AMERICAN
SPEECH-LANGUAGE-
HEARING
ASSOCIATION

(Central) Auditory Processing Disorders

Working Group on Auditory Processing Disorders

This technical report was developed by the American Speech-Language-Hearing Association (ASHA) Working Group on Auditory Processing Disorders. It was approved by ASHA's Executive board in April, 2005. Members of the Working Group (2002–2004) were Teri James Bellis (chair), Gail D. Chermak, Jeanane M. Ferre, Frank E. Musiek, Gail G. Rosenberg, and Evelyn J. Williams (ex officio). Members of the Working Group (2002–2003) included Jillian A. Armour, Jodell Newman Ryan, and Michael K. Wynne. Susan J Brannen, member 2004 and vice president for professional practices in audiology (2001–2003) and Roberta B. Aungst, vice president for professional practices in audiology (2004–2006) served as monitoring vice presidents.

Dedication

In loving memory of our dear friend and colleague Michael K. Wynne (1954–2003), whose vitality, intellect, and diligence helped make this work possible.

Introduction

The ASHA Working Group on Auditory Processing Disorders was composed of a panel of audiologists from a variety of clinical and research backgrounds, including educational, university, research, private practice, and medical settings, all of whom have demonstrated expertise in the area of (Central) Auditory Processing Disorders [(C)APD].

Reference this material as: American Speech-Language-Hearing Association. (2005). (Central) Auditory Processing Disorders. Available at http://www.asha.org/members/deskref-journals/deskref/default

Index terms: auditory processing disorders, assessment, intervention

Document type: Technical Report

Working Group members were selected to ensure that broad experience, varied philosophies, and multiple perspectives regarding (C)APD would be represented. The charge to the Working Group on Auditory Processing Disorders was to review the ASHA technical report, "Central Auditory Processing: Current Status of Research and Implications for Clinical Practice" (ASHA, 1996) and determine the best format for updating the topic for the membership. The decision was to write a new document in the form of a technical report and to issue the position statement "(Central) Auditory Processing Disorders—The Role of the Audiologist" (ASHA, n.d.) as a companion document. Rather than replacing the previous ASHA (1996) document, the present document was designed to augment and update the information presented therein, building on the cumulative scientific and professional advances over the past decade. Further, it was decided that the current set of documents would focus specifically on the audiologist's role in (C)APD diagnosis and intervention. Although speech-language pathologists (SLPs) are essential to the overall assessment and management of children and adults with (C)APD, specifically with regard to delineation of and intervention for cognitive-communicative and/or language factors that may be associated with (C)APD, it was felt that in-depth discussion of the role of the SLP and other professionals was beyond the scope of this report. It should be emphasized, however, that the Working Group embraced the concept that a multidisciplinary team approach to assessment, differential diagnosis, and intervention is imperative. The Working Group also considered the use of the term *auditory processing disorder*. The Bruton conference consensus paper (Jerger & Musiek, 2000) set forth the use of the term *auditory processing disorder* rather than the previously used *central auditory processing disorder*. However, there has been a great deal of confusion and controversy regarding the use of the new term, particularly as most definitions of the disorder focus on the *central* auditory nervous system (CANS). Therefore, the members of the group agreed to use the term *(central) auditory processing disorder [(C)APD]* for the purpose of this report, with the understanding that the terms *APD* and *(C)APD* are to be considered synonymous.

Definition of (C)APD

Broadly stated, (Central) Auditory Processing [(C)AP] refers to the efficiency and effectiveness by which the central nervous system (CNS) utilizes auditory information. Narrowly defined, (C)AP refers to the perceptual processing of auditory information in the CNS and the neurobiologic activity that underlies that processing and gives rise to electrophysiologic auditory potentials. (C)AP includes the auditory mechanisms that underlie the following abilities or skills: sound localization and lateralization; auditory discrimination; auditory pattern recognition; temporal aspects of audition, including temporal integration, temporal discrimination (e.g., temporal gap detection), temporal ordering, and temporal masking; auditory performance in competing acoustic signals (including dichotic listening); and auditory performance with degraded acoustic signals (ASHA, 1996; Bellis, 2003; Chermak & Musiek, 1997). (Central) Auditory Processing Disorder [(C)APD] refers to difficulties in the perceptual processing of auditory information in the CNS as demonstrated by poor performance in one or more of the above skills. Although abilities such as phonological awareness, attention to and memory for auditory information, auditory synthesis, comprehension and interpretation of auditorily presented information, and similar skills may be reliant on or associated with intact central auditory function, they are considered higher order cognitive-communicative and/or language-related functions and, thus, are not included in the definition of (C)AP. Definitions of other key terms used in this report can be found in the Appendix.

Nature of (C)APD

(C)APD is a deficit in neural processing of auditory stimuli that is not due to higher order language, cognitive, or related factors. However, (C)APD may lead to or be associated with difficulties in higher order language, learning, and communication functions. Although (C)APD may coexist with other disorders (e.g., attention deficit hyperactivity disorder [ADHD], language impairment, and learning disability), it is *not the result of* these other disorders. For example, children with autism or ADHD often present with listening and/or spoken language comprehension difficulties; however, these difficulties are not due to a deficit in the CANS per se, but rather to their higher order, more global disorder. Thus, it would not be appropriate to apply the diagnostic label of (C)APD to the listening difficulties exhibited by these children unless a comorbid deficit in the CANS can be demonstrated.

One particular area of debate has concerned the modality-specific nature of (C)APD and its differential diagnosis. Some definitions of (C)APD imply (or state outright) that the diagnosis of (C)APD can be applied only when a (perceptual) deficit is demonstrated in the auditory system and nowhere else (e.g., Cacace & McFarland, 1998; Jerger & Musiek, 2000; McFarland & Cacace, 1995). At its extreme, this would mean that individuals with auditory temporal processing deficits who also display pansensory temporal deficits (e.g., Tallal, Miller, & Fitch, 1993) would, therefore, not meet diagnostic criteria for (C)APD. An extensive literature in neuroscience influenced the Working Group's conclusion that the requirement of "modality-specificity" as a diagnostic criterion for (C)APD is not consistent with how processing actually occurs in the CNS. Basic cognitive neuroscience has shown that there are few, if any, entirely compartmentalized areas in the brain that are solely responsible for a single sensory modality (Poremba et al., 2003; Salvi et al., 2002). Instead, multimodality influences inform even the most basic neural encoding and manipulation of sensory stimuli (e.g., Calvert et al., 1997; Mottonen, Schurmann, & Sams, 2004; Sams et al., 1991). Evidence of convergent sensory "tracks," multisensory neurons, and neural interfacing further demonstrates the interdependent and integrated processing of sensory data, supported by cognitive domains (i.e., attention, memory) and language representations (e.g., Bashford, Reinger, & Warren, 1992; Bradlow & Pisoni, 1999; Groenen, 1997; Phillips, 1995; Salasoo & Pisoni, 1985). In fact, a rigorous assessment of multimodality function is not within the scope of practice of any one professional group or discipline. Therefore, based on an extensive review of the literature in auditory and cognitive neuroscience, neuropsychology, and related areas, this Working Group concluded that any definition of (C)APD 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. Nevertheless, it is recognized that individuals with (C)APD exhibit sensory processing deficits that are more pronounced in the auditory modality and, in some individuals, auditory-modality-specific effects may be demonstrated (Cacace & McFarland, 1998).

In addition to their primary auditory processing problems, individuals with (C)APD may experience a number of other difficulties. For school-aged children, (C)APD can lead to or be associated with difficulties in learning, speech, language (including written language involving reading and spelling), social, and related functions (Bellis & Ferre, 1999; Chermak & Musiek, 1997; Katz, 1992). However, the correlation between auditory deficits and language, learning, and communication sequelae is far from simple. For example, language comprehension problems can occur in the presence of normal central auditory processing and (C)APD does not always present with language problems. Different combinations of auditory deficits are likely to be associated with different functional symptoms, and the same auditory deficit may have an impact on different people in different ways, based on each individual's unique confluence of "bottom-up"(i.e., sensory and data driven) and "top-down" (i.e., central resources and concept driven) abilities and on the extent of their neurobiological disorder, neuromaturational delay, brain injury, neurological disorder or disease, or other neural involvement that affects CNS function, and a variety of social and environmental factors. This heterogeneity likely accounts for the inability reported by some researchers (e.g., Bishop, Carlyon, Deeks, & Bishop, 1999; Watson & Kidd, 2002) to find a significant predictive relationship between limited measures of discrete auditory abilities (e.g., gap detection) and higher order abilities such as reading or spelling.

In contrast, other researchers have shown that deficits in fundamental auditory processes are related to higher order reading and spelling difficulties in some cases; however, this relationship is affected differentially by the types of reading or spelling difficulties that are present as well as by the presence of significant variability in the nature of auditory deficits across subjects (e.g., Bellis & Ferre, 1999; Cestnick & Jerger, 2000; Heath, Hogben, & Clark, 1999). Because of the complexity and heterogeneity of (C)APD, combined with the heterogeneity of learning and related disorders, it is to be expected that a simple, one-to-one correspondence between deficits in fundamental, discrete auditory processes and language, learning, and related sequelae may be difficult, if not impossible, to demonstrate across large groups of diverse subjects. Rather than casting doubt on the existence or significance of (C)APD, however, this only serves to underscore the need for comprehensive assessment and diagnostic procedures that fully explore the nature of the presenting difficulties of each individual suspected of having (C)APD. The outcomes of these evaluations are used to develop a comprehensive intervention program.

(C)APD is best viewed as a deficit in the neural processing of auditory stimuli that may coexist with, but *is not the result of*, dysfunction in other modalities. At the same time, the noncompartmentalized brain, with its convergent sensory "tracks," multisensory neurons, and neural interfacing complicates a simple sorting out of causation versus coexistence. Thus, although many children with cognitive or language disorders may have difficulty processing spoken language, we should not automatically assume that a (C)APD is the underlying cause of their difficulties without the demonstration of an auditory deficit through appropriate auditory diagnostic measures.

In addition to the language and academic difficulties often associated with (C)APD, some individuals with (C)APD have a higher likelihood of behavioral, emotional, and social difficulties. Communication deficits and associated learning difficulties may adversely impact the development of self-esteem and feelings of self-worth. Early identification and treatment of (C)APD may potentially lessen the likelihood that these secondary problems might emerge. It should be noted, however, that psychosocial and emotional problems are not diagnostic of (C)APD. It cannot and should not be assumed that serious psychological disturbance, criminal behavior, or other psychosocial concerns are due to (C)APD, even when the individual in question does exhibit an auditory deficit. There is no direct evidence to support the view that (C)APD *causes* severe depression, sociopathy, psychopathy, juvenile delinquency, or criminal behavior, nor should there be, considering the auditory-based nature of (C)APD. When significant psychosocial concerns are present in an individual with (C)APD, the individual should be referred to the appropriate specialist for evaluation and follow-up. To assess the cluster of problems that are often seen in those with (C)APD more fully, a multidisciplinary approach is necessary.

Historical Perspective

Interest in the diagnosis, treatment, and management of (C)APD spans more than a half-century. Myklebust (1954) stressed the importance of clinically evaluating central auditory function, especially in children suspected of communicative disorders. In Italy, a team of physicians began developing more sensitive tests to quantify the auditory difficulties reported by their patients with compromised central auditory nervous systems (Bocca, Calearo, & Cassinari, 1954; Bocca, Calearo, Cassinari, & Migliavacca, 1955). A few years later, Kimura (1961) introduced dichotic testing and formulated a model to explain the physiology of the CANS underlying dichotic perception. However, it was not until a 1977 conference on (C)APD in children (Keith, 1977) that interest in research on pediatric (C)APD was stimulated (Katz & Illmer, 1972; Manning, Johnson, & Beasley, 1977; Sweetow & Reddell, 1978; Willeford, 1977). Since that time, many committees and conferences have been convened to consider the nature of (C)APD (ASHA, 1992, 1996; Katz, Stecker, & Henderson, 1992; Keith, 1981; J. Jerger & Musiek, 2000; Masters, Stecker, & Katz, 1998).

All tests used today to diagnose (C)APD have roots in this early work, as do auditory training approaches that exercise these processes (e.g., interaural intensity difference training, interhemispheric transfer training). Although efforts continue to develop more sensitive behavioral tests of central auditory function, electrophysiologic, electroacoustic, and neuroimaging procedures may soon transform clinical auditory processing test batteries (see, e.g., Estes, Jerger, & Jacobson, 2002, and J. Jerger et al., 2002). Likewise, cumulative developments in auditory and cognitive neuroscience are being translated into auditory training approaches and strategies training that may improve auditory function and listening (Bellis, 2002; Chermak & Musiek, 2002; Musiek, 1999).

Given their responsibility for children with *auditory imperception* (as used by Myklebust, 1954), SLPs have been key to the broader assessment and management of individuals with (C)APD, especially children (Wertz, Hall, & Davis, 2002). Specifically, SLPs are uniquely qualified to delineate cognitive-communicative and/or language factors that may be associated with (C)APD. The terms *language processing* and *auditory processing* are not synonymous; however, disorders of language and auditory processing may lead to similar behavioral symptoms. Therefore, the continuing involvement of SLPs in the team approach to assessment and management of (C)APD in children and adults and in the differentiation of (C)APD from language processing disorders is crucial to the efficacy of the intervention outlined in this document. The reader interested in the history of (C)APD is directed to Wertz et al. (2002) and Baran and Musiek (1999).

Knowledge Base and Ethical Considerations

ASHA's Code of Ethics clearly specifies that "individuals may practice only in areas in which they are competent based on their education, training, and experience" (ASHA, 2003a, p. 2). ASHA's scope of practice documents for the professions of audiology and speech-language pathology delineate those practice areas. Certain situations may necessitate that clinicians pursue additional education or training to expand their personal scope of practice (ASHA, 2001, 2003a, 2004b). To engage in (C)APD diagnosis and intervention requires familiarity with general neurophysiology, cognitive neuroscience, neuropsychology, cognitive psychology, and auditory neuroscience. Many of these subject areas may not have been addressed, or only tangentially addressed, in the typical audiology and speech-language pathology professional education programs in U.S. universities (Chermak, Traynham, Seikel, & Musiek, 1998). As more clinical doctoral programs are developed and more audiologists obtain this degree, it is anticipated that this area of practice will be taught and discussed more thoroughly, thus better preparing entry-level professionals. Therefore, participation in the diagnosis, assessment, and treatment and management of (C)APD typically requires additional training and education beyond the typical scope of the audiologist's, SLP's, and related professional's educational preparation. It is likely that these knowledge and skill areas will need to be gained as part of the professional's continuing education.

The Basic Science Connection

Clinicians interested in the evaluation and treatment of (C)APD should be well grounded in the basic science relative to this field. Clinicians who do not feel competent in the science related to (C)APD must take it upon themselves to acquire this necessary information or to refer to appropriately trained professionals. Presently, this basic science takes the form of neuroscience in general and, in a more specific form, auditory neuroscience. In regard to general neuroscience, familiarity with the areas of cognition, memory, sensory systems, and fundamental biology is valuable in developing a relevant knowledge base and an orientation to the auditory system (Shepard, 1994). Auditory neuroscience, which generally includes such areas as anatomy, physiology, pharmacology, and plasticity of the CANS, is highly relevant to the field of (C)APD (Bear, Connors, & Paradiso, 2003). There is an expectation that clinicians with knowledge and appreciation of auditory neuroscience will be best suited to serve children and adults with (C)APD, as well as to make significant contributions to the study of (C)APD (Musiek & Oxholm, 2000).

Neurochemistry and Auditory Processing

All aspects of audition, from pure-tone hearing to complex spoken language processing, rely on the transmission of neural information across synapses. Information about sound representation at the cochlea must be transmitted to the brain through a complex network of neural synapses. Synaptic transmission, from neurotransmitter synthesis, through binding and activation of receptors, to reuptake and degradation of neurotransmitters, is dependent on chemical processes. These neurochemical processes play an important role in the structure and function of the brain, including structural and functional hemispheric asymmetry and plasticity (Morley & Happe, 2000; Syka, 2002). Research in auditory neurochemistry has intensified over the last decade as scientists have recognized the potential for pharmacological treatments of auditory disorders. Recently, research has also demonstrated that pharmacologic intervention can alter physiologic and behavioral aspects of audition, including selective auditory attention and signal detection in noise (Art & Fettiplace, 1984; Feldman, Brainard, & Knudsen, 1996; Gopal, Daly, Daniloff, & Pennartz, 2000; Musiek & Hoffman, 1990; Sahley, Musiek, & Nodar, 1996; Sahley & Nodar, 1994; Wenthold, 1991; Wiederhold, 1986), underscoring the potential of pharmacologic intervention for treatment of (C)APD. Although several drugs have been shown to improve behavioral regulation and vigilance in ADHD, which may lead to improved performance on a number of behaviors including auditory processing, no pharmacologic agent has been demonstrated as effective specifically for (C)APD (Loiselle, Stamm, Maitinsky, & Whipple, 1980; Tillery, Katz, & Keller, 2000).

Screening for (C)APD

Screening for (C)APD typically involves systematic observation of listening behavior and/or performance on tests of auditory function to identify those individuals who are at risk for (C)APD. (C)APD screening can be conducted by audiologists, SLPs, psychologists, and others using a variety of measures that evaluate auditory-related skills. A number of screening test protocols, questionnaires, checklists, and other procedures have been suggested to identify individuals who are candidates for auditory processing evaluation (e.g., Bellis, 2003; J. Jerger & Musiek, 2000; Keith, 1986, 1994, 2000; Smoski, Brunt, & Tanahill, 1992). Typically, screening questionnaires, checklists, and related measures probe auditory behaviors related to academic achievement, listening skills, and communication. At this time, there is no universally accepted method of screening for (C)APD. There remains a need for valid and efficient screening tools for this purpose. It is important to emphasize that screening tools should not be used for diagnostic purposes.

The (C)APD Case History

The importance of the case history for diagnosis and treatment/management cannot be overstated. The information obtained can help determine the nature and type of disorder, as well as its impact and functional ramifications. The history should include information on the subject's family/genetic history; pre-, peri-, and postnatal course; health status (medications and other medical history); communication, listening, and auditory behavior; psychological factors; educational achievement; social development; cultural and linguistic background; and prior related therapies and current treatments. The history may be obtained through direct interview of the child or adult being tested, his or her family member, or another informant responsible for the individual, as well as through self-assessment protocols. Regardless of how this information is obtained, it needs to be reviewed carefully prior to the diagnostic examination.

Individuals suspected of having (C)APD frequently present with one or more of the following behavioral characteristics: difficulty understanding spoken language in competing messages, noisy backgrounds, or in reverberant environments; misunderstanding messages; inconsistent or inappropriate responding; frequent requests for repetitions, saying "what" and "huh" frequently; taking longer to respond in oral communication situations; difficulty paying attention; being easily distracted; difficulty following complex auditory directions or commands; difficulty localizing sound; difficulty learning songs or nursery rhymes; poor musical and singing skills; and associated reading, spelling, and learning problems. It is important to note that this list is illustrative, not exhaustive, and that these behavioral characteristics are not exclusive to (C)APD. Other diagnoses present with some subset of similar characteristics, including learning disorder (LD), language impairment, ADHD, and Asperger's syndrome; therefore, these behavioral characteristics are not specifically diagnostic of (C)APD.

Diagnosis of (C)APD

(C)APD is an auditory deficit; therefore, the audiologist is the professional who diagnoses (C)APD (ASHA, 2002a, 2004b). Consistent with the ASHA Scope of Practice in Speech-Language Pathology statement, the SLP's role in (C)APD focuses on "collaborating in the assessment of (central) auditory processing disorders and providing intervention where there is evidence of speech, language, and/or other cognitive-communication disorders" (ASHA, 2001, p. 5). Therefore, as previously stated, SLPs have a unique role in delineating cognitive-communicative and language-related factors that may be associated with (C)APD in some individuals, and in the differential diagnosis of language processing disorders from (C)APD. Full understanding of the ramifications of (C)APD for the individual requires a multidisciplinary assessment involving other professionals to determine the functional impact of the diagnosis and to guide treatment and management of the disorder and associated deficits; however, speech-language, psychological, and related measures cannot be used to diagnose (C)APD.

Because of the individuality of brain organization and the conditions that affect such organization, (C)APD can affect individuals differently. Hence, an individual approach must be taken for the selection of diagnostic measures and the interpretation of results. Factors such as chronological and developmental age; language age and experience; cognitive abilities, including attention and memory; education; linguistic, cultural, and social background; medications; motivation; decision processes; visual acuity; motor skills; and other variables can influence how a given person performs on behavioral tests. Many of these variables also may influence outcomes of some electrophysiologic procedures as well. Audiologists should consider the language, cognitive, and other nonauditory demands of the auditory tasks in selecting a central auditory diagnostic test battery.

The purpose of a central auditory diagnostic test battery is to examine the integrity of the CANS, and to determine the presence of a (C)APD and describe its parameters. To do this, the audiologist should examine a variety of auditory performance areas. The operational definition of (C)APD serves as a guide to the types and categories of auditory skills and behaviors that should be assessed during a central auditory diagnostic evaluation. With children, the neuromaturational status of the auditory nervous system should be considered. For both children and adults, consideration should be given to possible or confirmed neurologic site of dysfunction, especially in cases of known neurological disorder. Thus, a central auditory test battery should provide information about both developmental and acquired disorders of the central auditory system.

Test Principles

The following principles should be applied when determining the composition of a central auditory test battery. These principles are inherent throughout much of the literature and are also included in the ASHA Preferred Practice Patterns, scope of practice statements, and the Code of Ethics.

1. It is important that the audiologist, who has the responsibility for administering and interpreting the auditory processing test battery, have the knowledge, training, and skills necessary to do so.
2. The test battery process should not be test driven; rather, it should be motivated by the referring complaint and the relevant information available to the audiologist.
3. Tests with good reliability and validity that also demonstrate high sensitivity, specificity, and efficiency should be selected (see Clinical Decision Analysis below).
4. A central auditory test battery should include measures that examine different central processes.
5. Tests generally should include both nonverbal (e.g., tones, clicks, and complex waveforms) and verbal stimuli to examine different aspects of auditory processing and different levels of the auditory nervous system. Unless tests incorporating verbal stimuli are available in the individual's native language, evaluation may require reliance on nonverbal stimuli.
6. The audiologist should be sensitive to attributes of the individual. Attributes may include, but not be limited to, language development, motivational level, fatigability, attention, and other cognitive factors; the influence of mental age; cultural influences; native language; and socioeconomic factors. Individuals who are medicated successfully for attention, anxiety, or other disorders that may confound test performance should be tested under the influence of their medication.
7. The audiologist must review the test normative information and background carefully to be sure that the test is appropriate for the individual to be evaluated.
8. The audiologist should be sensitive to the influences of mental age on test outcomes. When testing children below the mental age of 7 years, task difficulty and performance variability render questionable results on behavioral tests of central auditory function. However, exceptions to this general case may occur following careful examination of the task's requirements and the child's capabilities and when using tests specifically designed for use with younger populations. Informal assessment, including use of screening tools as well as periodic follow-up, is rec-

ommended when appropriate tests of central auditory function are not available for younger children or other difficult-to-test populations suspected of having (C)APD. Likewise, and with the exception of the auditory brainstem response (ABR), neuromaturation, subject state, and cognitive factors will affect outcomes of many electrophysiologic procedures when used with children younger than 10 years of age. Therefore, clinicians must be cognizant of the effect of these factors on electrophysiologic measures and must administer and interpret electrophysiologic procedures in a manner appropriate to both the purpose of the evaluation and the child being tested.

9. Test methods should be consistent with the procedures defined in the original research of the test or as specified in the test manual or literature. Test methods include test conditions, directions, scoring and analysis, and the application of reinforcement (including feedback to the individual being tested) as well as other procedural variables.
10. The duration of the test session should be appropriate to the person's attention, motivation, and energy level, and should permit the measurement of a variety of key auditory processes. As with all behavioral tests, it is important that the audiologist continually monitor the individual's level of attention and effort and take steps to maintain a high level of motivation throughout the testing process.
11. SLPs, psychologists, educators, and other professionals should collaborate in the assessment of auditory processing disorders, particularly in cases in which there is evidence of speech and/or language deficits, learning difficulties, or other disorders. The speech-language pathology assessment provides measures of speech and language ability and communicative function, and assists in the differential diagnosis of an auditory processing disorder.
12. In cases in which there is suspicion of speech or language impairment, or intellectual, psychological, or other deficits, referral to the appropriate professional(s) should be made. In some cases, this referral should precede (C)AP testing to ensure accurate interpretation of central auditory results. In some cases, comorbid diagnoses will necessarily preclude (C)AP testing (e.g., significant intellectual deficit, severe hearing loss).
13. Test results should be viewed as one part of a multifaceted evaluation of the individual's complaints and symptoms. Examples of other data that should be examined include but are not limited to systematic observation of the individual in daily life activities, self-assessments, and formal and informal assessments conducted by other professionals. In addition, it is important to corroborate test findings by relating them to the individual's primary symptoms or complaints (e.g., difficulty hearing with the left ear vs. the right ear, difficulty understanding rapid speakers, difficulty hearing in backgrounds of competing noise, etc.).

Peripheral Auditory Dysfunction and Auditory Processing Diagnosis

Central auditory tests can be affected differentially by peripheral hearing loss (see Baran & Musiek, 1999, for review; Neijenhuis, Tschur, & Snik, 2004). Therefore, it is important that a thorough, basic evaluation of the auditory periphery be conducted prior to the assessment of central auditory function. When evaluating individuals with hearing loss, tests employing stimuli that are minimally affected by peripheral impairment should be selected whenever possible (e.g., tonal or other nonverbal stimuli, verbal stimuli with high linguistic redundancy) (Musiek, Baran, & Pinheiro, 1990; Musiek, Gollegly, Kibbe, & Verkest-Kenz, 1991; Musiek & Pinheiro, 1987). Carefully selecting tests and interpreting the test results can lead to accurate diagnosis of (C)APD in individuals with peripheral hearing loss. The experienced audiologist can apply several strategies in administering and interpreting central auditory tests to minimize the degree to which peripheral hearing loss influences central auditory test interpretation.

For example, if there is normal sensitivity at one or more frequencies, then behavioral and electrophysiologic tests should be administered at the normal frequencies, if possible. In addition, when hearing loss is similar (i.e., pure tones and speech recognition) in each ear, asymmetric results on central auditory processing tests (e.g., dominant ear effect on dichotic tests), especially when the better ear is depressed, may be interpreted as suggestive of a (C)APD. Even when hearing loss and speech recognition scores are bilaterally asymmetric, it still may be possible to deduce the presence of a (C)APD. For instance, if the ear with better hearing sensitivity demonstrates poorer performance on central auditory measures relative to the ear with poorer hearing sensitivity, one may consider the likelihood of an auditory processing disorder. In any case, central auditory test results obtained from persons with hearing loss should be interpreted with caution. The validity of these and other strategies used to separate peripheral from central effects must be ascertained through further research and should only be applied when absolutely necessary.

It is critical that a complete assessment of the peripheral auditory system, including consideration of auditory neuropathy/auditory dys-synchrony (AN/AD), occur prior to administering a central auditory test battery. At minimum, this would include evaluation of hearing thresholds, immittance measures (tympanometry and acoustic reflexes), and otoacoustic emissions (OAEs). When contradictory findings exist (e.g., present OAEs combined with absent acoustic reflexes or abnormal hearing sensitivity; abnormal acoustic reflexes with normal tympanometry and OAEs), additional follow up should occur to rule out AN/AD prior to proceeding with central auditory testing.

Clinical Decision Analysis Regarding Test Selection

The application of clinical decision analysis allows clinicians to evaluate the performance of diagnostic tests, such as those used for (C)APD, as well as to understand the probabilistic uncertainties associated with these tests (see Turner, Robinette, & Bauch, 1999, for review). Clinical decision analysis assumes that only two states exist: (1) that the individual has the disorder or dysfunction, or (2) that the individual does not have the disorder or dysfunction. Thus, any test for consideration only has two outcomes: (1) When positive, the test identifies the dysfunctional state, and (2) when negative, the test rules out the dysfunctional state. Clinical decision analysis provides information regarding test sensitivity, test specificity, and test efficiency, which are pivotal to a test's clinical utility.

Sensitivity refers to the ability of the test to yield positive findings when the person tested truly has the dysfunction. The sensitivity of a test is the ratio of the number of individuals with (C)APD detected by the test compared to the total number of subjects with (C)APD within the sample studied (i.e., true positives or hit rate). Specificity refers to the ability to identify correctly those individuals who do not have the dysfunction. The specificity of the test is the ratio of normal individuals (who do not have the disorder) who give negative responses compared to the total number of normal individuals in the sample studied, whether they give negative or positive responses to the test (i.e., 1 – sensitivity rate). Although the specificity of a test typically decreases as the sensitivity of a test increases, tests can be constructed that offer high sensitivity adequate for clinical use without sacrificing a needed degree of specificity.

The estimates of sensitivity and specificity of a symptom, test, or measure allow us to compute the predictive values of protocols used to make an appropriate decision or diagnosis. Efficiency is the combination of sensitivity and specificity. The computation of test efficiency is dependent on defining a gold standard, derived from well-defined, documented populations of individuals with the disorder and populations of individuals documented to be free of the disorder. Because of the variability and the nature of the profiles of (C)APD, there exists no absolute gold standard for deriving sensitivity and specificity data for tests of central auditory dysfunction; however, several options for determining test efficiency have been suggested. One option involves the use of children and adults referred for central auditory testing due to difficulties listening in noise and other behavioral symptoms of (C)APD. However, because the behavioral symptoms of (C)APD are also common to many other disorders (e.g., LD, ADHD, language disorder), it is not possible to state a priori whether a given individual in this population exhibits central auditory dysfunction or some other, similar disorder. As such, if efficiency data for tests of central auditory dysfunction were to be established on a population *suspected* of having central auditory dysfunction, there would be no means of establishing true measures of sensitivity and specificity.

Similarly, the use of children with LD to determine the predictive value of tests of central auditory processing is problematic. Although many children referred for diagnostic central auditory assessment exhibit some type of learning difficulty, the population of children with LDs is heterogeneous, and the relationship between (C)APD and LD is complex. Many children with LD do not exhibit auditory processing disorder, and auditory processing disorder does not necessarily lead to LDs. Therefore, it is impossible to state a priori whether a given child with LD exhibits (C)APD. Further, a significant proportion of the population with (C)APD consists of adults with auditory complaints who may or may not have exhibited learning difficulties as a child. Consequently, if populations with LD were used for sensitivity/specificity purposes, the results would provide a measure of test efficiency for LD rather than for (C)APD as, again, there would be no means of determining if the children in the chosen LD population actually exhibit central auditory dysfunction nor how this information applies to adults.

The third option involves the use of individuals with known pathology of the central auditory pathways to establish sensitivity and specificity data for tests of central auditory dysfunction. Although most individuals with (C)APD do not exhibit frank lesions of the CANS, there is substantial evidence that many individuals with (C)APD do, upon autopsy, exhibit neuromorphological abnormalities in auditory areas of the CNS. Moreover, the same or similar patterns of test findings that are seen in anatomically confirmed central auditory dysfunction also appear in children and adults suspected of having (C)APD who exhibit no frank lesion or pathology (Hendler, Squires, & Emmerich, 1990; S. Jerger, Johnson, & Loiselle, 1988; Rappaport et al., 1994). Finally, there is a clear precedent for the use of lesion studies in the establishment of test efficiency data in the cognitive and neuropsychological fields and in other professions that are charged with diagnosing CNS-related disorders in both children and adults. Therefore, as is standard procedure in other, similar professions, it seems reasonable that sensitivity/specificity data for tests of central auditory dysfunction could be derived from patients with known, anatomically confirmed central auditory dysfunction and used as a guide to identify the presence of central auditory dysfunction in children and adults suspected of (C)APD. Thus, test efficiency measured on subjects with known dysfunction of the CANS (e.g., well-defined lesions involving central auditory pathways) can serve as an important guide to the value and selection of the various diagnostic tests used in this arena. In addition, there is a growing body of research using electrophysiologic and neuroimaging procedures that assess the efficiency of behavioral measures and support the presence of neurophysiologic differences in CANS regions in children and adults with (C)APD (Estes et al., 2002; J. Jerger et al., 2002; J. Jerger, Martin, & McColl, 2004). These findings may provide additional methods of establishing sensitivity and specificity data for diagnostic tests of central auditory processing.

Types of (C)APD Tests

The following (C)APD tests reflect the variety of auditory processes and regions/levels within the CANS (and in some cases also include measures involving more peripheral regions [e.g., OAEs]) that underlie auditory behavior and listening, and which rely on neural processing of auditory stimuli. Some central auditory tests may involve stimuli and/or presentation features that span categories and exacerbate challenges to the individual's CANS. For example, time-compressed speech with reverberation, which can be categorized as both a monaural low-redundancy test and as a temporal processing test, provides an added challenge to the CANS and thus provides additional insights in the diagnostic process. As previously stated, the selection of a (central) auditory test battery should be individualized and based on the referring complaints and additional information obtained. Therefore, the following categorization of central auditory tests is not intended to suggest that all types be included in every central auditory diagnostic evaluation. Instead, this listing serves merely as a guide for clinicians to the types of measures that are available for central auditory assessment.

1. Auditory discrimination tests: assess the ability to differentiate similar acoustic stimuli that differ in frequency, intensity, and/or temporal parameters (e.g., difference limens for frequency, intensity, and duration; psychophysical tuning curves; phoneme discrimination).
2. Auditory temporal processing and patterning tests: assess the ability to analyze acoustic events over time (e.g., sequencing and patterns, gap detection, fusion discrimination, integration, forward and backward masking).
3. Dichotic speech tests: assess the ability to separate (i.e., binaural separation) or integrate (i.e., binaural integration) disparate auditory stimuli presented to each ear simultaneously (e.g., dichotic CVs, digits, words, sentences).
4. Monaural low-redundancy speech tests: assess recognition of degraded speech stimuli presented to one ear at a time (e.g., filtered, time-altered, intensity-altered [e.g., performance-intensity PI-PB functions]), speech-in-noise or speech-in-competition).
5. Binaural interaction tests: assess binaural (i.e., diotic) processes dependent on intensity or time differences of acoustic stimuli (e.g., masking level difference, localization, lateralization, fused-image tracking).
6. Electroacoustic measures: recordings of acoustic signals from within the ear canal that are generated spontaneously or in response to acoustic stimuli (e.g., OAEs, acoustic reflex thresholds, acoustic reflex decay).
7. Electrophysiologic measures: recordings of electrical potentials that reflect synchronous activity generated by the CNS in response to a wide variety of acoustic events (e.g., ABR, middle latency response, 40 Hz response, steady-state evoked potentials, frequency

following response, cortical event-related potentials [P1, N1, P2, P300], mismatch negativity, topographical mapping). The use of electrophysiologic measures may be particularly useful in cases in which behavioral procedures are not feasible (e.g., infants and very young children), when there is suspicion of frank neurologic disorder, when a confirmation of behavioral findings is needed, or when behavioral findings are inconclusive.

Test Interpretation

There are several approaches audiologists may use to interpret results of diagnostic tests of (C)APD. While work continues to ascertain the gold standard against which (C)APD should be gauged, additional approaches to test interpretation will contribute to accurate and meaningful analysis of an individual's test scores. In combination, these approaches assist audiologists and related professionals in differentially diagnosing (C)APD from disorders having overlapping behavioral attributes (e.g., ADHD, language disorder, cognitive disorder, LD).

Absolute or norm-based interpretation, probably the most commonly used approach, involves judging an individual's performance relative to group data from normal controls.

Relative or patient-based interpretation refers to judging an individual's performance on a given test relative to his or her own baseline. Patient-based interpretation may include:

- Intratest analysis, which is the comparison of patterns observed within a given test that provides additional interpretive information (e.g., ear difference scores, interhemispheric differences);
- Intertest analysis, which is the comparison of trends observed across the diagnostic test battery that provides additional interpretive information (e.g., presence of patterns consistent with neuroscience principles, anatomical site of dysfunction, and comorbid clinical profiles); and
- Cross-discipline analysis, which is the comparison of results observed across diagnostic tests of (C)APD and results from nonaudiological disciplines (e.g., speech-language, multimodality sensory function, psychoeducational, and cognitive test findings).

Diagnosis of (C)APD generally requires performance deficits on the order of at least two standard deviations below the mean on two or more tests in the battery (Chermak & Musiek, 1997). The audiologist should be alert, however, to inconsistencies across tests that would signal the presence of a nonauditory confound rather than a (C)APD even when an individual meets this criterion (e.g., left-ear deficit on one dichotic speech task combined with right-ear deficit on another). If poor performance is observed on only one test, the audiologist should withhold a diagnosis of (C)APD unless the client's performance falls at least three standard deviations below the mean or when the finding is accompanied by significant functional difficulty in auditory behaviors reliant on the process assessed. Moreover, the audiologist should re-administer the sole test failed as well as another similar test that assesses the same process to confirm the initial findings.

The interpretation of intertest and cross-discipline data should be correlated to well-established auditory neuroscience tenets or principles whenever possible, particularly as it relates to the identification of patterns indicative of anatomic site or region of dysfunction within the CANS (Bellis, 2003; Bellis & Ferre, 1999; Chermak & Musiek, 1997). The audiologist also should note qualitative indicators of behavior coincident to test performance (e.g., consistency of latency of response, distribution of errors across test trials), which might implicate cognitive factors (e.g., attention, memory), fatigue, motivation, or other sources of difficulty unrelated to (C)APD. When poor or inconsistent performance is found across all test results, regardless of the process measured or of when performance decrements occur over time and are alleviated by reinforcement, higher order cognitive, motivational, or related confounds should be suspected.

Today, there exist classifications systems, or models, that are used to profile individuals who have been diagnosed with (C)APD (Bellis, 2003; Bellis & Ferre, 1999; Katz, 1992). Clinicians may find these models, which are based on evolving theoretical constructs, helpful in relating findings on tests of central auditory function to behavioral symptoms and areas of difficulty in the classroom, workplace, and other communicative environments. Each model uses the results of the central auditory test battery to build a profile that can be used to assist a multidisciplinary team in determining deficit-specific intervention strategies. Although these subprofiling methods may serve as useful guides in the interpretation of central auditory test results and development of deficit-focused intervention plans, it should be emphasized that use of these models is not universally accepted at the present time and additional research into these and other subprofiling methods is needed.

Intervention for (C)APD

Intervention for (C)APD should be implemented as soon as possible following the diagnosis to exploit the plasticity of the CNS, maximize successful therapeutic outcomes, and minimize residual functional deficits. Given the potential impact of (C)APD on listening, communication, and academic success, and considering the frequent comorbidity of (C)APD with related language and learning disorders, it is especially crucial that intervention be undertaken broadly and comprehensively. The accumulated auditory and cognitive neuroscience literature supports comprehensive programming, incorporating both bottom-up (e.g., acoustic signal enhancement, auditory training) and top-down (i.e., cognitive, metacognitive, and language strategies) approaches delivered consistent with neuroscience principles (Chermak, 2002a, 2002b; Chermak & Musiek, 1997, 2002). Training should be intensive, exploiting plasticity and cortical reorganization; should be extensive, maximizing generalization and reducing functional deficits; and should provide salient reinforcement to promote learning (Merzenich & Jenkins, 1995; Tallal et al., 1996). In addition, it is important that training principles be extended from diagnosis to intervention, be it in the classroom, workplace, or home, to maximize mastery and ensure generalization of learned skills.

Treatment and management goals are determined on the basis of diagnostic test findings, the individual's case history, and related speech-language and psychoeducational assessment data, and should focus both on remediation of deficit skills and management of the disorder's impact on the individual. This is typically accomplished through three component approaches that are employed concurrently: direct skills remediation, compensatory strategies, and environmental modifications. Interest in computer-mediated software to supplement more traditional intervention materials and instruments has grown in recent years. Computerized delivery offers the advantages of multisensory stimulation in an engaging format that provides generous feedback and reinforcement and facilitates intensive training. Despite the potential of computerized approaches, additional data are needed to demonstrate the effectiveness and efficacy of these approaches, as well as of other behavioral interventions (Musiek, Shinn, & Hare, 2002; Phillips, 2002).

Direct skills remediation, or auditory training, consists of bottom-up treatment approaches designed to reduce or resolve the (C)APD. An accumulating literature has documented the potential of auditory training to change auditory behavior (e.g., Kraus, McGee, Carrell, Kind, Tremblay, & Nicol, 1995; Musiek, 2004; Tremblay & Kraus, 2002; Tremblay, Kraus, Carrell, & McGee, 1997; Tremblay, Kraus, & McGee, 1998; Tremblay, Kraus, McGee, Ponton, & Otis, 2001). Auditory training activities may include, but are not limited to, procedures targeting intensity, frequency, and duration discrimination; phoneme discrimination and phoneme-to-grapheme skills; temporal gap discrimination; temporal ordering or sequencing; pattern recognition; localization/lateralization; and recognition of auditory information presented within a background of noise or competition (Bellis, 2002, 2003; Chermak & Musiek, 2002). Because interhemispheric transfer of information underlies binaural hearing and binaural processing, exercises to train interhemispheric transfer using interaural temporal offsets and intensity differences, as well as other unimodal (e.g., linking prosodic and linguistic acoustic features) and multimodal (e.g., writing to dictation, verbally describing a picture while drawing) interhemispheric transfer exercises are important additions to auditory training programs for many individuals (Bellis, 2002, 2003; Musiek, Baran, & Schochat, 1999).

Compensatory strategies training is a top-down treatment approach designed to minimize the impact of the residual (C)APD that is not resolved through auditory training and that interacts and exacerbates deficits in other language, cognitive, and academic areas. By strengthening higher order central resources (i.e., language, memory, attention), individuals with (C)APD may buttress deficient auditory processing skills and enhance listening, communication, social, and learning outcomes. Metalinguistic strategies include: schema induction and discourse cohesion devices, context-derived vocabulary building, phonological awareness, and semantic network expansion (Bellis, 2002, 2003; Chermak, 1998, 2002b; Chermak & Musiek, 1997; Katz, 1983; Miller & Gildea, 1987; Musiek, 1999; Sloan, 1995). Metacognitive strategies include self-instruction, cognitive problem solving, and assertiveness training (Bellis, 2002, 2003; Chermak, 1998; Chermak & Musiek, 1997). Because motivation and a sense of self-efficacy are crucial to successful intervention, strategies designed to augment these areas often need to be addressed in the comprehensive intervention plan. Typically, such strategies are not themselves sufficient to remediate the impact of the (C)APD. All strategies should be practiced in a variety of contexts and settings to encourage the individual with (C)APD to use them as needed in the variety of contexts that individual will experience across the life span.

Environmental modifications include both bottom-up (e.g., enhancement of the signal and listening environment) and top-down (e.g., classroom, instructional, workplace, recreational, and home accommodations) management approaches designed to improve access to information presented in the classroom, at work, or in other communicative settings (ASHA, 2004a; Bellis, 2002, 2003; Chermak & Musiek, 1997; Hedu, Gagnon-Tuchon, & Bilideau, 1990). Environmental accommodations to enhance the listening environment may include but are not limited to preferential seating for the individual with (C)APD to improve access to the acoustic (and the visual) signal; use of visual aids; reduction of competing signals and reverberation time; use of assistive listening systems; and advising speakers to speak more slowly, pause more often, and emphasize key words (ASHA, 2003b; Crandell & Smaldino, 2000, 2001).

The first step in selecting appropriate bottom-up environmental modifications is to assess the acoustic environment to determine the need for and best methods of improving the acoustics of the physical space. Classrooms, workplaces, and home environments can be modified to reduce noise and reverberation and improve the associated visible aspects of the communication (ASHA, 2003b). These modifications may include decreasing reverberation by covering reflective surfaces (e.g., black/white boards not in use, linoleum or wood floors, untreated ceilings), using properly placed acoustic dividers, using other absorption materials throughout open or empty spaces (e.g., unused coat areas), and/or changing the location of “study” sites. External noise sources can be eliminated or moved away from the learning space (e.g., aquariums, fluorescent lights that hum, an open door or wall). ANSI Standard 12.60-2002, provides guidelines for acoustical performance and design criteria for school environments (ANSI, 2002).

Accommodations that utilize technology to improve audibility and clarity of the acoustic signal itself (assistive listening devices such as FM or infrared technology) may be indicated for some individuals with (C)APD. Recommendation of signal enhancement technology as a management strategy for individuals with (C)APD should be based on the individual’s profile of auditory processing deficits rather than as a general recommendation for all persons diagnosed with (C)APD. The strongest indicators for the use of personal FM as a management strategy are deficits on monaural low redundancy speech and dichotic speech tests (Bellis, 2003; Rosenberg, 2002). These listening tasks involve degraded signals, figure–ground, or competing speech that are similar to the effects of noise and reverberation in classroom, home, and workplace environments.

The benefits of personal FM and sound-field technologies for the general population and individuals at risk for listening and learning are well documented, but little data has been published documenting the efficacy of personal FM as a management strategy for students with (C)APD (Rosenberg et al., 1999; Stach, Loiselle, Jerger, Mintz, & Taylor, 1987). For individuals with greater perceptual difficulties, such as auditory processing disorder, a body-worn or ear-level FM system should be considered initially as the accommodation strategy due to their signal-to-noise (S/N) enhancement capabilities (Crandell, Charlton, Kinder, & Kreisman, 2001). Fitting, selecting, training, and monitoring of an assistive listening device or system is a process; each step must be implemented to ensure the appropriateness and the effectiveness of the management strategy (ASHA, 2002a) and binaural listening remains the preferred goal of this type of intervention. Newer technology being developed (e.g., signal manipulation, adaptive signal processing) holds promise for additional improvements in acoustic accessibility and speech perception.

When working with students with (C)APD, it is important to increase all team members’ awareness (including teachers’ and parents’) of the student’s specific profile/deficits to assist in the implementation of specific instructional accommodations and strategies. Access to communication and learning within the classroom and at home becomes critically important to the success of the student. It is incumbent upon audiologists or other professionals working with the classroom team to understand the instructional style of the primary teachers and the curriculum so that modifications that accommodate the student with (C)APD can be arranged. Classroom/instructional accommodations typically are designed to increase the student’s ability to access the information and may include recommendations regarding the manner or mode by which instructional material is presented, the management of the classroom, the structure of auditory information, and communication style. Specific suggestions may include support for focused listening (e.g., use of note-takers, preview questions, organizers), redundancy (e.g., multisensory instruction, computer-mediation), and use of written output (e.g., e-mail, mind-maps) (Bellis, 2002, 2003; Chermak, 2002a, 2002b; Chermak & Musiek, 1997). Efforts to improve acoustic access and communication for individuals of any age require an analysis of functional deficits and specific recommendations for change in their everyday settings (e.g., home, occupational, social, educational).

The intervention plan must include measurable outcomes to determine whether treatment goals and objectives have been achieved. The overall goal of intervention should be to provide the individual with (C)APD the ability to communicate more effectively in everyday contexts (e.g., the classroom, home, work). Specific goals and objectives are included in an individualized education program (IEP) and are reflected in measures of job-related success and in a variety of other measures documenting positive outcomes of the management plan. Outcome measures can include indices of auditory performance (e.g., pattern tests, dichotic digits, speech recognition for time-compressed speech), functional indices of metalanguage (e.g., phonemic analysis, phonemic synthesis), and/or more global measures of listening and communication (e.g., self-assessment or informant communication and education scales).

Typically, clinicians will obtain baseline performance data prior to starting intervention, at regular intervals during the course of treatment, and again at the termination of intervention (with options for longer term follow-up). Repeated measurement allows clinicians to assess an individual's progress, to modify intervention as needed, and to determine treatment outcomes and effectiveness. This information also allows clinicians to quantify the neuromaturation of the auditory system. It should also be recognized that as listening and learning demands change over time, alterations to the treatment and management plan will be indicated. As such, the relative efficacy of each treatment and management approach implemented should be monitored on an ongoing basis and suggestions for change made as needed.

Communicating the Results

Once a diagnosis is made, the audiologist should consult with other team members to design an intervention plan that addresses the range of communication, educational, and social issues associated with the (C)APD. Key to this collaboration is the audiologist's clearly worded diagnostic report that identifies the auditory processing deficits and recommends specific treatment/management approaches. Vocabulary, professional terms, and acronyms must be clarified. Such a report helps the client with (C)APD, family members, and the professional team understand the ramifications of the (C)APD, the treatment strategies, and the prognosis. For the school-aged child, this information is conveyed to the team of parents, teachers, and support personnel who will develop a plan to address the adverse effects of a (C)APD on the child's day-to-day communicative and educational functioning. Audiologists responsible for diagnosing (C)APD in school-aged children should familiarize themselves with the educational environment and available educational options. This can be accomplished through consultation with the school team. Likewise, audiologists who diagnose (C)APD in other populations, including young adults and older adults, must consider the range of communication, occupational, educational, and social ramifications associated with (C)APD.

Recommendations should be based on sound principles of intervention and management. When working with a school team, these recommendations also should take into account current educational philosophies and practices. For school-aged children, day-to-day modifications in the learning environment (e.g., a smaller learning environment or a quieter learning environment) may be included in an IEP, a 504 Plan, or a school-based instructional plan. For adults, these recommendations may take the form of a letter to a college, rehabilitation counselor, or an employer.

When recommending environmental and/or instructional modifications or specific compensatory strategies or services, the deficit areas to be addressed and the desired changes should be identified. An array of treatment options is currently available purporting to improve AP skills and communication. These include direct skill remediation through auditory training, compensatory strategies training, enhancement of the acoustic signal and the listening environment, and instructional modifications. Although an accumulating body of research suggests the efficacy of several approaches (e.g., Brand-Gruwel, Aarnoutse, & Van Den Bos, 1997; McKenzie, Neilson, & Braun, 1981; Musiek, 1999; Rosenberg et al., 1999; Tremblay & Kraus, 2002; Tremblay et al., 2001), considerable research must be accomplished to substantiate objectively the efficacy of specific intervention programs for (C)APD. It is important, therefore, that treatment programs and approaches be described relative to the skill areas to be addressed rather than simply specified by name. Goals and outcomes should be well defined and tied to expectations and prognosis. Engagement of the client, family members, and all professional team members is essential throughout this process.

Advocacy

Client or patient advocacy is important to the success of any intervention plan, especially when working with children. The audiologist, SLP, teachers, parents, and other professionals involved in the diagnosis, assessment, and intervention program must advocate for the individual's needs and work together to implement recommendations (e.g., preferential seating, use of personal FM system) designed to improve skills and minimize the adverse effects of the (C)APD on the individual's communication, academics, social skills, occupational function, and quality of life. The professional team and family members should help those with (C)APD develop self-advocacy skills by demonstrating techniques, providing materials and resources, and offering reinforcement that can empower them. This may take the form of teaching the individual specific self-advocacy skills or, in the case of children, providing parents with techniques to teach these skills at home; sharing printed materials that educate the individual with (C)APD and his or her family; identifying reliable Internet information or product resources; and facilitating access to appropriate related professionals and/or support groups as needed.

Reimbursement

Service providers may choose to require payment in full at the time services are rendered rather than to accept third-party assignment. For those providers who choose to accept third-party assignment, there is continuing frustration relative to fair reimbursement for diagnosis, treatment, and management of (C)APD. At the time of this writing, there is a limited number of procedure codes in the Current Procedural Terminology (CPT) guide (American Medical Association, 2004) available to the audiologist and SLP for billing purposes. These codes include those describing specific diagnostic tests as well as so-called "bundled" codes that can include a variety of procedures (e.g., Central Auditory Function Tests, CPT 92589; Evaluation of Auditory Processing, CPT 92506). However, CPT procedures specific to audiological evaluation of central auditory function have been accepted by the CPT Editorial Panel and new time-based codes for central auditory assessment became effective January 1, 2005. These codes include 92620 (Evaluation of Central Auditory Processing, initial 60 minutes) and 92621 (Evaluation of Central Auditory Processing, each additional 15 minutes). At the same time, the previous code, 92589 (Central Auditory Function Tests) has been deleted. As the scope of audiologic rehabilitation is expanded, more treatment codes may become available, increasing opportunities for more exact reporting of procedures; however, it is important to note that, at the present time, audiologists are not considered eligible for reimbursement by Medicare for audiologic rehabilitation, including (C)APD intervention, whereas SLPs may bill for intervention under Medicare.

ASHA and other related professional organizations are currently seeking additional CPT codes through the Medicare system. The process for expanding procedural terminology is both time and labor intensive, leaving providers in a "wait and see" position as to the introduction of new codes and reimbursement values. Audiologists and SLPs should familiarize themselves with currently accepted procedure and diagnosis codes used for third-party assignment. Billing scenarios are available (Thompson, 2002) to assist service providers in obtaining reimbursement.

Further complicating the reimbursement process are the many variations among health plan carriers with respect to description of services attached to specific codes (despite the universal nature of the CPT reference book), type of provider eligible to use certain codes, accepted forms of billing invoices, and coverage eligibility and restrictions for their members (e.g., need for referral from a primary care physician, "hearing tests" not a covered benefit). Clients and/or their families should be advised to contact their health plan provider to clarify these issues, preferably in writing, prior to evaluation or treatment. The specifics of payment assignment to a third party other than a health plan (e.g., billing to a school district) should be clarified in writing prior to evaluation or treatment.

Future Research Needs

As is true for most areas of practice within the professions of audiology and speech-language pathology, additional research is needed in auditory processing and its disorders. There is a pressing need for the development of testable models of auditory processing disorder to resolve the controversy surrounding multimodality and supramodality concerns (McFarland & Cacace, 1995). Additional behavioral diagnostic tests must be developed that are based on psychophysical principles, that meet acceptable psychometric standards, that have been validated on known dysfunction of the CANS, and that can be made available through commercial venues for practicing clinicians. Similarly, there is a need to develop more efficient screening tools to identify individuals at risk for (C)APD, as well as both screening and diagnostic measures appropriate for multicultural/multilingual populations. The role of physiologic testing, including neuroimaging procedures, in the diagnostic process must be examined further, as must the topic of differential diagnostic criteria for (C)APD. Relationships among performance on various categories of central auditory diagnostic tests and higher order language, learning, or communication sequelae need to be examined in a systematic manner. However, because of the complexity of auditory and related disorders, basic correlation procedures may be inadequate for this task. Instead, studies of these relationships will need to take into account the heterogeneity of both (C)APD and learning, language, or related disorders through the use of appropriately sized subject groups and advanced statistical procedures, such as cluster analysis, discriminant function, and factorial analyses. Research is also needed in the area of treatment efficacy to enhance the selection of deficit-specific remediation approaches and to guide recommendations regarding necessary and sufficient frequency, intensiveness, and duration of treatment programs and treatment termination.

Conclusion of the Working Group

This Working Group concludes that there is sufficient evidence to support the neurobiological and behavioral existence of (C)APD as a diagnostic entity. Further, the accumulated evidence reviewed by this Working Group is reflected in the conceptualization, the conclusions, and the recommendations contained in this technical report to guide diagnosis and assessment of the disorder, as well as to guide the development of more customized, deficit-focused intervention plans.

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Appendix: Definition of Terms Used in This Document

- Assessment: Formal and informal procedures to collect data and gather evidence (i.e., delineation of functional areas of strength or weakness and/or determination of ability or capacity in associated areas).
- Comorbidity: The coexistence of two or more disorders, diseases, or pathologic processes that are not necessarily related.
- Diagnosis: Identification and categorization of impairment/dysfunction (i.e., determination of presence and nature of disorder).
- Differential diagnosis: Distinguishing between two or more conditions presenting with similar symptoms or attributes.
- Evaluation: Interpretation of assessment data, evidence, and related information.
- Intervention: Comprehensive, therapeutic treatment and management of a disorder.
- Management: Procedures (e.g., compensatory strategies, environmental modifications) targeted toward reducing the effects of a disorder and minimizing the impact of the deficits that are resistant to remediation.
- Pansensory: Referring to higher level mechanisms that are common to and that support processing across all modalities.
- Prevention: Procedures targeted toward reducing the likelihood that impairment will develop.
- Reliability: The consistency, dependability, reproducibility, or stability of a measure.
- Remediation/treatment: Procedures targeted toward resolving the impairment.
- Screening: Procedures used to identify individuals who are "at-risk" for an impairment.
- Validity: The degree to which a test measures what it is intended to measure.