

AUDITORY PROCESSING DISORDERS

Assessment, Management, and Treatment

FOURTH EDITION

Donna Geffner, PhD, CCC-SLP/A
Deborah Ross-Swain, EdD, CCC-SLP





9177 Aero Drive, Suite B
San Diego, CA 92123

email: information@pluralpublishing.com
website: <https://www.pluralpublishing.com>

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Foreword

In the seven decades since Helmut Mykelbust coined the phrase “auditory perceptual disorders,” our understanding of auditory processing and its role in spoken-language processing and related listening problems has evolved, yet a consensus on its definition and significance continues to elude us. Despite the ongoing debate, one fact remains clear: auditory processing undeniably plays a substantial role in spoken-language processing, intricately woven into the fabric of everyday listening, interacting with cognition, language, and learning.

As the editors/authors embarked on this latest edition of the textbook on auditory processing disorders, we found ourselves at the intersection of tradition and innovation. Leading clinicians and researchers, driven by a passion for advancing our scope of understanding and comprehension of auditory processing, have joined forces to present the most comprehensive edition to date. The culmination of their efforts provides a cutting-edge resource for professionals in audiology, speech-language pathology, psychology, and cognitive neuroscience.

Divided into three sections—Identification, Assessment, and Management; Management; and Treatment and Intervention Programs—this text is a testament to the collaborative spirit driving the field forward. Drawing upon the latest research and clinical expertise, the international authors guide the reader through the intricate processes and neurophysiology that underlie effective

listening, communication, and learning. Recognizing that numerous factors can impact successful processing and listening, from neural transmission to cognitive and behavioral issues, the authors emphasize the need for a thorough assessment to pinpoint the specific processing systems affected, which then can assist in decisions related to treatment interventions, management, educational placement and programs.

In the pursuit of understanding the underlying pansensory effects of auditory processing disorders, the text introduces new assessment approaches and advocates for an interdisciplinary, collaborative model. Audiologists, speech-language pathologists, psychologists, and cognitive neuroscientists come together, armed with various tools, knowledge, expertise, and practices to identify and comprehend the intricacies of processing-related difficulties. This collaborative approach allows for the derivation of individualized recommendations, ensuring that interventions meet the unique needs of each client.

The journey through this text concludes with the presentation of novel approaches to address auditory and spoken-language processing and related listening disorders with a valuable compilation of resources and websites. The practitioners engaging with this text will find themselves equipped with the knowledge and tools to navigate the ever-evolving landscape of auditory processing assessments and intervention.

This edition places the professional on the cutting edge of auditory and spoken-language processing and related listening challenges, empowering them to address the specific listening needs of clients with expertise, compassion, and innovation. The international contributing authors are well respected in their field and the book reads like a “Who’s Who” in auditory processing. Each author brings an element of

new information and expertise as well as expansive thinking and innovation. As the field continues to evolve, and as this textbook has evolved from the first edition (2007) to this fourth, so too will our understanding and knowledge. This text serves as a beacon guiding us toward greater clarity and efficacy in the assessment and intervention of auditory and spoken-language processing and related listening disorders.

—Jack Katz, PhD, CCC-A/SLP
Professor Emeritus, University of
New York at Buffalo
Research Professor, University of
Kansas Medical Center
Director, Auditory Processing
Service
Kansas City, MO

Preface

It is with great enthusiasm and pride that we present the fourth edition of *Auditory Processing Disorders: Assessment, Management, and Treatment*. Over the past two decades, the field of auditory processing, spoken language processing, and listening problems has undergone remarkable advancements. Since the inception of our journey in 2007, we have witnessed an extraordinary evolution in our understanding of auditory processing and related issues, propelled by the collaborative efforts of international experts hailing from diverse disciplines, including neurophysiology, cognitive neuroscience, neurobiology, and mathematics.

Our commitment to unraveling the complexities of auditory processing and spoken-language processing as well as listening disorders has remained steadfast. This edition reflects not only the enduring dedication of our team but also the invaluable contributions of researchers and practitioners worldwide. As pioneers in the field, we have delved into the interrelatedness of auditory processing with comorbid conditions such as ADHD, the lingering impacts of COVID-19, Pediatric Autoimmune Neuropsychiatric Disorder Associated with Streptococcal Infections (PANDAS), and other conditions affecting auditory processing and listening challenges. This edition addresses the intricate relationships among these factors, acknowledging their significance in the broader context of auditory processing disorders and related listening challenges.

In response to the evolving landscape of neurodivergence, we present an examination of auditory and spoken language processing in conditions such as autism spectrum disorder (ASD). Our exploration extends beyond traditional boundaries, offering fresh insights into auditory processing and neurodivergence. Our exploration of the interconnection of systems aims to foster inclusivity and provide a more comprehensive framework for clinicians, researchers, and educators working with diverse populations.

Central to this edition is our emphasis on the pansensory nature of auditory and spoken-language processing and listening disorders. We explore the intricate interplay between auditory processing and other sensory and cognitive systems, acknowledging the complex integrative and complex nature of the central nervous system. This holistic approach reflects our commitment to understanding the multifaceted nature of auditory processing disorders and its impact on individuals' overall sensory experiences and well-being.

Moreover, by virtue of this textbook and the three that preceded it, we are able to affirm the legitimacy of auditory processing as a bona fide, important, and vital area of study and research which helps us to better understand the relationship between auditory processing, communication, listening, and learning. As a testament to our collaborative efforts, this edition incorporates research findings from a variety of disciplines; this infusion of knowledge

enriches our understanding beyond the traditional boundaries of audiology and speech-language pathology.

As we embark on this new edition, we are proud to present a significant milestone in the ongoing journey of auditory processing research. We express our deepest gratitude to the international community of experts, reviewers, and researchers whose collective wisdom, knowledge, and experience have shaped the content of this

comprehensive textbook. May it serve as a beacon for current and future generations of researchers and practitioners, inspiring continued exploration and innovation in the dynamic field of auditory and spoken-language processing and listening disorders. We invite readers to explore the pages ahead and join us in the ongoing pursuit of unraveling the intricacies of auditory processing and its profound impact on human communication, literacy, and cognition.

—Donna Geffner, PhD, CCC-SLP/A
Deborah Ross-Swain, EdD, CCC-SLP

About the Editors



Donna Geffner, PhD, CCC-SLP/A is a dually licensed and certified speech-language pathologist and audiologist. She served as full professor, Department Chair, Director of the Speech and Hearing Center (which she founded), Director of the Graduate Programs (which she founded), and the Long Island AuD Consortium (which she co-founded) at St. John's University prior to her retirement after 40 years. She is the author of seven books: *Attention Deficit Hyperactivity Disorder: What Every Speech-Language Pathologist Should Know*, *The Navigator* (with Dale Seiden), *Auditory Processing Disorders: Assessment, Management, and Treatment* (four editions, co-edited with Deborah Ross-Swain), and a monograph on the *Language and Speech Skills of Deaf Children*

(with Harry Levitt); two tests (Auditory Skills Assessment, with Ron Goldman, and The Listening Inventory, with Deborah Ross-Swain), and over 300 publications and chapters in her discipline. Dr. Geffner has presented over 200 papers at national and international conferences. She wrote and co-produced a 10-part series for NBC which received an Emmy nomination for Outstanding Instructional Programming, and a 27-part series for CBS which was recognized by the President's Council on Rehabilitation. Dr. Geffner is the recipient of the St. John's University President's Medal and many statewide and national honors (New York State Speech-Language Hearing Association Honors, Long Island Speech-Language Hearing Association Honors, and New York City Speech-Language-Hearing Association Honors) and awards, including the American Speech-Language Hearing Association (ASHA) Fellow and ASHA Honors. Providence College bestowed upon her an Honorary Doctorate in Education. She is the former President of the New York State Speech, Language Hearing Association, and former Vice President of Academic Affairs for ASHA. Dr. Geffner was ASHA President in 1999 and served on its Executive Board for 6 years. She continues to write, consult, publish, provide expert testimony, present nationally and internationally, and conduct national webinars in her areas of specialty. She maintains a private practice in the areas of auditory processing disorders, language impairment, learning disabilities, and ADHD in Long Island, New York.



Deborah Ross-Swain, EdD, CCC-SLP is the clinical director and CEO of The Swain Center for Listening, Communicating and Learning. She is Vice President of Government Affairs and Public Policy for the American Speech-Language-Hearing Association (ASHA) and served as chair of the Government Affairs and Public Policy committee. She is past president of the California Speech-Language-Hearing Association (CSHA) and served on the CSHA Board of Directors for 10 years. Dr. Swain is a former Chief of Speech-Language Pathology at the University of California, Davis Medical Center and held a clinical staff appointment to the School of Medicine. Dr. Swain has received numerous ASHA, CSHA, and university

awards for leadership, advocacy, clinical service, and professional achievement. Dr. Swain is Fellow of ASHA and served as Editor of *ASHA SIG 17 Perspectives Journal*. She is a Distinguished Scholar and Fellow of the National Academies of Practice. Dr. Swain served as founder and chair for CSHA's Early Intervention and International Committees. She chaired the committee in attaining policy change for the use of SLPAs in early intervention speech-language services in California. She has presented hundreds of papers at state, national, and international meetings and conferences. She has contributed chapters in various professional books and publications. Dr. Swain was the producer of *200 by 2*, an information video for physicians on communication development in 2-year-olds. Dr. Swain has served on ASHA's Legislative Council. Her most recent publication, *Confidence and Joy: Success Strategies for Kids with Learning Differences* is an Amazon best-selling book. She is the author of numerous books and standardized test batteries: *Auditory Processing Disorders: Assessment, Management, and Treatment* (four editions, co-edited with Donna Geffner); *The Receptive-Expressive Social Communication Assessment-Elementary*; *The Auditory Phoneme Sequencing Test*; *The RIPA series of tests*; *The Listening Inventory*; *The Swallowing Ability and Function Test*; *Aphasia Rehabilitation: An Auditory and Verbal Treatment Hierarchy*; and *The Cognitive-Linguistic Improvement Program*. Dr. Swain is an internationally and nationally recognized speaker and author. She was inducted into her high school's Hall of Fame for her outstanding competitive swimming achievement. She continues to serve as CEO and clinical supervisor for her clinic in Santa Rosa, California, specializing in early Intervention, auditory and spoken-language disorders, learning differences, and cognitive neuroscience.

Contributors

Fatima Abbas, BSc

Medical Audiology Sciences–RA
Auditory Processing Institute
Beirut, Lebanon
Chapter 12

**Angela Loucks Alexander, AuD,
CCC-A, MNZAS**

Auditory Processing Specialized
Audiologist
Auditory Processing Institute and
APDsupport.com
Sunshine Coast, Queensland,
Australia
Chapter 12

Courtney L. Baker, AuD, CCC-A

Owner/Principle Audiologist
Hearing Brain Audiology, PLLC
Chicago, IL
Chapter 16

**Matthew Barker, AuD, CCC-A,
MNZAS**

Founder and Director
Acoustic Pioneer
Amarillo, TX
Chapter 15

Michael J. Brenner, MD, FACS

Associate Professor of
Otolaryngology–Head and Neck
Surgery
Kresge Hearing Research Institute
University of Michigan
Ann Arbor, MI
Chapter 10

Martha S. Burns, PhD, CCC-SLP

Director of Neuroscience Education

Carnegie Learning Corporation
Pittsburgh, PA
Chapter 8

Sharon Cameron, PhD

Senior Research Fellow
Faculty of Medicine, Health and
Human Sciences
Macquarie University
New South Wales, Australia
Chapter 4

Harvey Dillon, PhD

Director
National Acoustic Laboratories
Adjunct Professor
Macquarie University
Sydney, Australia
Chapter 4

Michelle D’Mello, MA, CCC-SLP

Speech-Language Pathologist
Justine Sherman and Associates
Claremont, CA
Chapter 7

Mazen K. EL-Banna, AuD, ABAC

Senior Audiologist
Hearing Care Center Audiology Clinic
Beirut, Lebanon
Chapter 3

Jeanane M. Ferre, PhD, CCC-A

Central Auditory Evaluation and
Treatment
Adjunct Faculty Northwestern
University, Evanston IL
Adjunct Faculty Rush University,
Chicago IL
Oak Park, IL
Chapter 16

**Donna Geffner, PhD, CCC-SLP/A,
EdD (Hon)**

Speech-Language Pathologist and
Audiologist

Donna Geffner and Associates
Port Washington, NY

Chapter 1, 13, Appendix A, B

James W. Hall III, PhD

Professor

Osborne College of Audiology

Salus University

Elkins Park, PA

Chapter 3

Jack Katz, PhD, CCC-A/SLP

Professor Emeritus, University of New
York at Buffalo

Research Professor, University of
Kansas Medical Center

Director, Auditory Processing Service

Kansas City, MO

Chapter 10

Lindsay Elizabeth Lerro, PhD

Coordinator, College to Career
Program

Disability Resources Department

Santa Rosa Junior College

Santa Rosa, CA

Chapter 18

Michelle Limon Freeman, PsyD

Pediatric Neuropsychologist

Summit Center, Associate Director

Summit Center, Director of Assessment

Executive Director, Neuropsychological
Evaluation Center

Walnut Creek, CA

Chapter 9

Jeannie M. Lopez, PhD, FDN-P

Clinical Psychologist,

Neuropsychologist, and Health

Consultant

Summit Center

Walnut Creek, CA

Chapter 11

Larry Medwetsky, PhD, CCC-A

Professor

Department of Hearing, Speech, and
Language Sciences

Gallaudet University

Washington, DC

Chapter 2

Deborah Moncrieff, PhD, CCC-A

Assistant Professor, Audiology

Director, Auditory Processing Laboratory

The University of Memphis

Memphis, TN

Chapter 14

Daniel B. Peters, PhD

Licensed Psychologist

Executive Director

Summit Center

Walnut Creek, CA

Chapter 9

Gary Rance, PhD, FAudSA(CC)

Professor, Graeme Clark Chair in

Audiology and Speech Science

Department of Audiology and Speech

Pathology

The University of Melbourne

Melbourne, Australia

Chapter 5

Deborah Ross-Swain, EdD, CCC-SLP

Speech-Language Pathologist

Founder and CEO, The Swain Center
for Listening, Communicating and

Learning

Santa Rosa, CA

Chapters 6, 7, Appendix A, B

Bunnie Schuler, MA, CCC-SLP,

TSSLD

Clinical Supervisor / Adjunct Professor

Adelphi University/Private Practice
Queens, NY
Chapter 17

John J. Whicker, AuD, PhD, CCC-A
Pediatric Audiologist
Little Heroes Pediatric Hearing Clinic
Utah State University
Layton, UT
Chapter 7

Thomas R. Zalewski, PhD, CCC-A
Professor of Audiology

Bloomsburg University
Bloomsburg, PA
Chapter 10

Julien Zanin, PhD, MCIAud
Early Career Academic
Department of Audiology and Speech
Pathology
University of Melbourne
Carlton, VIC, Australia
Chapter 5

Section I

Identification, Assessment, and Management

1

Central Auditory Processing Disorders: Definition, Description, Behaviors, and Comorbidities

Donna Geffner

Overview

This chapter reviews the definition of auditory processing and auditory processing disorders and describes the behaviors that are associated with the disorder. The formal definitions originated from the American Speech-Language-Hearing Association's (ASHA) technical report of 2005, the Task Force Consensus Report 1996, and the American Academy of Audiology's (AAA) guidelines for (C)APD (AAA, 2010). The Consensus Panel of the Bruton Consensus Conference (Jerger & Musiek, 2000) also influenced the definition. At this time, thinking is changing regarding the age at which one can be tested—broadening the scope of the disorder to other populations heretofore not tested—and the role of the audiologist and speech-language pathologist in testing and diagnosing the impairment. Another area of discussion is whether Auditory Processing Disorder (APD) is a hidden auditory pathology. These areas of concern have preempted previous areas of controversies such as the following: whether CAPD is modality-specific or multimodality; and whether it is a bottom-up process or a result of a multimodal weakness in attention, working memory, or cognition. We have come to

recognize central auditory processing as a legitimate disorder that is often a comorbid condition/impairment among other impairments in an integrated neural system. It is frequently comorbid, making it hard to isolate what is the auditory dysfunction from other areas of impairment. Auditory processing can impact listening, attention, learning, reading, and social function as a result of the Central Auditory Nervous System (CANS)' interactions with other networks which all impact the integrated brain. Behaviors associated with an auditory processing disorder are those typically described by the child's performance in the classroom. However, an auditory processing disorder is often a "silent disability." It is not readily observed, but rather manifested when the listening conditions become too difficult or when work increases in demand and reading and comprehension become challenged. Nevertheless, clinical observations of behaviors and symptoms can set up a "red flag" to the classroom teacher, parent, and health-care professional. Such behaviors should make one more able to identify these children in order to provide them with proper evaluation and treatment. The comorbidity with attention-deficit/hyperactivity disorder (ADHD), its similarities and differences, along with other disorders such as learning and language impairment, reading disability, and auditory neural dysynchrony are discussed in this and other chapters. Possible causes and predisposing factors that lead to an Auditory Processing Disorder (APD) are explored. At this time, there is no one cause that has been determined. At best, we can only surmise causes and associate underlying event(s) or precipitating factors that predispose one to have a CAPD. In the aftermath of the COVID-19 pandemic, there are remnant factors that have left people with deficient auditory processing systems, otherwise known as a "brain fog"—a lingering, yet debilitating condition that often compromises the listening mechanism. More will be said about the sequelae of COVID and the listening brain.

What Is Auditory Processing?

Central auditory processing is the efficiency and effectiveness by which the central nervous system utilizes audi-

tory information. It encompasses the perceptible processing of auditory information in the central nervous system and the neurobiologic activity that underlies that processing and gives rise to electrophysiologic auditory potentials. This definition was provided by

the ASHA technical report (2005) after an extensive study by its Working Group on Central Auditory Processing. CAPD, now more commonly referred to as APD, is a deficit in the neural processing of auditory stimuli that is not due to higher order language, cognitive, or related factors (ASHA, 1996, 2005). This is important as many families attribute CAPD to autism and receptive language impairments. Of late, it is more common to test children with autism and find a preponderance of processing disorders. However, there is a distinction to be made between these disorders. Children and adults with CAPD/APD are a heterogeneous group of people who have difficulty using auditory information to communicate and learn (Jerger & Musiek, 2000). There is a set of problems that occur in different and difficult listening conditions, with a deficiency in processing auditory input as the listening environment becomes more unfavorable. We often see these individuals struggling with “listening” and understanding of speech, especially when there is noise present or the acoustics in the room are unfavorable. Such challenges result in difficulty using and understanding language and learning. CAPD/APD can lead to difficulties in higher order language learning and communication, but it is not the result of these disorders.

The AAA guidelines (2010) establish CAPD as a true clinical disorder and indicate a strong link between lesions of the central auditory nervous system (CANS) and deficits in behavioral and electrophysiologic measures of auditory skills. Other studies show a link between central auditory test findings and functional imaging tests (Moncrieff et al., 2008), thus corroborating the neurological link. The diagnosis, accord-

ing to the AAA guidelines, should be made on the basis of a selected battery of sensitive and specific behavioral and electrophysiologic measures, observation, and case history. All consensus groups agree that the diagnosis should be made by an audiologist trained in the area of CAPD. However, a multidisciplinary assessment is useful to determine other comorbid conditions. Psychologists in their battery, particularly using the Wechsler Intelligence Scale for Children (WISC), often diagnose an auditory processing disorder, based on the outcome of the phonological processing segment. Nevertheless, the scope of practice (ASHA, 2018) clearly designates the audiologist as the primary diagnostician in the identification of APD.

Children and adults with CAPD present with a pattern of difficulties and poor performance in one or more of the following skills (ASHA, 2005):

- **Sound Localization and Lateralization:** The ability to know where sound has occurred in space. Localization is the ability to identify the source of sound.
- **Auditory Discrimination:** The ability to automatically distinguish one sound from another.
- **Auditory Pattern Recognition:** The ability to determine similarities and differences in patterns of sounds.
- **Temporal Aspects of Audition:** The ability to process acoustic stimuli over time, including the following:
 - **Temporal Masking:** The potential to mask (muffle or obliterate) weaker phonemes after (backward) or before (forward) stronger phonemes. The ability of one sound to

- mask another that precedes or follows it.
- **Temporal Resolution:** The perception of fast changing signals.
- **Temporal Integration:** The ability to integrate acoustic energy in brief sounds and add up information over time or duration. The area of temporal integration refers to the ability to sequence sounds, integrate a sequence of sounds, and process stimuli over time by both ears.
- **Temporal Ordering:** The ability to process durational patterns in sequence and perceive a sequence of sounds (Rawool, 2006).
- **Auditory Performance Decrements With Competing Acoustic Signals:** The ability to perceive speech or other sounds when another signal is present. Such a signal may be noise or another speech signal.
- **Auditory Performance Decrements With Degraded Acoustic Signals:** The ability to perceive a signal in which some information is missing, such as parts of the sound spectrum, high or low frequencies extracted, or when the sound is compressed in time.
- There are other patterns identified in the spectrum of APD such as amblyaudia—a neural integration type of the disorder. Amblyaudia, as described by Moncrieff and Black (2008), is an abnormal asymmetry between the two ears during binaural integration tasks (Moncrieff et al., 2016) often with normal performance in the dominant ear. There must

be a stable interaural asymmetry across two or more tests of dichotic listening. Children diagnosed with amblyaudia may show deficiencies in attention, working memory, and/or language. For an in-depth discussion of amblyaudia and the latest outcome measures and treatment, see Chapter 14 in this book, authored by Deborah Moncrieff. Another conceptual framework of the disorder is the evidence that there exists a spatial processing disorder (SPD) that impacts the timing of two signals reaching the ears at different times. Children use spatial hearing to integrate signals arriving at the two ears from sound sources that vary in location in space. Spatial hearing depends on the ability of the auditory system to integrate the two signals in a mechanism that allows the differences between the ears to adjust in time of arrival and intensity (Cameron et al., 2014). For a more in-depth discussion of spatialized hearing, the reader is referred to Chapter 4 in this book, authored by Sharon Cameron and Harvey Dillon.

If one could put the definition into layman's terms so that parents understand it, it would be safe to describe APD in the words of Jack Katz: "It is what the brain does with what we hear" (Lasky & Katz, 1983). See Chapter 10 in this book, authored by Jack Katz, Thomas R. Zalewski, and Michael J. Brenner, on the impact of otitis media (OM). As APD has evolved in scope and identification, it is possible to recognize greater prevalence among other populations not heretofore tested, indicating that there may be a greater inci-

dence such that it may be reasonable to establish subclinical entities that lead to the development of reference standards and specific treatment for each type of APD (Vermiglio, 2016, 2017). We already have specialized treatment for spatialized noise disorder (LisN-T test, Sound Storm treatment). One is referred to Chapter 4 for further detail.

It has been cited that there are approximately 3% to 5% of school-age children with an APD (Chermak & Musiek, 1997). Depending on the research, Katz (2005) found a prevalence of 20% and DiMaggio and Geffner (2003) found a prevalence of 12%. Data regarding prevalence have been scarce, leaving one to wonder how widespread it is. Further, APD is not limited to children. It is prevalent in adults and more pronounced in people over the age of 60. Further, given the deluge of the pandemic, upper respiratory disease (RSV), and conditions such as PANDAS (Pediatric Autoimmune Neuropsychiatric Disorders) and PANS (Pediatric Acute-onset Neuropsychiatric Syndrome), there are greater occurrences, more public awareness of the disorder, and more testing approved. When the education community realizes that this exists and is more accepting of the ability to test for it, diagnose it, and recognize such diagnosis as a true impairment for educational purposes (i.e., Individual Education Plan [IEP]), then more youngsters and adults can be identified and helped.

Functional Definition

Often, youngsters in the classroom send signals that raise a “red flag” to the teacher that “they are not getting

the message.” Functionally, one then can define (C)APD as a disorder in the ability to take in the spoken message clearly, so that it can be made meaningful and interpreted. The latter goes beyond the auditory system to some degree as it involves an understanding of language and an ability to process a message that is linguistic in content. Once the auditory stimuli enter the ear, they can become lexical and then linguistic in nature which requires interpretation by the brain. However, the auditory system initiates the input for the process to begin, a bottom-up process, thus providing evidence for a multimodality function. In this chapter, the terminology of CAPD and APD will be used interchangeably as they refer to the same processing disorder but we consider the entire auditory system (APD) as opposed to restricting the disorder to the central system (CAPD) only.

Audiologist’s Definition

Audiologists generally agree that CAPD exists; however, there is disagreement about whether it is a purely central part of a multimodality deficit, or a more sensory modality-specific auditory deficit. The current thinking is that CAPD encompasses the entire auditory system and its related processes. This is particularly relevant in regard to the child with a hearing loss or a conductive loss that precludes the organ from hearing clearly. The interference from the conductive block interferes with the clarity of the message. We know that for those with long-standing otitis media, there is a higher risk of a speech discrimination loss, especially in noise and a degradation of signal clar-

ity as one gets older due to the deprivation effect of occluding the conductive pathway (Machado & Teixeira, 2018; Rubin et al., 1997). (See Chapter 10 in this book for sequelae of otitis media.)

Historically, some researchers argued that APD was a modality-specific disorder (Cacace & McFarland, 1995, 1998). At that time, the authors conducted a comprehensive review of the literature and concluded that the primary deficit in APD should be manifested in tasks that require the processing of acoustic information, and where it should not manifest, to a lesser extent, is when similar types of information are presented to other modalities. They distinguished it from cognitive, language-based, polysensory, and attentional problems in which modality-specific perceptual dysfunctions do not occur. Therefore, individuals with problems that are not of a unimodal nature, or a perceptual nature, can be misdiagnosed. Their review of the literature did not reveal the modality-specific nature of auditory-based learning problems, largely due to the “inclusive” framework used in the evaluation of APD. They argued that the modality-specific nature should be what is ultimately evaluated.

The Bruton Consensus Conference (Jerger & Musiek, 2000, p. 468) stated APD is a modality-specific perceptual dysfunction not due to peripheral hearing loss. Thus, hearing loss should be ruled out before one can be diagnosed with an APD. However, it has come to be known that those with hearing loss are not exempt from exhibiting an APD. What prevents it is how one tests for it. There is often a correlation with reading problems. If problems occur when recognizing the sound sys-

tem of language then one can predict there will be problems when the child attempts to match sounds to letters, a skill underlying the basis for reading and writing. Such problems lead to comprehension difficulties and poor academic performance (ASHA, 1996). The ASHA technical report (2005) supports the multisensory model and concludes that “Any definition that specifies complete modality-specificity as a diagnostic criterion is neurophysiologically untenable. Instead, our definition and conceptualization of (C)APD must be consistent with the manner in which auditory and related processing occurs in the CNS” (central nervous system; ASHA, 2005, p. 2). According to the British Academy of Audiology (BAA), auditory processing disorders encompass auditory linguistic aspects such as auditory short-term memory and phonological processing (BAA, 2011). Filipini et al. (2019) spoke about the heterogeneity in subject selection that leads to confounding results in studies of APD. Not only are definitions variable, often resulting in misdiagnoses, the very existence of APD has been challenged by speech-language pathologists who have ascribed a child’s inability to process phonemes, blend sounds, and understand the relationship between letters and their corresponding sounds to be a function of language and reading, separate from auditory neural substrates. However, if phonemes are the sound of letters, what is phonological processing without the input of auditory cues? The ASHA technical report made it clear on its exclusion:

Although abilities such as phonological awareness, attention to and memory for auditory information,