 dB HL for that particular sound.

**Decibel sound pressure level (dB SPL):** Expresses the ratio of measured sound pressure to a reference sound pressure to indicate the intensity of a sound stimulus.

**Decoding:** The ability to follow the rules of print by understanding the phoneme–grapheme association relationship.
Decruitment: The opposite of recruitment; where the individual response is generated at a higher intensity than expected based on the peripheral hearing threshold.

Dementia: An age-associated syndrome with a negative impact on memory, cognition, attention, problem solving, and language.

Detection: A part of the auditory development framework that includes being aware of the mere presence of a sound.

Diagnostic: Related to identifying a disease or illness.

Diagnostic audiometry: A process by which ear-specific information and thresholds are established for individual frequencies. When air and bone conduction are tested, type of hearing loss and severity can be established.

Dichotic auditory training (DAT): Therapy that addresses the ability of a listener to transfer information across the corpus callosum, from the right to left hemisphere and back.

Dichotic listening: Both ears working together to process an auditory message. Dichotic tests provide information on the function of the left and right hemispheres and the transfer of auditory information between hemispheres. Dichotic listening tests are diagnostically significant in that, during the transmission of the dichotic signal, information is transferred through the dominant contralateral pathways.

Differential diagnosis: Method used to clinically distinguish or differentiate one disorder from another that presents with many of the same or similar symptoms and characteristics. Key concerns include the correct diagnosis of hearing loss and the identification of possible additional comorbid conditions.

Digital modulation technology: Works similarly to FM technology, but the audio signals are digitized and packaged in very short digital bursts of code and broadcast several times at different channels between 2.4000 and 2.4835 GHz.

Diplacusis: The phenomenon of perceiving one tone as two separate tones.

Direct audio input (DAI): Circuitry included in many BTE hearing aids that allow an external source or device to be connected directly into the hearing aid as an input that bypasses the microphone. This allows the hearing aid to be connected to external devices for a direct signal transmitted directly into the hearing aid. For example, this can be used with a television, telephone, computer, or CD player; however, this circuitry is not available on smaller ITE, ITC, or CIC hearing aids.

Disability: Any restriction or lack of ability to perform an activity.

Discrimination: A part of the auditory skill development framework that includes the ability to differentiate between two auditory stimuli.

Displacement: In regards to sound waveforms, movement of air molecules away from the rest position.

Distortion product otoacoustic emission (DPOAE): A type of evoked otoacoustic emission (see evoked otoacoustic emission) that is measured by inserting a probe tip into the external auditory canal and presenting a stimulus that consists of two simultaneous tones of different frequencies.

Domains of language: The center of a multimodal language framework, including phonology, morphology, syntax, semantics, and pragmatics/discourse.

Dynamic range (DR): Mathematical difference between the lowest level that an individual begins to hear (threshold) and the upper limit of what the individual finds uncomfortable (UCL).

Ear canal volume (ECV): The volume, measured in cubic centimeters or ML, of the external ear canal.

Early Hearing Detection and Intervention (EDHI): National public health initiative that intends to maximize linguistic competence and literacy development for children who are deaf or hard of hearing by early identification of hearing loss through universal newborn hearing screening, timely audiologic and medical evaluations and monitoring, early intervention, and ongoing connections to family support services.

Earphones: Sound transducers that change an electrically generated signal into an acoustic signal that is capable of being heard by the individual being tested.

Ear pit: Abnormality of the pinna characterized by a small hole typically located about the tragus.

Ear tag: Abnormality of the pinna characterized by a small additional piece of skin typically located about the tragus.

Educational model: A model of service delivery used by school systems to provide accommodations and modifications within a classroom for a particular child. Typically, this model is managed through a set of laws and regulations established by the U.S. Department of
Education via educational mandates. This model varies significantly from a medical model of service delivery.

**Effusion:** In reference to middle ear pathology, the fluid that is generated by the cells lining the middle ear space as a response to infection.

**Elastic:** The property of an object to resist deformity and return to its rest position.

**Electroacoustic calibration:** The annual evaluation of audiometric equipment completed by a professional trained in such practices, which ensures compliance of the equipment to American National Standards Institute requirements for accurate sound generation. Typically, annual calibration compliance is reflected by placing a “calibration sticker” on the equipment that lists the agency providing services and the precise date of calibration.

**Electroacoustic measure:** An acoustic measurement of function that provides objective information about how portions of the peripheral auditory system function.

**Electronystagmography (ENG):** Evaluates the inner ear balance system and records a symptom called nystagmus. Nystagmus is an involuntary rhythmic oscillating movement of the eyes, which work in connection with the organs of the vestibular system to establish our sense of balance.

**Electrophysiological measures:** Evaluates functional integrity of various structures along the auditory pathway beyond the cochlea, at the level of the 8th cranial nerve and brainstem.

**Endocochlear electrical potential:** The difference in ionic concentration between endolymph and perilymph gives rise to this “cochlear battery.”

**Endolymph:** Fluid found in the scala media, which has a higher concentration of potassium than sodium ions. The difference in ionic concentration between endolymph and perilymph gives rise to an endocochlear electrical potential that helps conduct neutral transmission of sound.

**Environmental/classroom modifications:** The use of HAT in the form of assistive listening devices to overcome the poor acoustical characteristics in a room.

**Equilibrium:** During the propagation of sound, the resting state to which the air molecules return after the force is removed.

**Eustachian tube (ET):** Part of the middle ear anatomy that connects the middle ear space to the back of the throat. The Eustachian tube equalizes the pressure of the middle ear space with our environment (normal atmospheric pressure).

**Eustachian tube dysfunction:** A condition whereby pressure cannot be properly equalized between the middle ear cavity and the nasal pharynx.

**Evidence-based practice (EBP):** Conscientious, explicit, and judicious use of current best evidence in making decisions about the care of the individual patient.

**Evoked otoacoustic emissions:** A type of otoacoustic emission (see otoacoustic emission) that is clinically useful as an electroacoustic measure (see electroacoustic measure) and that can be useful in the diagnosis of hearing loss as a nonbehavioral indirect estimate of peripheral hearing. The sounds are elicited by presentation of a stimulus via a probe tip inserted into the external ear canal.

**Executive function:** A set of cognitive processes that allows a person to appropriately function and engage in his or her own environment.

**External auditory canal:** Portion of the ear that connects the pinna to the tympanic membrane and middle ear cavity.

**External auditory meatus:** See external auditory canal; also known as external ear canal.

**False-negative response:** In relation to hearing screening, a person who does have a condition, but passes the hearing screening and is not identified as having or being at risk of having the target condition.

**False-positive response:** In relation to hearing screening, a person who does not have the condition, but fails the hearing screening and is wrongly identified as having or being at risk of having the target condition.

**Formal auditory training:** Standard remedial practices centered on the ability to train the impaired auditory system in the practices of listening and understanding acoustic information.

**Familiar sounds audiogram:** A counseling tool that may be used to explain to patients and their families what kind of impact the hearing loss may have on the ability to function and respond to sounds that are routinely encountered in everyday life.

**Family Education Rights and Privacy Act (FERPA):** That portion of IDEA, which among other things, protects the confidentiality of all students’ educational records.
Five stages of grief model: Dr. Elizabeth Kübler-Ross’ framework to explain the experience of dying patients, who progress through denial, anger, “bargaining for time,” depression, and acceptance. These stages are also observed in people and family members experiencing personal change and emotional upset resulting from factors other than death and bereavement.

Flat hearing loss: Configuration of hearing loss where hearing thresholds reveal very little variation in intensity across frequencies.

Fluency: The ability to read text with appropriate rate, pause, and intonation; it is the result of well-developed decoding skills and thus intact phonemic awareness and phonics skills.

Force: A push or pull on an object with both magnitude and direction (vector). Force is mathematically determined to be the product of mass multiplied by acceleration.

Frequency: The number of cycles of vibration per second.

Functional auditory assessment: An assessment of listening that encompasses observations of functional listening behaviors and abilities in addition to diagnostic assessments of the child’s listening skills on a variety of tasks.

Genetic: A hearing loss linked to one’s familial history through the generations.

Guidelines: Any document that aims to streamline particular processes according to a set routine. Following guidelines/best practices is not mandatory.

Handwriting: Motor skills that develop during the preschool and early elementary years when children are first exposed to the use and function of writing implements.

Hard of hearing: Preferred terminology for a person presenting with a hearing loss who can derive benefit from hearing aids and uses aural/oral speech for communication.

Hearing assistance technology (HAT): Terminology encompassing any technology that assists an individual with hearing loss, beyond the use of a hearing aid, BAHA, or cochlear implant.

Hearing handicap: The difficulty an individual experiences as a result of an impairment and/or disability, as a function of barriers, lack of accommodations, and/or lack of appropriate auxiliary aids and services.

Hearing Handicap Inventory for the Elderly: A self-assessment tool that explores quality-of-life questions using the patient’s or family’s view of communication status. This tool is a 25-item questionnaire that measures an individual’s perceived activity limitation and participation restriction as a result of hearing loss.

Hearing impairment/hearing status: As defined by IDEA, an impairment in hearing, whether permanent or fluctuating, that adversely affects a child’s educational performance but that is not included under the definition of deafness.

Hearing screening: A means to separate apparently healthy individuals from those for whom there is a greater probability of having a disease or condition, so that those with an increased risk can be referred for appropriate diagnostic testing (ASHA, 1994).

Helicotrema: The point where the scalae vestibuli and tympani communicate in the cochlea.

Hertz (Hz): The unit of measurement for frequency.

High-frequency sensorineural hearing loss (HF SNHL): A hearing loss of greater severity in the higher frequencies than in the lower frequencies, where thresholds may be in the normal to near normal range. There may be normal or relatively normal hearing up to approximately 2000 Hz, and then a sloping hearing loss at frequencies of 3000 Hz and above.

Highest qualified provider: Terminology in education law (that may vary from state to state), which deems a hierarchy of professionals to speak on a specific discipline for which they are qualified.

Hyperacusis: A heightened sensitivity to sound, such that even “low” levels of sound may cause pain and discomfort.

Identification: The level in the hierarchy of auditory skill development whereby a label can be placed on an auditory stimulus or event.
Impacted cerumen: An excessive buildup of wax in the external auditory canal, which causes occlusion and potential hearing loss.

Impedance-matching transformer: The combined functions of the middle ear system that allow sound to overcome the difference in impedance between the air-filled cavity of the middle ear versus the fluid-filled cavity of the inner ear.

Incidental learning: The learning that occurs naturally and spontaneously as a result of a child being aware of and interacting in his or her environment, without the use of any formal direction or structure.

Incus: The middle bone of the ossicular chain that comprises two processes: the short crus, which fits into a recess wall of the tympanic membrane, and the long crus, which is attached to the head of the stapes.

Individual Family Service Plan (IFSP): A legal document drafted by early intervention services that outlines the specialized services provided to a child from birth through the third birthday.

Individualized Education Plan (IEP): A legal document that allows a child aged 3–21 years to receive special education services as mandated by the processes of the U.S. Department of Education.

Individuals with Disabilities Education Act (IDEA): Laws that ensure that services to special needs students throughout the United States are equal and homogenous. These laws include part (C), early intervention, and part (B), children 3–21 years.

Inertia: All bodies remain at rest or in a state of uniform motion unless other forces act in opposition. The amount of inertia is directly proportional to a body’s mass.

Informal auditory therapy: Activities that may be performed in the home and are recommended to supplement formal auditory training.

Inner hair cells: Cells that form a row in the proximity of the tectorial membrane, near the modiolus of the cochlea. More than 90% of these hair cells are neurologically connected to the brain via nerve fibers, and they encode sound and send it further along the auditory nervous system up to the brain for interpretation.

In-service training: Education to staff members of a facility pertaining to a certain topic or event.

Intensity: A physical measurement of the sound pressure needed along with frequency to generate a tonal stimulus. Intensity is measured in decibels. The psychological correlate of intensity is loudness.

Interaural attenuation: The reduction, in dB, caused by the skull as sound travels from the test ear to the nontest ear. This dB level is what is absorbed by the skull.

Interprofessional collaboration: The concept of collaborating with other professionals to reach a common goal.

Interrupter switch: The button or switch that allows the tester to present the sound to the patient.

In-the-canal (ITC) hearing aid: A hearing aid that is custom molded to fit the shape of the concha and outer ear canal portion of an individual’s ear. In these devices, all components are housed within one hard shell.

In-the-ear (ITE) hearing aid: A hearing aid that is custom molded to fit the shape of the individual’s ear. Typically, ITE hearing aids are smaller than BTEs and thus more cosmetically appealing to some individuals.

Invisible in-canal (IIC) hearing aid: Type of hearing aid style that is custom molded to fit the shape of the individual’s ear, but is inserted even deeper into the canal to be the least noticeable as compared with other in-the-ear (ITE) or completely-in-the-canal (CIC) devices.

Keloids: Abnormality of the pinna characterized by large growth irregular in shape, which is formed as a result of excessive collagen.

Keyboarding: Motor skills that develop during the preschool and early elementary years when children are first exposed to transposing information into electronic format.

Language: The ability to receive and express thoughts and ideas. Language extends across four modalities to include speaking, listening, reading, and writing.

Language domains: The center of a multimodal language framework, including morphology, phonology, syntax, semantics, and pragmatics/discourse.

Least restrictive environment (LRE): Specified as part of IDEA, which states that to the maximum extent appropriate, children with disabilities, including children in public or private institutions or other care facilities, are educated with children who are nondisabled. In addition, special classes, separate schooling, or other removal of children with disabilities from the regular educational environment occurs only if the nature or severity of the disability is such that education in regular
classes with the use of supplementary aids and services cannot be achieved satisfactorily.

**Linear scale:** Measuring scale with a true zero point, each increment on this scale is equal to every other increment, and you can sum incremental units by addition.

**Linguistic comprehension:** (Pertaining to literacy) The ability to process language in written form.

**Listening and spoken language (LSL):** A model of therapeutic intervention that combines aural/oral and auditory/verbal educational models to promote spoken language skills in children with hearing loss.

**Listening check:** See biological calibration.

**Literacy:** The ability to process information in written form.

**Logarithmic scale:** Relative scale where there is no zero point, the zero point does not represent the absence of what is being measured, and each successive unit is larger than the one preceding it; therefore, each increment is not equal and represents increasingly large numerical differences.

**Look-alike diseases:** Also known as imitator diseases; conditions that present with many of the same or similar symptoms and characteristics as another disorder.

“**Look, play, talk**”: Variation of the informal observation in which the clinician should look at the child for nonverbal communication behaviors, observe play behavior, and listen to the child talk. This will allow the clinician to earn the trust of the child and determine developmental level and abilities.

**Loudness:** The perception of a sound’s intensity.

**Loudness discomfort level (LDL):** See uncomfortable listening level (UCL).

**Loudness recruitment:** Abnormal growth of loudness.

**Low-redundancy speech:** Tasks that involve testing when the natural redundancy of speech is compromised by noise or poor signal quality. The ability to interpret degraded speech and make auditory closure is a problem found in some listeners who experience (C)AP difficulties (Geffner & Ross-Swain, 2006). In order to make closure, a listener must be familiar with the speech signal and be able to fill in missing elements when speech is not clear.

**Malignant (necrotizing) otitis externa:** A cancerous condition occurring in the immunocompromised patient. Some characteristics include tenderness of the tragus, otalgia, irritation and itching, aural fullness, and discharge from the ear canal.

**Malleus:** The most lateral of the three bones making up the ossicular chain, which is embedded slightly into the tympanic membrane at the manubrium. When the tympanic membrane vibrates from the sound energy impinging on it, the malleus also moves at the same vibratory speed.

**Manual communication:** Visual communication system used to convey a message, such as sign language.

**Manually coded English (MCE):** Spoken language/sign concept that incorporates the use of finger spelling and signing to represent spoken English; MCE follows the rules of English syntax. Finger spelling is used to transmit morphemes that do not translate with sign, and the use of amplification is not always used with MCE.

**Masking:** Process where one sound is blocked out by another in order to prevent the test sound from being heard by the nontest ear.

**Mass:** The quantity of matter present that is unaffected by gravitational forces.

**Mastoidectomy:** A surgical procedure to remove diseased portions of the mastoid bone.

**Mastoiditis:** Infection/inflammation of the mastoid bone.

**Medicaid:** Established in 1965 by the Social Security Amendment Act to the Social Security Act of 1935; a health and medical services program available to qualified individuals with low incomes and limited resources.

**Medical home:** Term used to describe the management and coordination of health care for an individual throughout a lifetime. This model of service provision enables a healthcare provider to coordinate and track infants and children who have failed their newborn hearing screening or are at risk for progressive/late-onset hearing loss to assure that follow-up is routinely in place and that these infants and children are not lost in the follow-up process.

**Medical model:** A model of health care, used in an acute care facility, which depends on an interdisciplinary group of trained professional and paraprofessionals working with a single patient. This interdisciplinary team is led by a primary physician who manages the overall care of the patient and forms this interdisciplinary team based on the needs of the patient. Written requests for consultation by members of the team are required for all preventative, curative, consultative, and rehabilitative
services. No care can be provided to a patient without orders from the primary care physician.  

**Medicare:** Established in 1965 by the Social Security Amendment Act to the Social Security Act of 1935; a social health insurance program that covers individuals 65 years of age or older, as well as individuals under age 65 with certain disabilities.  

**Membranous labyrinth:** Soft-tissue, fluid-filled channels within the osseous labyrinth containing the end-organ structures of the hearing and vestibular systems.  

**Meniere’s disease:** A chronic and progressive inner ear condition characterized by a buildup of fluid in the labyrinth and a loss of balance.  

**Meningitis:** Inflammation of the meninges of the brain, caused by the spread of infection.  

**Metalinguistics:** Top-down skill that equips the child to take responsibility for his or her listening successes and failures. Metalinguistic analysis may be due to problems in applying the rules of language to incoming auditory input.  

**Microtia:** Malformation of the pinna, such that when the pinna is visualized it appears smaller in shape and size than normal. This condition may or may not accompany atresia.  

**Middle ear:** That portion of the ear that connects the outer ear anatomy to the inner ear anatomy and encompasses the ossicular chain, the Eustachian tube, middle ear cavity, and middle ear attic.  

**Middle ear implant (MEI):** Hearing aid in which the receiver or entire hearing aid is inserted into the middle ear. For sensorineural hearing loss, it delivers vibratory mechanical energy to the ossicular chain located in the middle ear system and then sends mechanical energy to the cochlea at the round window via motion of the stapes. For conductive or mixed hearing loss, mechanical energy is sent directly to the cochlea through direct bone conduction circumventing the ossicular chain in the middle ear.  

**Minimal/slight hearing loss:** That classification of auditory impairment that, although the very nature of its term is to be “minimal,” can have significant manifestation in children’s speech, language, and communication development including phonological, vocabulary, and language delays; difficulty understanding speech presented with background noise; difficulty localizing the source of a sound; problems with reading comprehension; and educational difficulties.  

**Minimum Data Set for Nursing Home Residents Assessment and Care Screening Tool (MDS):** Part of the U.S. federally mandated process for clinical assessment that is to be administered to all nursing home patients in Medicare- and Medicaid-certified nursing homes within the first 14 days of admission.  

**Minimum response level (MRL):** A type of measurement that recognizes that the person’s true hearing ability might be better than the results would otherwise indicate.  

**Mixed hearing loss:** A hearing loss that is a combination of a conductive component plus a sensorineural component. Bone conduction thresholds are outside of normal (sensorineural component), and air conduction is even further abnormal (conductive component), showing an air-bone gap on the audiogram.  

**Modified play technique:** Technique for modifying the conditioned play audiometry activity to its very simplest form.  

**Monaural:** Of or pertaining to one ear individually.  

**Monaural low redundancy:** Speech that is unfamiliar (open set) to the listener, which is presented to each ear individually. Monaural low redundancy training will help individuals who have difficulty hearing with background noise, understanding rapid connected speech, or when the auditory signal is not optimal. Clinicians may introduce background noise during therapy sessions and may introduce auditory-closure activities and vocabulary-building activities in training.  

**Most comfortable listening level (MCL):** The dB level that is mutually decided on by the audiologist and patient as being the most comfortable level for the patient when listening to connected speech.  

**Multimodal language framework:** The idea that language extends across four modalities to include speaking, listening, reading, and writing.  

**Multitiered systems of support (MTSS):** A broader approach to intervention that includes response to intervention as one component.  

**Natural environment:** Includes the home and community settings in which an individual lives, and functions, daily.  

**Neurofibromatosis type 2:** A genetically linked condition most commonly associated with bilateral vestibular schwannomas.
Noise-induced hearing loss (NIHL): An auditory condition that occurs as the result of overexposure to loud sound of any type.

Noise notch: Common hearing loss configuration that is related to high-intensity noise exposure over time.

Occupational Safety and Health Act: Act of 1970 that created the Occupational Safety and Health Administration (OSHA), an agency within the United States Department of Labor that was authorized to assure safe and healthful working conditions for working men and women by providing training, outreach, education, and assistance.

Omnibus Budget Reconciliation Act (OBRA): Requires all nursing homes receiving federal funding to assess each new patient using the MDS. The MDS is part of the U.S. federally mandated process for clinical assessment that is to be administered to all nursing home patients, in Medicare- and Medicaid-certified nursing homes, within the first 14 days of admission. OBRA further addresses screening procedures for patients in the nursing home facility, including procedures of a hearing screening.

Open-set assessment: Assessment containing items on the test that are unknown to the child and in which there is no defined set (for example, 4 to 6) of answer choices from which the child may choose, thus increasing the difficulty level.

Organ of Corti: Contains the sensory cells of hearing, which lie on the basilar membrane within the cochlear duct.

Osseous labyrinth: The bony structure of the inner ear, which lies within the temporal bone and houses both the auditory and vestibular labyrinth.

Ossicles: See ossicular chain.

Ossicular chain: Three connected bones in the middle ear that form a chain. From lateral to medial, these bones are the malleus, the incus, and the stapes; they are collectively responsible for taking the acoustic energy at the tympanic membrane, converting it to mechanical energy, and delivering it to the oval window.

Ossicular discontinuity: Disruption (or break) of the ossicular chain.

Ossicular malformation: A malformation of the bones that make up the ossicular chain.

Otalgia: Ear pain.

Otitis externa: Also known as swimmer’s ear; the general term used to describe an inflammation of the skin of the external ear canal.

Otitis media: An inflammation of the middle ear system, which may or may not include the collection of fluid in the middle ear cavity, primarily due to a dysfunctional Eustachian tube. When fluid is present, it typically becomes infected. This condition is also known commonly as an “ear infection.”

Otoacoustic emissions (OAEs): Sounds that emanate from the ear, thought to be the product of outer hair-cell activity in the cochlea. In some forms, this sound can be measured clinically and can be useful in the indirect measurement of hearing sensitivity.

Otoacoustic emission screening: Electroacoustic screening tool that can infer the presence of hearing loss by measuring cochlear integrity.

Otosclerosis: A condition that causes fixation of the stapes bone in the middle ear, resulting in a conductive hearing loss.

Otoscopy: An instrument that provides magnification and a light source to examine that portion of the ear from the external auditory canal to the eardrum.

Otoscopy: Process of examining the external auditory meatus, especially the eardrum, which allows the examiner to identify several common problems that preclude the sound from entering the ear.

Otospongiosis: Also sometimes referred to as otosclerosis; a condition that causes fixation of the stapes bone in the middle ear, resulting in a conductive hearing loss.

Ototoxicity: The deleterious effects that certain drugs/substances have on the organs of hearing and balance in the ear.

Outer ear: Comprising two structures, the pinna (or auricle) and the external auditory meatus (ear canal), that collect sound and direct sound to the middle ear.

Outer hair cells: Hair cells that form three rows. The base of the cells sits on top of the basilar membrane, and the stereocilia at the tops of the cells embed themselves in the tectorial membrane above; they connect with the cochlear branch of the 8th cranial nerve (vestibulocochlear). The vibration of the basilar membrane causes the cilia of the outer hair cells to bend, and the length of the outer hair cells increases to generate an electrical response created by the incoming
stimulus. Outer hair cells are tuned to sound intensity to act as transducers by changing fluid energy into electrical energy.

**Output switch:** The part of the audiometer that allows the tester to specify the condition for the testing to be performed (either on the right or left ear and through “air” or “bone”).

**Oval window:** One of the two tissue-covered openings found on the cochlea, which is covered by the stapes footplate.

**Pars flaccida:** More compliant, smaller section of the tympanic membrane located superiorly to the pars tensa.

**Pars tensa:** Stiffer, larger, section of the tympanic membrane located inferiorly to the pars flaccida.

**Pascal (PA):** A linear unit of measurement that describes sound pressure.

**Perforated tympanic membrane:** A tear in the thin membrane that separates the outer ear canal from the middle ear cavity.

**Periauricularly:** Relating to the tissues surrounding the external ear.

**Perilymph:** Fluid found in the scalae vestibuli and tympani that has a higher concentration of sodium ions than potassium ions. The perilymph wave displaces the scala media, setting up a wave on the basilar membrane, which moves from the base to the apex.

**Phonemically balanced (PB):** Words that have been statistically analyzed for their phoneme content and compared with a sampling of spoken discourse.

**Phonemic awareness:** The ability to segment, blend, and manipulate phonemes within words.

**Phonics:** The knowledge of phoneme–grapheme correspondence and is generally taught during the primary school years.

**Pinna:** The visible part of the ear, also called the auricle, which is shaped like a funnel to collect and send sound waves through the ear canal. The pinna also assists in sound localization and helps to protect the entrance to the external auditory canal.

**Pitch:** The subjective perception of frequency.

**Planning:** (As it relates to literacy) The portion of executive functioning skills concerned with the motor planning process as related to writing.

**Plasticity:** The process of being easily shaped.

**Portable audiometer:** A device designed to carry out audiometric testing that can be easily transported from site to site.

**Presbycusis:** The decline in hearing that is associated with the aging process.

**Present levels of academic achievement and functional performance (PLAAFP):** Procedurally the initial written statement in a student’s individual education program document that is a written discussion of the child’s ability and current achievement at the time the IEP is written. Such statement should contain information regarding the student’s strengths and weaknesses as seen by the current instructional lead for the child. In an initial IEP document, the PLAAFP may contain the summary results of evaluations that lead to the decision to determine the eligibility of a child for special education and related services.

**Pressure wave:** When air molecules are set into vibration, they produce a pressure wave. When air molecules near a vibrating object are displaced, adjacent air molecules are also displaced and so on. This wave motion is propagated through the air to the human ear.

**Propagation:** Movement of a disturbance (vibration), which is generally represented as a wave.

**Pseudohypacusis:** False, exaggerated, or psychogenically motivated hearing loss.

**Pure tone:** The resultant pressure wave formed by areas of alternation condensation/compression and rarefaction changing at a steady rate. Pure tones move in simple harmonic motion and are represented graphically by a sine wave.

**Pure tone average (PTA):** Average of the thresholds, in decibels, for pure tone air conduction results at 500, 1000, and 2000 Hz, and may be used as a reliability check for the speech reception threshold.

**Rarefaction:** Thinning of air molecules, which creates areas of decreased air pressure and density.

**Recruitment:** Term used to describe an abnormal growth of loudness that comes from a sudden increase in the perceived loudness of a sound with only a slight increase in the volume intensity.

**Related services:** Defined in the IDEA regulations as “transportation and such developmental, corrective, and other supportive services as are required to assist a child with a disability to benefit from special education.”
**Response to intervention (RTI):** A portion of the federal education laws that requires school systems to put in place interventions that attempt to meet the needs of a child for academic success in the general education setting and emphasize prevention through special education services rather than failure. RTI must be school wide and provide high-quality instruction matched to individual student needs, include frequent monitoring of student progress to inform changes in instruction, and utilize child response data to make educational decisions.

**Retrocochlear pathology:** Pathological condition that is located beyond (retro) the level of the cochlea.

**Reverberation:** Characteristic of sound when it is reflected off of a (usually hard) surface rather than absorbed by a (usually soft) surface.

**Reverberation time:** The time delay to a normal auditory system caused by sound reflected off of a surface, which is usually inaudible but has a significant effect on speech intelligibility in an impaired auditory system.

**Reverse curve:** Hearing loss that is depicted when individual thresholds are more significantly impaired in the lower frequencies than in the higher frequencies.

**Revising:** (Pertaining to literacy) The executive function skills related to the ability to review one's own work for accuracy and ease of comprehension.

**Round window:** One of the two tissue-covered openings found on the cochlea that is between the scala tympani and middle ear.

**Saccule:** One of the two organs of balance housed within the vestibule.

**Scala media:** One of three chambers within the cochlea, in which endolymph circulates.

**Scala tympani:** One of three chambers within the cochlea, in which perilymph circulates.

**Scala vestibuli:** One of three chambers within the cochlea, in which perilymph circulates. When the stapes footplate rocks back and forth in the oval window, a wave is established within the scala vestibuli.

**Screening:** Testing that is completed to determine if further evaluation or examination is warranted.

**Screening procedure:** Technique used to examine an individual to identify a possible disorder.

**Section 504 (504 Plan):** A portion of the Rehabilitation Act of 1973, which protects individuals from discrimination based on a disability via a written document specifying service provision. 504 Plans were reauthorized by the ADA in 1990.

**Self-regulation:** The executive function skills associated with how children (or individuals in general) achieve desired goals; in the context of this text, the term refers to the skills needed to achieve writing goals.

**Semicircular canals:** Sensory end organs of balance within the vestibular labyrinth.

**Sensitivity:** A screening test's ability to accurately separate those who have a disorder from those who do not; it represents the percentage labeled positive on the test that truly have the target condition.

**Sensorineural hearing loss:** Hearing loss in the inner ear due to damage to the cochlea and/or retrocochlear pathway, resulting in alterations of perception of sound frequency and intensity. This hearing loss also results in a loss of speech clarity due to damage to the neural fibers located in the cochlea.

**Services plan:** A plan that sets forth the special education and related services that the district provides to a parentally placed private school child with disabilities.

**Shadow curve:** Responses of the normal hearing ear are recorded falsely as responses of the “bad” ear, caused by cross hearing.

**Signal-to-noise ratio (SNR):** The mathematical ratio between a primary signal (for example, speech) and the measurement of simultaneous noise.

**Silent ear infection:** A confounding element of otitis media whereby some individuals show no signs or symptoms of the disease.

**Simple harmonic motion (SHM):** The type of motion characteristic of pure tones, which is due to areas of alternating condensation and rarefaction occurring at a steady rate of change. When pure tones move in SHM, they take the same amount of time to complete each cycle of vibration, or are periodic.

**Simple view of reading:** The theoretical model stating that reading comprehension is the product of decoding and linguistic comprehension.

**Simple view of writing:** The theoretical model stating that writing is the triangular relationship among transcription, text generation, and executive function skills, which are all dependent upon working memory.

**Ski slope:** Hearing loss that is characterized by a rapid decrease in threshold responses after 250Hz and 500 Hz.
**Sound:** Physical phenomenon described as the movement or propagation of a disturbance (i.e., a vibration) through an elastic medium (e.g., air molecules) without permanent displacement of the particles. Three prerequisites are necessary for production of sound: a source of energy, a vibrating object, which generates an audible pressure wave, and a medium of transmission.

**Specificity:** A screening test’s ability to accurately separate individuals who have a disorder from those who do not; it represents the percentage labeled negative who are truly free of the target condition.

**Speech audiometry:** Formal measurements of an individual’s ability to hear and/or understand speech.

**Speech awareness threshold (SAT):** See speech detection threshold (SDT).

**Speech banana audiogram:** A counseling tool used to convey the significance and impact of a person’s hearing loss. The speech banana audiogram is a typical audiogram with a shaded “banana shape” area representing the approximate area where speech sounds typically occur, with the individual phonemes placed where they will fall on the audiogram based on their frequency and intensity.

**Speech detection threshold (SDT):** Minimum hearing level for speech at which an individual can just detect the presence of speech stimuli.

**Speech discrimination testing:** See word discrimination testing (WDT).

**Speech reception threshold (SRT)** Measurement of person’s threshold for the recognition of 50% of simple speech (spondee) stimuli. This indicates how loud speech has to be for a person to just barely recognize it as a speech signal and repeat the word(s) accurately.

**Speech recognition threshold (SRT):** See speech reception threshold (SRT).

**Spondee:** Words made up of two syllables in which equal emphasis is placed on both syllables when spoken (e.g., hotdog, downstairs, baseball, toothbrush).

**Spontaneous otoacoustic emissions:** Sounds that are generated by and emitted from the inner ear spontaneously, without stimulation. Spontaneous otoacoustic emissions are not present in all people, and therefore hold little clinical application.

**Standard:** A design or format applicable because it is recognized by an official organization or because it is used by a majority of users. Following standards is mandatory.

**Stapedius muscle:** Muscle of the middle ear that contracts bilaterally in response to high-intensity sounds to stiffen the ossicular chain, which protects the inner ear from intense sounds. This contraction results in attenuation of sound pressure reaching the inner ear.

**Stapes:** The stapes is the most medial bone in the ossicular chain and looks like a stirrup; it fits very neatly in the oval window of the cochlear wall to help push sound (as mechanical energy) into the inner ear.

**Subacute care:** Comprehensive inpatient care designed for someone who is recovering from an acute illness, injury, or exacerbation of a disease process. It is goal-oriented treatment immediately after, or instead of, acute hospitalization (Kuchar, 2006). Patients are sent to the subacute facility once they have been stabilized in the medical facility and no longer meet the criteria for that acute hospital setting. These settings cover a wide range of services and may specialize in a specific type of care either long term or rehabilitative in nature.

**Suppurative:** Containing discharge or pus.

**Swimmer’s ear:** The general term used to describe an inflammation of the skin of the external ear canal caused by a sensitivity to the microorganisms within water in which an individual has been swimming; see also otitis externa.

**Tectorial membrane:** A gel-like membrane that forms the roof of the basilar membrane. The outer hair cells are embedded into the tectorial membrane, with the inner hair cells in close proximity.

**Telecoil (T-Coil):** Circuitry within a hearing aid device that is designed to pick up an electromagnetic signal. Such circuitry is most often found in the ITE- and BTE-style hearing aids. The T-coil is useful for amplifying sound from older model telephones and also useful in some designs of assistive listening technology.

**Telecommunication device for the deaf (TDD):** See text telephone (TTY).

**Telescope vocal development:** Progression from immature verbalizations to the production of the entire range of vocal behaviors.

**Teletype device:** See text telephone.

**Temporal cues:** Those time-related aspects of speech that include inflectional information related within a conversation to emphasize emotion or connect the spoken word with the meaning or feeling behind it.

**Temporal processing/sequencing:** Ability to recognize the timing aspects of acoustic stimuli. This
is an important function for the processing of auditory signals, especially for the interpretation of speech. Intact and accurate temporal processing/sequencing is critical for the perception of rapidly altering speech sounds and is needed for the interpretation of prosodic aspects of speech.

Tensor tympani muscle: Muscle of the middle ear that runs parallel to the Eustachian tube and assists in its function. When the tensor tympani muscle contracts, it pulls the malleus to draw the tympanic membrane inward, which increases the pressure in the middle ear and Eustachian tube.

Text comprehension: A more broadly defined area of reading comprehension that includes all that an individual can do to gain meaning from written text.

Text generation: The coding of ideas into strands of language consciously, though not out loud, and then utilizing transcription skills to produce written language at the semantic, syntactic, and discourse levels.

Text telephone (TTY): System of communication via telephone using typewritten messages instead of speaking and listening. TTY has a keyboard for typing out messages and a display for the incoming messages.

Threshold: The softest level at which an individual can respond to a stimulus 50% of the time.

Threshold of discomfort (TD): See uncomfortable listening level (UCL).

Tinnitus: Ringing or buzzing in the ear.

Tonotopic organization: The auditory nerve fibers are arranged on the basilar membrane in this fashion, meaning nerve fibers at the apical end of the cochlea respond preferentially to low-frequency stimuli, and high-frequency sounds are encoded at the base. The auditory nerve is tonotopically arranged so that low-frequency sounds are found in the core of the auditory nerve and high-frequency sounds are arranged around the periphery.

Total communication: A philosophy of education for the deaf that encompasses spoken language/sign concepts, which can use many modalities to communicate, such as ASL, Sign Exact English, finger-spelling, lip-reading, nonverbal cues, or amplification. The speaker will use spoken language with manual/visual methods simultaneously to successfully communicate with a child with hearing loss/deafness.

Transcription: The skill of transposing one’s thoughts from cognition to written form. Skills include handwriting, keyboarding, and spelling accuracy.

Transducer: Object that changes one form of energy to another form. For example, the ear is a transducer because acoustic energy is changed to fluid/electrical energy via mechanical energy of the middle ear, which allows the ear to analyze various physical parameters to perceive in the brain what the ear has heard.

Transient-evoked otoacoustic emission (TEOAE): A type of evoked otoacoustic emission (see evoked otoacoustic emission). The sound used to elicit a response with this testing is a transient, click sound, stimulus of brief duration.

Traveling wave theory: The concept by which sound travels and is coded within the cochlea.

Tympanic membrane: Anatomic boundary between the outer and middle ear, which comprises multiple layers of tissue that are both concentric and radial. Also commonly known as the eardrum.

Tympanogram: Graphic display reflecting the volume, compliance, and pressure of the outer and middle ear systems.

Tympanometric compliance: The amount of mobility (movement) the eardrum demonstrates.

Tympanometric pressure: The measure of pressure in the middle ear cavity referencing normal atmospheric pressure measured in daPa.

Tympanometry: An evaluation of the physical working properties of the middle ear system based on the mathematical principles of pressure, compliance, and volume.

Uncomfortable listening level (UCL): Limit at which the patient would find sound to be unacceptably loud, or painful to listen to, for any significant period of time.

Uniform circular motion: Projected movement of an air molecule if it were to move around the circumference of the circle, formed by the trough directly beneath the peak of a sine wave, at a constant rate.

Unilateral hearing loss: A hearing loss characterized by normal hearing sensitivity in one ear, while the other ear presents with thresholds outside of the range of normal.

Unilaterally: Pertaining to one ear.

Universal newborn hearing screening (UNHS): Ensures that all infants have equal access to
early hearing loss identification. UNHS is supported by the passage of national and state legislation that has resulted in a significant decrease in the age at which children are diagnosed with hearing loss.

**Universal precautions:** Recommendations developed by the Centers for Disease Control and Prevention to control the spread of infectious diseases.

**Upwardly sloping:** A hearing loss characterized by thresholds of greater degree in the lower frequencies as compared to those in the higher frequencies.

**Utricle:** One of the two organs of balance housed within the vestibule.

**Vector:** Object that has magnitude (some amount greater than zero) and direction.

**Vestibular labyrinth:** The portion of the ear that includes the semicircular canals and the vestibule, which houses the saccule and utricle. This sensory end organ of ear, in conjunction with the vision and proprioception, is responsible for maintaining our balance system.

**Vestibular membrane:** The membranous roof of the cochlear duct.

**Vestibule:** This connects the two end organs of hearing and balance (the cochlea and semicircular canals) and houses the saccule and utricle.

**Veterans Affairs facility:** A hospital or medical facility that services those who have served or are serving in the armed forces.

**Videonystagmography (VNG):** An evaluation of the inner ear balance system that records a symptom called nystagmus. Nystagmus is an involuntary rhythmic oscillating movement of the eyes, which work in connection with the organs of the vestibular system to establish our sense of balance. Video goggles are used that incorporate a camera to record and measure the person's eye movements.

**Visual reinforcement audiometry (VRA):** An audiometric testing technique that utilizes the sound field and operant conditioning. A typical VRA response would be a head turn reinforced by a visual stimulus. This testing technique is most appropriate for those with a developmental age of 6 months through 2 years.

**Wavelength:** A graphic representation of the disturbance created by the sound wave in a medium, which is measured in units of length and represented by the Greek letter lambda (λ).

**Wernicke’s area:** That area of the brain within the lower temporal lobe, where speech perception is located.

**Word discrimination testing:** Procedure by which phonemically balanced word lists are used to estimate how well a person is able to understand speech once it has been made comfortably loud enough for them.

**Word recognition testing:** See word discrimination testing (WDT).

**X-linked:** A genetic condition whereby the mother has the recessive trait but only passes the trait to male offspring.
References


INDEX

A

AABR screening. See Automated auditory brainstem response (AABR) screening
ABEL. See Auditory Behavior in Everyday Life (ABEL)
ABR study. See Auditory brainstem response (ABR) study
Absolute scale, 22
Acceleration, 16
Acoustic conversation, 307
Acoustic cues, 307–308, 309
Acoustic neuroma (AN), 191–192
Acoustic Pioneer, 460
Acoustics, 16
Acoustic (stapedial) reflexes, 29, 100–102
testing, 165
ACPT. See Auditory Continuous Performance Test (ACPT)
Acquired hearing loss, 7
Acute care, 468–471
consulting audiologists, 468, 470
specialty clinics, 470
Veterans Affairs facility, 470–471
ADA. See Americans with Disabilities Act (ADA)
ADAAA. See Americans with Disabilities Amendments Act of 2008 (ADAAA)
ADHD. See Attention-deficit/hyperactivity disorder (ADHD)
Adult Case History Form, 57–58
Adults
hearing assistance technology
for. See Hearing assistance technology (HAT)
hearing loss in, 40–41
mild hearing loss in, 141
moderate hearing loss in, 142–143
moderately severe hearing loss in, 144
AIED. See Autoimmune inner ear disease (AIED)
Air blower, hearing aid, 245, 246
Air-bone gap, 126, 146
Air conduction (AC) symbols, audiogram, 120–122
Air conduction audiometry, 64–67, 207–214
client preparation and instructions, 210–213
equipment, 207–210
methodology, 64–66
results, 214
test environment, 210
test sequence, 213–214
working of, 64
Air conduction pathway, 64
Air molecules, 16, 17
concentration/density of, 17–18
displacement, 21
in longitudinal wave, 18
ALDs. See Assistive listening devices (ALDs)
Alerting systems, 271–273
Amblyaudia, 450
American National Standards Institute (ANSI), 290–291
American Sign Language (ASL), 395, 397
American Speech-Language-Hearing Association (ASHA), 39, 290
audigogram symbols, 119–120, 136, 137
and electroacoustic calibration of test equipment, 8
Guidelines for Manual Pure-Tone Audiometry, 65
practice policy documents, 10–11
SLP service delivery domains, 3–5
Americans with Disabilities Act (ADA), 270, 288, 378, 473
Title III of, 288
Title II of, 288, 379
Title IV of, 288
Americans with Disabilities Amendments Act of 2008 (ADAAA), 286–287
Amplitude, 21
AN. See Acoustic neuroma (AN)
Analog hearing aids, 237–238
Anotia, 181
ANSD. See Auditory neuropathy spectrum disorder (ANSD)
ANSI. See American National Standards Institute (ANSI)
Antihelix, 26
AP. See Auditory processing (AP)
APD. See Auditory processing disorder (APD)
ASD. See Autism spectrum disorder (ASD)
ASHA. See American Speech-Language-Hearing Association (ASHA)
ASL. See American Sign Language (ASL)
Assistive listening devices (ALDs), 258–259
Assistive technology service, 386
ASSR study. See Auditory steady-state response (ASSR) study
Asymmetrical hearing loss, 128–129
degree of, 148–151
AT. See Auditory training (AT)
Atresia, 179, 181
Attention-deficit/hyperactivity disorder (ADHD), 44–45, 440
APD and, 444
Attenuation, 70
Attenuator, 209
Audiogram
  aided, 158–161
  and determination of hearing loss
type, 126–128
  familiar sounds, 172–173
  frequencies on, 118
  intensity on, 118, 119
  interpreting. See Audiogram
  interpretation
  reviewing, 168–169
  speech banana, 171–172
  symbols. See Symbols, audiogram
Audiogram interpretation, 118–119
  aids, 158–161
  and determination of hearing loss
type, 126–128
  familiar sounds, 172–173
  frequencies on, 118
  intensity on, 118, 119
  interpreting. See Audiogram
  interpretation
  reviewing, 168–169
  speech banana, 171–172
  symbols. See Symbols, audiogram
Audiologist
  accessing/locating, 7
  role in APD diagnosis, 444–447
  role in literacy acquisition for
  children with HI, 419–420
  scope of practice for, 5–7
Audiology, defined, 279, 378
Audiology services, 283–284,
  377–400
  classroom listening assessment.
  See Classroom listening
  assessment (CLA)
  communication approaches,
  395–397
  counseling, 389–390
  EAA resources to assist, 400
  educational service provision,
  392–395
  habilitation services, 388–389
  hearing assistance technology,
  386–387
  hearing loss prevention, 387–388
  identification of children with
  hearing impairment, 380
  IEP, 389, 390
  methods to deliver, 398–400
  overview, 378–379
  parent counseling and
  training, 387
  self-advocacy, 390–391
  self-determination, 390–391
  student service and placement
  considerations, 397–398
  Audiology sound booth, 60
  Audiometer, 61–62
  components of, 208–209
  diagnostic, 62
  screening device, 61
  Audiometric screening, 474
  Audiometric zero, 118, 138
  Audition, teaching language
  through, 303–305
  Auditory access, 304, 306–307
  Auditory Behavior in Everyday Life
  (ABEL), 346
  Auditory brainstem response (ABR)
  study, 110, 166, 167, 343
  equipment used for, 110
  methodology, 111–112
  working of, 111
  Auditory Continuous Performance
  Test (ACPT), 444
  Auditory cortex, 32–34
  Auditory Decoding Deficit
  Profile, Bellis/Ferre model
  subprofile, 455
  Auditory development
  of children with hearing loss,
  297, 303
  in typically developing children,
  296–303
  Auditory discrimination, 447, 453
  Auditory disorder
  defined, 199
  prevalence of, 199
  Auditory environment, 308
  Auditory habilitation, 389
  Auditory impairment, 199. See also
  Hearing impairments (HI)
  Auditory labyrinth, 29
  Auditory Learning Guide (ALG),
  306, 323–325
  Auditory masking, 70
  Auditory neuropathy spectrum
disorder (ANSD), 165, 193
  Auditory-oral communication
  approach, 396
  Auditory Perception Test for the
  Hearing-Impaired (APT/
  HI-R), 314
  Auditory processing (AP), 440
  language and, 443–444
  Auditory processing disorder
  (APD), 394
  ADHD and, 444
  assessment, results of, 454
  behavioral tests for, 447
  Bellis/Ferre model, 454–455
  Buffalo model, 455
  comorbidity of, 443
  compensatory strategies, 458–459
  defined, 440–441
  diagnosis of, 444–447
  electrophysiological measures,
  453–454
  environmental/classroom
  modifications, 458
  informal auditory therapy, 461
  low-redundancy speech, 452
  referral for testing, 441–442
  speech language intervention,
  461–462
  temporal processing/sequencing,
  451–452
  testing, age and skills for, 442–443
  treatment of, 458
  Auditory Rehabilitation: Memory,
  Language, Comprehension
  Test Probes (Stefanakos &
  Prater), 313
  Auditory skill development, 305–311
  levels of, 305
  model, implementation of,
  306–311
  Auditory skills checklist, 311,
  327–329
  Auditory steady-state response
  (ASSR) study, 112–113
  methodology, 112–113
  working of, 112
  Auditory trainer, 258
Auditory training (AT), 441, 455–456
device, 258
features, 456–457
Auditory-verbal (AV) communication approach, 396
Auditory-verbal development, in typically developing children, 298–303
Aural atresia, 342
Aural habilitation, 305
Aural rehabilitation, 7
groups, 477–478
Auricle. See Pinna
Autism, 278
Autism spectrum disorder (ASD), 43–44, 443
Autoimmune inner ear disease (AIED), 191
Automated auditory brainstem response (AABR) screening, 339–342
Autosomal dominant, 192
Autosomal recessive, 192

B
Background noise, 383
BAHA/BAHS. See Bone-anchored hearing aid/bone-anchored hearing system (BAHA/BAHS)
Basilar membrane, 30, 31–32
Battery tester, hearing aid, 245, 246
Behavioral observation audiometry (BOA), 73–74
conditioned orientation reflex, 74–76
conditioned play audiometry, 76
tangible reinforcement operant conditioned audiometry, 74–76
visual reinforcement audiometry, 74–76
Behavioral procedure, audiologic screening, 201–202
Behavioral tests, 441
for APD, 447
for (central) auditory processing, 448–449
for temporal processing/sequencing, 451–452
Behind-the-ear (BTE) style hearing aid, 238, 239–240 open-fit, 240
Bel, 23
Bell, Alexander Graham, 234–235
Bellis/Ferre model, 454–455
Berkeley, George, 16
Best practice, 10–11
Bilateral Meniere's disease, 190
Bilingual-bimodal communication approach, 396
Bilingualism, 397
Bimodal hearing amplification, 254–255
Binaural condition, 83
Binaural integration, 447
Binaural interaction, 447
tests for, 453
Binaural separation, 447
Biological calibration, 209–210
Bluetooth-compatible hearing devices, 244–245, 264–265
Bone-anchored hearing aid/bone-anchored hearing system (BAHA/BAHS), 584
Bone conduction, 68
Bone conduction audiometry, 67–69
preparation for, 69
working of, 69
Bone conduction (BC) symbols, audiogram, 122–124
Bone conduction hearing aid, 250
bone-anchored hearing aid/bone-anchored hearing system, 584
headband-style, 250
middle ear implant, 251–252
Bone conduction oscillator, 67–69
placement of, 69
Bone conduction pathway, 67
Bone line, 125
Boyle's law, 18
BrainTrain, 460
Broca's area, 33
Brown, Robert, 16
Brownian motion, 16
Buffalo model, of APD, 455

C
CADS. See Classroom audio distribution systems (CADS)
Calibration
daily biological, 8
electroacoustic, 8
CAN. See Computer-assisted note-taking system (CAN)
CANS. See Central auditory nervous system (CANS)
CAPDOTS, 460
CapTel. See Captioned telephone (CapTel)
Captioned telephone (CapTel), 268
CART. See Communication access real-time translation (CART)
Case history, 38–42, 471–473
informal observation, 41–42
“look, play, talk” process, 42
patient interview, 38–41
Central auditory nervous system (CANS), 441, 447
(Central) auditory processing, behavioral tests for, 448–449
(Central) auditory processing disorders (C)APD, 440
Cerumen, 26, 90, 92, 182
Child Find program, 380
Children
with ADHD, 45
auditory development in, 296–303
and binaural interaction tests, 453
complications associated with, 39–40
dichotic listening tests in, 450–451
handicap, screening tools for, 223–224
hearing assistance technology for. See Hearing assistance technology (HAT)
with hearing loss, literacy in. See Literacy, in children with hearing impairments
hearing screening, 211–213
and incidental learning, 138
mild hearing loss in, 141
moderate hearing loss in, 142
Children (cont.)
- moderately severe hearing loss in, 144
- with multiple disabilities, 358
- ruptured tympanic membrane in, 183
- and sensory integration testing, 444

Children with hearing loss
- auditory development of, 297, 303
- teaching language through audition, 303–305

Cholesteatoma, 184, 185–186

CI. See Cochlear implants (CI)
CIPP. See Colorado Individual Performance Profile (CIPP)
Circumaural earphones, 62–63
Civil Rights of Institutionalized Persons Act (CRIPA), 289
Classroom Acoustical Screening Survey Worksheet, 409
Classroom acoustics, 379, 382–384
- reverberation time, 383, 384–386
- signal-to-noise ratio, 383, 384

Classroom audio distribution systems (CADS), 262–264
Classroom listening assessment (CLA), 379, 380–384
- classroom acoustics, 382–384
- functional assessment, 385–386
- observation, 382
- self-assessment, 385–386

Classroom Participation Questionnaire (CPQ), 385, 386, 411–414
Clincs, specialty, 470
Closed captioning, 266
Closed-set auditory assessments, 313, 314
Cochlea, 29, 68, 108
Cochlear implants (CI), 158–161, 252–254, 304, 387
- components of, 255
- monitoring and troubleshooting, 254

Collaborative model, and APD diagnosis, 444–447
Colorado Individual Performance Profile (CIPP), 398

Common Core State Standards, 462
Communication
- approaches for deaf/hard of hearing children, 395–397
- manual, 389

Communication access real-time translation (CART), 269–270
Communications assistant (CA), 268
Comorbidity
- of auditory processing disorder, 443
- of hearing loss, 43

Compensatory strategies, 458–459
Completely-in-canal (CIC) hearing aid, 240–241
Comprehension, 305
Compression, 18

Computer-assisted note-taking system (CAN), 269–270
Computer-mediated auditory training programs, 459
- Acoustic Pioneer, 460
- BrainTrain, 460
- CAPDOTS, 460
- Earobics, 460
- Fast ForWord, 460
- HearBuilders, 460
- Laureate Learning Systems, 460
- LiSN and Learn, 460–461
- sound auditory training, 461

Concha, 26
Condensation, 18

Conditioned orientation reflex (COR), 74–76
Conditioned play audiometry (CPA), 76, 211
Conductive hearing loss, 34, 93, 126–127, 178–179
- degree of, 145–146
- otitis media and, 184

Congenital cholesteatoma, 185
Congenital hearing loss, 7, 39
Conscious attention, 426
Consonant-vowel-consonant consonant (CC-V-CC) format, 80
Consonant-vowel-consonant (CVC) format, 80
Consulting audiologists, 468, 470

Conventional hearing aids
- anatomy of, 241–244
- behind-the-ear hearing aid, 239–240
- completely-in-canal hearing aid, 240–241
- defined, 239
- direct audio input, 243–244
- frequency lowering technology, 244–245
- in-the-ear hearing aid, 240
- invisible-in-canal hearing aid, 240–241
- on-off control switch, 242
- power source options, 241–242
- telecoil circuitry, 242–243
- volume control, 242

Cookie bite, 130, 153

COR. See Conditioned orientation reflex (COR)

Covered entities, under HIPAA, 288–289
CPA. See Conditioned play audiometry (CPA)
CPQ. See Classroom Participation Questionnaire (CPQ)
CRIPA. See Civil Rights of Institutionalized Persons Act (CRIPA)

Cross hearing, 70

Cued speech, 389, 396

D

DAI. See Direct audio input (DAI)
DAT. See Dichotic auditory training (DAT)

Deaf, 9

Deaf-blindness, 278

Deafness
- defined, 278, 394
- universal sign for, 473

Deaf patient, in subacute care, 473

Decibel (dB), 21–24, 118
Decibel hearing level (dB HL), 25

Decibel sensation level (dB SL), 25

Decibel sound pressure level (dB SPL), 23

Decoding, 422–423
Degree of hearing loss, 66–67
asymmetrical hearing loss, 148–151
conductive hearing loss, 145–146
cookie bite, 153
determination of, 136–145
high-frequency sensorineural hearing loss, 151–153
mild hearing loss, 140–141
minimal/slight hearing loss, 138–140
mixed hearing loss, 147–148
moderately severe hearing loss, 143–144
noise notch, 151–153
normal hearing, 137–138
reverse curve, 153–154
sensorineural Hearing Loss, 146–147
severe and profound hearing loss, 144–145
Dehumidifier, 246–247
Dementia, 46–47
Depression, 45–46
Detection, of sound, 305
Developmental Index of Audition and Listening (DIAL), 345
Development stages, complications during, 39–41
Diagnostic audiometer, 62
Diagnostic audiometry, vs. screening procedures, 198
Diagnostic evaluations, 60
Dichotic auditory training (DAT), 457–458
Dichotic listening tests, 447, 450–451
Diagnostic diagnosis, 38, 39
attention-deficit/hyperactivity disorder, 44–45
autism spectrum disorder, 43–44
dementia, 46–47
depression, 45–46
process of, 42–47
Digital hearing aid, 238
Digital modulation (DM) technology, 259–262
induction loop coupling for, 262
Direct audio input (DAI), 243–244, 260–261
Disability, hearing screening for, 199–200
Disclosure of Cleaning Materials document, 9
Discrimination, 305 under Section 504 of Rehabilitation Act of 1973, 287–288
Displacement, 17 of air molecule, 21 force of, 18
Distortion product otoacoustic emission (DPOAE), 107, 108, 165, 340
DM technology. See Digital modulation (DM) technology DPOAE. See Distortion product otoacoustic emission (DPOAE)
DR. See Dynamic range (DR)
Duration Pattern Test, 451–452 Dynamic range (DR), 85

E

EAA. See Educational Audiology Association (EAA)
EAC. See External auditory canal (EAC)
Ear anatomy and physiology of, 25–34 inner. See Inner ear middle. See Middle ear outer. See Outer ear as transducer, 25
Ear canal volume (ECV), 98–99, 162–163
Early Hearing Detection and Intervention (EHDI), 110, 297, 395 defined, 337 goal of, 336, 338 and hearing screening. See Hearing screening process, SLP role in, 358–360
Early Listening Function (ELF), 346
Early Speech Perception (ESP) Test, 313
Ear mold, 239
Earobics, 460
Earphones, 62–64, 208 insert, 63–64 placement error, 65 standard, 62–63
Ear trumpets, 234
Ear wax. See Cerumen
EBP. See Evidence-based practice (EBP)
ECV. See Ear canal volume (ECV)
Edison, Thomas, 235
Educational Audiology Association (EAA), 7 resources to assist audiology services, 400
Educational audiology services. See Audiology services
Educational model, of service delivery, 468, 469
Educational record, defined, 284
Education for All Handicapped Children Act (EHA), 276. See also Individuals with Disabilities Education Act (IDEA)
Effusion, 28, 184
EHA. See Education for All Handicapped Children Act (EHA)
EHDI. See Early Hearing Detection and Intervention (EHDI)
Eighth cranial nerve acoustic neuroma, 191–192 diagnoses of, 191–192
EI services. See Early intervention (EI) services
Elasticity, 17
Elastic molecules, 16
Electroacoustic calibration, 8, 208
Electroacoustic measures, 106
equipment, 106–107
Electroacoustic testing, 441
Electronystagmography (ENG), 113–114
Electrophysiological testing, 441
Electrophysiologic measures, 109–110, 453–454
auditory brainstem response study, 110
Elementary and Secondary Education Act, 420
ELF. See Early Listening Function (ELF)
Endocochlear electrical potential, 29
Endolymph, 29
Energy, source of, 16
ENG. See Electronystagmography (ENG)
Environmental/classroom modifications, 458
Equilibrium, 17
Equipments, pure tone audiometry, 60–62, 207–210
audiology sound booth, 60
audiometer, 61–62
diagnostic audiometer, 62
Equivalent ear canal volume (EECV). See Ear canal volume (ECV)
Eustachian (auditory) tube, 28–29
Eustachian tube dysfunction, 154, 185
Evidence-based practice (EBP), 11
Evoked otoacoustic emissions, 107, 108
Executive function skills, 426
External auditory canal (EAC), 90, 342
External auditory meatus, 26, 92
collapse of, 181

F
False-negative response, 201
False-positive response, 201
Familiar sounds audiogram, 172–173
FAPI (Functional Auditory Performance Indicators), 346
Fast ForWord (FFW), 460
Feedback, 476
FERPA. See Family Educational Rights and Privacy Act of 1974 (FERPA)
Five stages of grief model (Kübler-Ross), 472
Fluency, 423
FM amplification systems. See Frequency-modulated (FM) amplification systems
FM Listening Evaluation, 347
Force, 16–17, 21
displacement, 18
Forehead placement, 69
Formal auditory training, 459
Free and appropriate public education (FAPE), 398
Frequency defined, 118
pitch vs., 19–20
as sound wave attribute, 19
Frequency lowering technology, 244–245
Frequency-modulated (FM) amplification systems, 259–262
induction loop coupling for, 262
Frequency switch, 209
Functional auditory assessment, 311–315, 343, 345–347
closed-set assessment, 313, 314
comprehensive assessments, 314
open-set assessment, 313–314, 315
questionnaires, 312–313
Functional Auditory Performance Indicators (FAPI), 346
GIN test. See Gaps-In-Noise (GIN) test
Glendonald Auditory Screening Procedure (GASP), 313
GreenClean, 9
Guidelines for Manual Pure-Tone Audiometry (ASHA), 65
Guide to Access Planning (GAP), 391
Handwriting, 425
Hard of hearing, 9–10, 378
HAT. See Hearing assistance technology (HAT)
Head shadow effect, 150
Health Insurance Portability and Accountability Act (HIPAA), 288–289
Healthy People 2000, 337
HearBuilders, 460
Hearing aid, 158–161
analog, 237–238
care, 245–247, 476–477
conventional. See Conventional hearing aids
digital, 238
historical background, 234–236
maintenance, 245–247
problems, 248–250
routine checking of, 387
troubleshooting, 247–249
Hearing assistance technology (HAT), 258–273, 382, 385, 386–387
alerting systems, 271–273
assistive listening devices, 258–259

G
Gap detection tests, 451
Gaps-In-Noise (GIN) test, 451
GASP. See Glendonald Auditory Screening Procedure (GASP)
Genetic hearing loss, 39, 192–193, 344–345

H
Habilitation services, to school-aged children, 388–389
Handicap, hearing screening for, 200, 222–226
client preparation and instructions, 225
equipment/tools, 223–224
results and recommendations, 225–226
test environment, 224–225
test sequence, 225
Handwriting, 425
Hard of hearing, 9–10, 378
HAT. See Hearing assistance technology (HAT)
Head shadow effect, 150
Health Insurance Portability and Accountability Act (HIPAA), 288–289
Healthy People 2000, 337
HearBuilders, 460
Hearing aid, 158–161
analog, 237–238
care, 245–247, 476–477
conventional. See Conventional hearing aids
digital, 238
historical background, 234–236
maintenance, 245–247
problems, 248–250
routine checking of, 387
troubleshooting, 247–249
Hearing assistance technology (HAT), 258–273, 382, 385, 386–387
alerting systems, 271–273
assistive listening devices, 258–259
captioned telephone, 268
classroom audio distribution systems, 262–264
closed captioning, 266
communication access real-time translation, 269–270
computer-assisted note-taking system, 269–270
defined, 258
digital modulation (DM) technology, 259–262
frequency-modulated (FM) amplification systems, 259–262
lesson capture devices, 270–271
real-time communication options, 268–269
remote, 264–265
for sound enhancement and alerting devices, 265–273
telecommunication device for the deaf, 267
telephone amplifiers, 266–267
teletype device, 267
television amplification, 265–266
video relay service, 267–268
Hearing handicap, 200
Hearing Handicap Inventory for the Elderly, 475
Hearing Handicap Inventory for the Elderly– Screener version (HHIE-S), 475
Hearing Healthcare Infant/Toddler Case History Questionnaire (HHITCH-Q), 367–373
Hearing impairments (HI), 420–422 children with. See Children with hearing loss
defined, 278, 394
literacy acquisition for, role of SLPs and AUDs in, 419–420
reading interventions, 428–430
simple view of reading in, 424–425
simple view of writing in, 426–428
Hearing/listening age, 310–311
Hearing loss, 34–35, 167–168
acquired, 7
in adults, 40–41
associated, syndromes with, 193
asymmetrical, 128–129, 148–151
attention-deficit/hyperactivity disorder and, 44–45
autism spectrum disorder, 43–44
case history information related to, 472
children with. See Children with hearing loss
comorbidity of, 43
conductive, 34, 93, 126–127, 145–146
configuration of, 128–132
genetic, 39, 192–193, 344–345
high-frequency sensorineural, 130, 151–153
incidence of, 336
in infants, 297
look-alike disorders, 42–43
mixed, 35, 128, 147–148
noise-induced, 188–189
noise notch, 130–131, 151–153
prevention, 387–388
progressive, 155
reverse curve, 131, 153–154
sensorineural, 34–35, 127–128, 146–147, 188
ski slope, 132, 154–155
unilateral, 128
vir al causes of, 192
Hearing Loss Association of America (HLAA), 477
Hearing screening assessment and treatment, 200
behavioral vs. nonbehavioral procedure, 201–202
client for, 202
clinician’s role in, 200
defined, 198
for disability, 199–200
for disorder, 199
documentation, 226
form, 231
for handicap. See Handicap, hearing screening for
for impairment, 199
by 1 month of age, 339–343
otoacoustic emission screening. See Otoacoustic emission screening
permissions for, 202
principles of, 200–202
procedures, diagnostic audiometry vs., 198
pure tone air conduction screening. See Pure tone air conduction screening
purpose of, 200
questionnaires, 204
results, 226
sensitivity, 201
by 6 month of age, 347–349
specificity, 201
by 3 month of age, 343–347
tools, 474–476
universal precautions, 203–204
visual inspection/ otoscopy, 204–207
Hearing status, 378
Helicotrema, 30
Helix, 26
Hertz (Hz), 19, 118, 209
HHIE-S. See Hearing Handicap Inventory for the Elderly–Screener version (HHIE-S)
Highest qualified provider, 379
High-frequency sensorineural hearing loss (HF SNHL), 130, 151–153
HIPAA. See Health Insurance Portability and Accountability Act (HIPAA)
HLAA. See Hearing Loss Association of America (HLAA)
Hyperacusis, 189

ICF. See International Classification of Functioning, Disability and Health (ICF)
IDEA. See Individuals with Disabilities Education Act (IDEA)
IDEA 2004 key regulations, 405–407
Identification, of children with hearing impairment, 297, 380
IEP. See Individualized Education Plan (IEP)
IFSP. See Individualized Family Service Plan (IFSP)
Imitator diseases, 42–43
Impacted cerumen, 182
Impedance-matching transformer, 27
Incidental learning, 138, 308, 310
Incudomalleolar joint, 27
Incus, 27
Individualized Education Plan (IEP), 11, 354, 379, 420
audiology services, 389, 390
Consideration of Special Factors, 394–395
services, IDEA and, 277–278
Individualized Family Service Plan (IFSP), 283, 348, 349, 395
development of, 353
review, 353
services outlined in, 353–354
Individuals with Disabilities Education Act (IDEA), 276–284, 348, 378, 441
Child Find program, 380
disagreements under, 281–282
educational service under, 379
and EI services, 349
IEP services, 277–278
least restrictive environment, 280–281
obligations under, 276
parent counseling and training, 387
and prevention of hearing loss, 387–388
school district’s initial evaluation, 276–277
services plan, 281
special education services, 281
Induction loop coupling, for FM/DM systems, 262
Inertia, 16, 17
Infants. See also Children hearing loss in, 297
hearing screening, 343–349
Infant-Toddler Meaningful Auditory Integration Scale (IT MAIS), 312–313, 347
Informal auditory therapy, 461
Informal observation, 41–42
Inner ear, 29–32
autoimmune inner ear disease, 191
diagnoses of, 188–191
Meniere's disease, 190
noise-induced hearing loss, 188–189
ototoxicity, 189
presbycusis, 190–191
sensorineural hearing loss, 188
trauma, 189–190
Inner hair cells, 31
Insert earphones, 63–64
In-service training, 478–479
Integration Deficit Profile, Bellis/Ferre model subprofile, 455
Intensity, sound
on audiogram, 119
defined, 118
loudness vs., 24–25
and measured pressure, 24
measurement of, 21–24
Interacoustics otoacoustic emissions testing equipment, 106
Interact-AS system, 270
Interaural attenuation, 70, 149
International Classification of Functioning, Disability and Health (ICF), 3
International Outcome Inventory for Hearing Aids (IOI-HA), 476
Internet, and deaf community, 268–269
Interpreting services, 279
Interprofessional collaboration, 2–3
benefits of, 2
Interrupter switch, 209
Interview, patient, 38–41
In-the-canal (ITC) hearing aid, 240
In-the-ear (ITE) hearing aid, 240
Invisible-in-canal (IIC) hearing aid, 240–241
IOI-HA. See International Outcome Inventory for Hearing Aids (IOI-HA)
IT MAIS (Infant-Toddler Meaningful Auditory Integration Scale), 347
J
JCAHO. See Joint Commission on the Accreditation of Healthcare Organizations (JCAHO)
JCIH. See Joint Committee on Infant Hearing (JCIH)
Joint Commission on the Accreditation of Healthcare Organizations (JCAHO), 291–292
Joint Committee on Infant Hearing (JCIH), 338
and EI services for deaf/hard of hearing children. See Early intervention (EI) services, for deaf/hard-of-hearing children and rules in 1-3-6 trilogy, 339–349. See also Hearing screening
Year 2007 JCIH Position Statement, 341, 356–358, 397
K
Keloid, of pinna, 92
Keyboarding, 425–426
Koop, C. Everett, 337
Kübler-Ross, Elisabeth, 472
L
Language
domains, 418
and literacy, 418–419
multimodal framework, 418–419
teaching through audition, 303–305
Language delay/deficit, 443–444
Laureate Learning Systems, 460
Laws/regulations
Americans with Disabilities Act (ADA), 288
Civil Rights of Institutionalized Persons Act (CRIPA), 289
Health Insurance Portability and Accountability Act (HIPAA), 288–289
Individuals with Disabilities Education Act. See Individuals with Disabilities Education Act (IDEA)
Rehabilitation Act, Section 504 of, 285–288
Social Security Act, 289–290
Least restrictive environment (LRE), 280–281
Left ear advantage (LEA), 450
LENA (language environment analysis) system, 310
Linear scale, 22
logarithmic scale and, 23
Linguistic comprehension, 423–424, 425
Linguistic cues, 308
LiSN and Learn program, 460–461
Listening checks, 8
framework for developing, 306
Listening and spoken language (LSL), 396, 398
Listening check, 209–210
Listening in Spatialized Noise-Sentences Test, 453
Listening Inventory for Education (L.I.F.E.), 385
Listening tube, hearing aid, 245
Literacy, in children with hearing impairments defined, 419
language and, 418–419
SLPs/AUDs role in acquisition, 419–420
LittlEARS Auditory Questionnaire, 313, 346
Logarithmic scale, 22–23
linear scale and, 23
Longitudinal waves, 18
Long-term care facilities. See nursing homes/long-term care facilities
“Look, play, talk” process, 42
Look-alike diseases, 42–43
Loudness, 21, 118
intensity vs., 24–25
Loudness discomfort level (LDL), 84. See also Uncomfortable listening level (UCL)
Loudness recruitment, 190
Low-redundancy speech, 452
LRE. See Least restrictive environment (LRE)
Malignant (necrotizing) otitis externa, 183
Malleus, 27
Manual communication, 389
Manually coded english (MCE), 397, 398
Masking, 70–71, 87
Mass, 16
Mastoidectomy, 186
Mastoiditis, 184
Mastoid placement, 69
MCE. See Manually coded english (MCE)
MCL. See Most comfortable listening level (MCL)
MDS. See Minimum Data Set for Nursing Home Residents Assessment and Care Screening Tool (MDS)
Meaningful Auditory Integration Scale (MAIS), 312–313
Medicaid, 289, 290
Medical history, 40–41
Medical home, 338
Medical model, of service delivery, 468, 469
Medicare, 289–290
MEI. See Middle ear implant (MEI)
Mels, 19–20
Membranous labyrinth, 29
Meniere's disease (MD), 190
Meningitis, 184
Metalinguistic analysis, 446
Microfiber cloth, 246
Microtia, 92, 179, 181
Middle ear, 26–29
acoustic ( stapedral) reflexes, 100–102
diagnoses of, 168, 183–188
Eustachian tube dysfunction, 185
muscles of, 28–29
ossicular discontinuity, 187–188
otitis media, 183–185
otosclerosis, 186–187
perforated tympanic membrane, 183
tests, 96–103
Middle ear implant (MEI), 251–252
Mild hearing loss, 140–141
Minimal/slight hearing loss, 138–140
Minimum Data Set for Nursing Home Residents Assessment and Care Screening Tool (MDS), 474
Minimum response level (MRL), 73
Mixed hearing loss, 35, 128
degree of, 147–148
Moderate hearing loss, 141–143
Moderately severe hearing loss, 143–144
Modified play technique, 211–212
Monaural condition, 83
Monaural low-redundancy training, 457
Most comfortable listening level (MCL), 83–84
methodology, 83–84
working of, 83
MRL. See Minimum response level (MRL)
MTSS. See Multitiered systems of support (MTSS)
Multimodal language framework, 418–419
Multiple disabilities, 278
Multitiered systems of support (MTSS), 392, 393
Muscles, of middle ear, 28–29
National Center for Hearing Assessment and Management (NCHAM), 356
Natural environment, 348
Neonatal development stage, complications during, 39
Neurofibromatosis type 2 (NF2), 191
Newborn and Infant Hearing Screening and Intervention Act, 337
Newborn hearing screening automated auditory brainstem response, 339–342
barriers to, 342–343
otoacoustic emission screening, 339–342
Newton, Isaac, 16
NF2. See Neurofibromatosis type 2 (NF2)
NIHL. See Noise-induced hearing loss (NIHL)
No Child Left Behind Act, 11, 12
Noise-induced hearing loss (NIHL), 188–189
Noise notch, 130–131, 151–153
Nonbehavioral procedure, audiologic screening, 201–202
No response symbol, audiogram, 124–125
Nursing homes/long-term care facilities, 473–479
hearing aid care in, 476–477
hearing screening tools, 474–476
in-service training, 478–479
Minimum Data Set for Nursing Home Residents Assessment and Care Screening Tool, 474 staff, 474
Nystagmus, 113

O

OAE. See Otoacoustic emission (OAE)
OBRA. See Omnibus Budget Reconciliation Act of 1987 (OBRA)
Occupational Safety and Health Act of 1970, 291
Occupational Safety and Health Administration (OSHA), 8, 291

Omnibus Budget Reconciliation Act of 1987 (OBRA), 474
On Death and Dying (Kübler-Ross), 472
Open-fit BTE, 240
Open-set auditory assessments, 313–314, 315
Organ of Corti, 30
Osseous labyrinth, 29
Ossicles, 27
Ossicular discontinuity, 187–188
Ossicular malformation, 187
Otalgie, 182
Otitis externa, 182–183
Otitis media, 28, 40, 92, 183–185
Otoacoustic emission (OAE), 31, 106, 380
evoked, 107, 108
preparation for, 108–109
screenings. See Otoacoustic emission screening spontaneous, 107, 108
Otoacoustic emission screening, 107, 214–218, 339–342
client preparation and instructions, 216–217
equipment, 215–216
results, 217–218
test sequence, 217
Otosclerosis, 163, 186–187
Otoscope, 91, 92
Otoscopy, 90, 91–96, 204–207
client preparation and instructions, 205–206
equipment, 91–92, 205
methodology, 93–96
observations and recommendations, 206–207
of outer ear, 178
test environment, 205
test sequence, 206
working of, 93
Otospongiosis, 186–187
Ototoxicity, 189
Outer ear, 26, 97
atresia, 179, 181
cerumen, 182
collapsed canals, 181
diagnoses of, 168, 178–183
foreign bodies in, 182
microtia, 179, 181
otitis externa, 182–183
tympanometric findings, 179–180
Outer hair cells, 30–31
Output switch, 209
Oval window, 30
Overhearing, 308, 310

P

Parent counseling and training, 280, 387
Pars flaccida, 27
Pars tensa, 27
Pascal (Pa), 22
PB. See Phonemically balanced (PB)
PEACH (Parents’ Evaluation of Aural/Oral Performance of Children), 346–347
Perforated tympanic membrane, 183
Periauricularly, 181
Perilymph, 29
Perinatal development stage, complications during, 39
Period, as sound wave attribute, 19
Personal hearing instruments, monitoring, 387
“Person first” view, 10
Phase, as sound wave attribute, 21
Phonemically balanced (PB), 80
Phonetic awareness, 423
Phonetic alphabet, 234–235
Phonics, 423
Phon level, intensity, 24–25
Physical volume test (PVT). See Ear canal volume (ECV)
Pinna, 26
abnormalities, 91, 92
visual inspection of, 90–91
Pitch, 118
frequency vs., 19–20
PLAAFP. See Present levels of academic achievement and functional performance (PLAAFP)
Planning, 426
Plasticity, 455
Portable audiometer, 207–208
Precipitously sloping hearing loss. See Ski slope hearing loss
Prenatal development stage, complications during, 39
Presbycusis, 154, 190–191
Preschool SIFTER, 313
Present levels of academic achievement and functional performance (PLAAFP), 278
Pressure equalization (PE) tube, 96
Pressure wave, 17
Process-based auditory remediation, 455, 456
Progressive hearing loss, 155
Propagation, 16
Prosodic Deficit Profile, Bellis/Ferre model subprofile, 455
Prosody, 307–310
Pseudohypacusis, 41, 156, 169–171
PTA. See Pure tone average (PTA)
Pure tone, 19
Pure tone air conduction screening, 207–214
Pure tone audiometry, 60–69
air conduction audiometry. See Air conduction audiometry
bone conduction audiometry, 67–69
equipments. See Equipments, pure tone audiometry
Pure tone average (PTA), 81, 155–156

Q
Questionnaires, 312–313
as hearing screening tool, 204, 474–476

R
Random Gap Detection Test (RGDT), 451
Rarefaction, 18
REA. See Right ear advantage (REA)
Reading interventions, 428–430
simple view of, 422–425
Recruitment, 84
Regulations. See Laws/regulations
Rehabilitation counseling services, 280
Related services, 276, 279
Remote hearing assistance technology, 264–265
Response to intervention (RTI), 11–12, 392, 393
model of, 11–12
opponents of, 12
proponents of, 12
Retrocochlear auditory pathway, 32–34
Reverberation, defined, 260
Reverberation time, 383
determination of, 384–386
Reverse curve hearing loss, 131, 153–154
Revising, 426
RGDT. See Random Gap Detection Test (RGDT)
Right ear advantage (REA), 450
Risk indicators, 356–358
Round window, 30
RTI. See Response to intervention (RTI)
Ruptured tympanic membrane, 183
Scaphoid fossa, 26
School, for deaf audiology services in. See Audiology services
historical perspective, 391
School-Based Audiology Advocacy Series (EAA), 400
Scope of Practice in Speech-Language Pathology (ASHA), 3
Screening device, audiometer, 61
Screening Instrument for Targeting Educational Risk (SIFTER), 313
Screening tools, hearing, 474–476
SDT. See Speech detection threshold (SDT)
application of, 285–286
discrimination under, 287–288
Self-advocacy, 390–391
Self-Assessment of Communication for Adolescents (SAC-A), 385
Self-determination, 390–391
Self-regulation, 426
SEMI. See Special Education Medicaid Initiative (SEMI)
Semicircular canals, 29
Sensation level (SL), 25
Sensitivity, 201
Sensorineural hearing loss, 34–35, 127–128, 188
degree of, 146–147
high-frequency, 130
Sensory integration testing, 444
Services plan, 281
Shadow curve, 70, 149
Signal-to-noise-ratio (SNR), 383
determination of, 384
Significant Other Assessment of Communication-Adolescents (SOAC-A), 385
Silent ear infection, 184
Simple harmonic motion (SHM) characteristics of, 19–21
element of, 19
and sound, 19–21
Simple view of reading, 422–424
in children with HI, 424–425
Index

Simple view of writing, 425–426 in children with HI, 426–428
Simultaneous communication, 396
Site of lesion, nonspecified, 192–193
SKI-HI Institute, 358
Ski slope hearing loss, 132, 154–155
SLI. See Specific language impairment (SLI)
Slight hearing loss. See Minimal/ slight hearing loss
SLP. See Speech-language pathologist (SLP)
SNR. See Signal-to-noise-ratio (SNR)
Social Security Act, Title XVIII of, 289–290
Sone level, intensity, 25
Sound characterisics of, 16–25
defined, 16
intensity. See Intensity, sound production, prerequisites for, 16
simple harmonic motion and. See Simple harmonic motion (SHM)
waves. See Waves, sound
Sound auditory training (SAT), 461
Sound field
aided, 158–161
air conduction symbols in, 122
defined, 71
unaided data, 157–158
Sound field (SF) testing, 71–73
equipment, 71
VRA system and, 71
Sound transduction
error of. See Hearing loss
insert earphones, 63–64
standard earphones, 62–63
traveling wave theory of, 32
Special Education Medicaid Initiative (SEMI), 290
Specialty clinics, 470
Specificity, 201
Specific language impairment (SLI), 443
Speech audiometry, 79–87, 155–157
dynamic range, 85
findings, 168
masking, 87
most comfortable listening level, 83–84
overview, 80
speech detection threshold/
speech awareness threshold, 82–83, 156
speech reception (recognition) threshold, 81–82, 155–156
uncomfortable listening level/
loudness discomfort level/
threshold of discomfort, 84–85
word discrimination testing,
85–87, 156–157
word lists, derivation of, 80–81
Speech awareness threshold (SAT), 82–83, 156
methodology, 83
working of, 82
Speech banana audiogram, 171–172
Speech detection threshold (SDT), 82–83, 156
methodology, 83
working of, 82
Speech discrimination testing, 85.
See also Word discrimination testing (WDT)
Speech-in-noise tests, 452
Speech-Language-Hearing Case History Form, 38, 51–56
Speech/language impairment, 278
Speech language intervention,
461–462
Speech-language pathologist (SLP),
2, 44, 468
in acute care setting, 468–471
areas of practice for, 5
audiological test equipment,
guidelines for usage of, 7–8
delegation of audiology responsibilities, 379
domains of professional practice, 5
and EHDI process, 358–360
evidence-based practice, 11
job responsibilities, 3
role in APD diagnosis, 444–447
role in literacy acquisition for children with HI, 419–420
scope of practice for, 3–7
service delivery domains, ASHA, 3–5
Speech-language pathology, 2, 280
Speech reception (recognition) threshold (SRT), 81–82,
155–156
defined, 81
methodology, 81–82
working of, 81
Spondoe, 80
Spontaneous otoacoustic emissions, 107, 108
SRT. See Speech reception (recognition) threshold (SRT)
Standard earphones, 62–63
Standards, 276
for acoustics in classroom, 284
Stapedial reflexes. See Acoustic (stapedial) reflexes
Stapedius muscle, 28, 29
Stapes, 27
Subacute care, 471–473
defed patient in, 473
hard-of-hearing patients in, 473
Supra-aural earphones, 62, 63
placement of, 65
Swimmer’s ear, 182–183
Symbols, audiogram, 119–126,
136, 137
air conduction, 120–122
bone conduction, 122–124
no response, 124–125
responses, connecting, 125–126
T
Tangible reinforcement operant conditioned audiometry (TROCA), 74–76
TDD. See Telecommunication device for the deaf (TDD)
Tectorial membrane, 30
Telecoil circuitry, 242–243
Telecommunication device for the deaf (TDD), 267
Telephone amplifiers, 266–267
Telepractice model, 355–356
Telescope vocal development, 304
Teletype device (TTY), 267
Television amplification, 265–266
Temporal cues, 244
Temporal processing/sequencing, 451–452
training for, 458
Tensor tympani muscle, 28, 29
TEOAE. See Transient-evoked otoacoustic emission (TEOAE)
Text comprehension, 423–424
Text generation, 426
Threshold of discomfort (TD), 84. See also Uncomfortable listening level (UCL)
Thresholds, 120, 138
air conduction, 137, 138, 140, 141, 143
audiometric, 140, 141, 143
speech reception/recognition. See Speech reception (recognition) threshold (SRT)
Tinnitus, 183
Title II, of ADA, 288, 379
Title III, of ADA, 288
Title IV, of ADA, 288
Title XVIII of Social Security Act, 289–290
Toddlers, 343, 344
development stage, complications during, 39–40
Tonotopic organization, 33
Total communication (TC) approach, 396
“Toward Equality: Education of the Deaf” (report), 337
Tragus, 26
Transcription, 425–426
Transducers, 62–64, 208
ear as, 25
Transient-evoked otoacoustic emission (TEOAE), 107, 108, 165, 340
Transition services, 280
Trauma, 189–190
Traveling wave theory, 32
Triangular fossa, 26
TROCA. See Tangible reinforcement operant conditioned audiometry (TROCA)
TTY. See Teletype device (TTY)
Tympanic membrane, 26–27, 94
Tympanogram
classification of, 161
ear canal volume, 162–163
interpretation of, 161–165
type A, 163
type Ad, 164
type As, 163
type B, 164
type C, 164–165
Tympanometry, 97
Tympanometric compliance, 98
Tympanometric pressure, 98
Tympanometry, 90, 97–100, 109
compliance values, 98
ear canal volume, 98–99
methodology, 99–100
pressure values, 98
screening. See Tympanometry screening
working of, 98
Tympanometry screening, 218–222
client preparation and instructions, 220
equipment, 218–220
results, 221–222
test sequence, 220–221
Type As tympanogram, 163
Type A tympanogram, 163
Type B tympanogram, 164
Type C tympanogram, 164–165

U
Uncomfortable listening level (UCL), 84–85
levels, measurement of, 84
methodology, 84–85
working of, 84
UNHS. See Universal newborn hearing screening (UNHS)
Uniform circular motion, 21
Unilateral hearing loss, 128
severe-profound sensorineural, 150
Unilateral microtia, 181
Universal newborn hearing screening (UNHS), 43–44, 336, 338
Universal precautions, 8–9, 91
Universal serial bus (USB) device, 269
Universal sign, for deafness, 473
Upwardly sloping, reverse curve hearing loss, 131
Utricle, 29

V
VA facility. See Veterans Affairs (VA) facility
Vascular lobe, 26
Vector, 16, 18
Velocity, of sound wave, 20–21
Vestibular labyrinth, 29
Vestibular membrane, 30
Vestibule, 29
Veterans Affairs (VA) facility, 470–471
Videonystagmography (VNG), 113–114
Video otoscope, 94
Video relay service (VRS), 267–268
Visual inspection, 90–91, 164, 204–207
client preparation and instructions, 205–206
equipment, 205
methodology, 91
observations and recommendations, 206–207
of outer ear, 178
test environment, 205
test sequence, 206
working of, 90
Visual reinforcement audiometry (VRA), 71, 74–76
VNG. See Videonystagmography (VNG)
Vocabulary, 423
VRA. See Visual reinforcement audiometry (VRA)
VRS. See Video relay service (VRS)

W
Waterproof hearing aid case, 247
Wavelength, 18, 20
Waves, sound, 20
  attributes of, 19
  longitudinal, 18
  velocity of, 20–21
Wax removal tools, hearing aid, 245–246
WDT. See Word discrimination testing (WDT)
Websites, for families of children with hearing loss, 365–366
Wernicke’s area, 33
Whispered Voice Screening Test, 80, 476
Word discrimination testing (WDT), 85–87, 156–157
  methodology, 86–87
  working of, 86
Word recognition testing, 85. See also Word discrimination testing (WDT)
World Health Organization
  International Classification of Functioning, Disability and Health (ICF), 3
Writing
  interventions, 430–431
  simple view of, 426–428
X
  X-linked, 192
Y
  Year 2007 JCIH Position Statement, 341, 356–358, 397