Auditory Processing Disorders: An Update for Speech-Language Pathologists

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Abstract (Summary)
Unanswered questions regarding the nature of auditory processing disorders (APDs), how best to identify at-risk students, how best to diagnose and differentiate APDs from other disorders, and concerns about the lack of valid treatments have resulted in ongoing confusion and skepticism about the diagnostic validity of this label. This poses challenges for speech-language pathologists (SLPs) who are working with school-age children and whose scope of practice includes APD screening and intervention. The purpose of this article is to address some of the questions commonly asked by SLPs regarding APDs in school-age children. This article is also intended to serve as a resource for SLPs to be used in deciding what role they will or will not play with respect to APDs in school-age children. The methodology used in this article included a computerized database review of the latest published information on APD, with an emphasis on the work of established researchers and expert panels, including articles from the American Speech-Language-Hearing Association and the American Academy of Audiology. The article concludes with the authors' recommendations for continued research and their views on the appropriate role of the SLP in performing careful screening, making referrals, and supporting intervention.

In the introduction of the report of the Consensus Conference on the Diagnosis of Auditory Processing Disorders in School-Aged Children, Jerger and Musiek (2000) stated: **"The reality of auditory processing disorders in children can no longer be doubted. There is mounting evidence that, in spite of normal hearing sensitivity, a fundamental deficit in the processing of auditory information may underlie problems in understanding speech in the presence of background noise, in understanding degraded speech, in following spoken instructions, or in discriminating and identifying speech sounds"** (p. 467). Despite this claim, authorities in related fields and within our own profession have expressed doubt about the relevance and very existence of auditory processing disorders (APDs) in school-age children (Cacace & McFarland, 1998; Watson et al., 2003).

Speech-language pathologists (SLPs) are affected by this current state of uncertainty because their **professional responsibilities include screening for APD, making appropriate referrals, and providing intervention services (ASHA, 2001). Also, nearly 60% of certified SLPs work in schools (ASHA, 2002b), and it is during the school years that children move from listening to and learning language to using language for learning. In fact, 67% of the ASHA-certified SLPs who work with school-age children report regularly serving students who have APD (ASHA, 2004c).**

The purpose of this article is to provide an **update on current APD literature** for SLPs who work with school-age children to guide them in their role with respect to APDs. Will they accept this disorder as a reality and assume roles in referral and intervention of students or will they deem the available evidence insufficient for that course of action? The article uses a question-and-answer format, focusing on questions commonly asked by SLPs. Answers are based on information from position papers, technical reports, expert panels, controlled studies, and the most frequently published authorities. The questions and answers that follow are designed to elucidate the major issues surrounding the disorder, which include the following:

1. What is the definition of APD?

2. What are its primary characteristics?

3. What diagnostic tests are available to audiologists?

4. What associations exist between APD and specific language and learning disorders?

5. What are the ASHA-defined roles and responsibilities of SLPs and audiologists as related to children with this disorder?

6. How are school-age children screened for APD?

7. Who might make poor candidates for this testing?

8. What management approaches are available and effective?

1. What Is the Definition of APD?

According to an ASHA (2005) technical report, APDs refer to difficulties in the perceptual processing of auditory information in the auditory nervous system as demonstrated by poor performance in one or more of the following skill areas: auditory discrimination, auditory pattern recognition, temporal aspects of audition, auditory performance in competing acoustic signals, and auditory performance with degraded acoustic signals. Further, the Consensus Conference on the Diagnosis of Auditory Processing Disorders in School-Aged Children (Jerger & Musiek, 2002) emphasized the importance of establishing that poor performance on tests of auditory processing is due to "an auditory-specific perceptual deficit in the processing of speech input" (p. 19) rather than due to some other factor(s). ASHA (2005) agreed that individuals who have APD "exhibit sensory processing deficits that are more pronounced in the auditory modality" (p. 2), but the report added that because sensory processing in the central nervous system necessarily involves multiple modalities supported by cognitive and language systems, complete modality specificity as a requirement for APD is not plausible. The fact that this continues to be a controversial issue in APD assessment is evidenced by the devotion of an entire recent issue of the American Journal of Audiology to the topic, with several contributing articles devoted to whether APD should be diagnosed in a unimodal fashion. These issues are discussed in more detail in this article.

Some confusion exists regarding the literature's use of the terms central auditory processing disorder and auditory processing disorder. The Consensus Conference on the Diagnosis of Auditory Processing Disorders in School-Aged Children (Jerger & Musiek, 2000) **objected to the original term, central auditory processing disorder,** for three reasons: (a) it was not sufficiently operationalized, (b) it inappropriately referred to anatomical loci, and (c) it did not reflect potential peripheral and central interactions. The Consensus Conference suggested that it be replaced with auditory processing disorder. The ASHA (2005) technical report on central auditory processing disorders, noting the confusion created by the change in terminology, recommended continued use of the term central auditory processing disorder but added that the two terms could be considered synonymous. In this article, auditory processing disorder (APD) will be used.

2. What Are the Primary Characteristics of School-Age Children Who Have APD?

According to the ASHA (2005) technical report, individuals suspected of having APD frequently exhibit one or more of the following characteristics:

(a) difficulty with speech understanding in adverse listening environments, (b) misunderstanding messages, (c) responding inconsistently or inappropriately, (d) frequently asking that information be repeated, (e) difficulty attending and avoiding distraction, (f) delay in responding to oral communication, (g) difficulty following complex auditory directions, (h) difficulty with sound localization, (i) reduced musical and singing skills, and (J) associated reading, spelling, and learning problems. Empirical support for some of these behaviors is noted in a study by Smoski, Brunt, and Tannahill (1992), who found that children diagnosed with APD were judged by their teachers to be poorer listeners than a group of control participants and that the greatest listening difficulty was noted in the presence of noise. This is consistent with Jerger and Musiek (2000), who stated that **processing deficits involved in APD can be exacerbated in unfavorable acoustic settings.**

This long list of behavioral signs associated with APD has evoked considerable criticism because of its heterogeneous nature. This is certainly a far cry from what Friel-Patti (1999) called for when stating that APD must be "defined on the basis of a unique cluster of behaviors reflecting impairment in some underlying mechanism" so that "clear descriptions of mutually exclusive and exhaustive diagnostic criteria can be specified" (p. 347). In fact, APD has been associated with a wide range of clinical populations, including young children with histories of otitis media, school-age children with learning difficulties, individuals who have neurological deficits, and older individuals (Bellis, 2003). While these wide-ranging associations may fuel skepticism regarding the validity of APD as a diagnostic category, they also may provide information that APDs may interfere with normal auditory functioning in a wide variety of individuals at all ages.

3. What Diagnostic Tests of Auditory Processing Are Available to the Audiologist and What Information Do They Provide?

Assessment for APD is performed by a battery of auditory measures that theoretically assess various aspects of the construct. In order to make these measures more effective in identifying disorders of the central auditory system, they have been "sensitized" in some way, typically by **increasing the complexity or reducing the redundancy of the test stimuli**. Sensitization has been achieved by filtering out frequency information, adding background noise, or presenting competing auditory information simultaneously to both ears. Cacace and McFarland (1998) have noted that this process of "sensitization" makes these tasks susceptible to nonperceptual influences, such as attention. It is widely understood that speech-based auditory tests also engage resources of attention and verbal working memory and, as such, can provide important information about integration of auditory neural pathways with these resources across development (Hugdahl, 1995).

As summarized in Table 1, four major types of behavioral tests are typically used in current test batteries. Auditory discrimination tests assess the students' ability to detect subtle differences in similar sounds, including (a) acoustic sounds that differ in frequency, intensity or temporal characteristics or (b) similar sounding words or nonsense syllables mat differ, as in minimal pairs. Tests of auditory pattern recognition may provide information about the perception of suprasegmental cues in speech (Bellis, 2003). Dichotic tests assess the student's ability to either integrate or separate out different auditory stimuli presented simultaneously to both ears and provide information regarding neuromaturation of the central auditory system (Bellis, 2003). Monaural low-redundancy speech tests assess students' ability to understand degraded speech, as might occur in background noise or if speech is presented at a rapid rate.

Jerger and Musiek (2000) recommended that **behavioral measures be clinically supplemented with electrophysiological and electroacoustic measures, specifically otoacoustic emissions and the auditory brainstem and middle latency responses.** Katz and colleagues (2002) disagreed, stating that research has not supported the premise that such measures are valuable in APD assessment or remediation. Jerger and colleagues (2002) reported behavioral and electrophysiological data from a study of fraternal twin girls, only one of whom appeared to exhibit some type of auditory perceptual disorder. The researchers found that although "there was little to differentiate the two twins" on behavioral measures, they differed significantly on event-related potential measures, with the twin who demonstrated reduced performance in noise also demonstrating abnormal brain activation patterns in response to auditory but not visual stimuli (p. 459). Finally, Moncrieff, Jerger, Wambacq, Greenwald, and Black (2004) found that some children with reading deficits also exhibited left ear evoked response deficits on dichotic testing.

A survey of audiologists' APD diagnostic practices by Emanuel (2002) reported that none were using a protocol that met the minimum guidelines as recommended in the Consensus Conference report (Jerger & Musiek, 2000). Despite efforts to characterize a battery of tests that can minimally diagnose an auditory processing deficit in school-age children, a true consensus has yet to be well established. Regarding the use of auditory measures alone to diagnose APD, Cacace and McFarland (2005a) stated that because the current "unimodal" testing approach leads to misclassification of children whose deficits are not perceptual in nature, such test protocols should be "abandoned in favor of a more valid approach" (p. 120). They proposed the use of an APD test battery that compares performance on auditory and analogous visual tasks. According to the researchers, the child who truly has a "pure" APD will perform poorly only on the auditory tasks; a child whose deficits are more global in nature (i.e., supramodal, nonperceptual) will demonstrate difficulties on all tasks. Importantly, this latter group will perform poorly on auditory measures as part of a broader problem and not because they have an isolated APD; this distinction is not possible using a unimodal battery, according to the researchers. Cacace and McFarland also believe that establishing modality specificity as a diagnostic criterion for APD would address the potential influence of uncontrolled factors, such as attention and motivation. For example, the child whose performance on visual measures is normal but whose performance on analogous auditory measures is abnormal most likely has some type of auditory deficit that is not due to lack of attention or motivation to the tasks.

In response to Cacace and McFarland's suggestions, Katz and Tillery (2005) cited two cases of children who demonstrated reduced performance only on one competing condition of the Staggered Spondaic Word Test (Katz, 1986). The researchers contrasted this profile with a third individual whose performance was depressed in all four conditions. They suggested that nonauditory factors can have a negative impact on performance in general but are less likely to influence performance in only one condition of the test. The researchers concluded that such intraindividual comparisons are effective for separating out auditory from nonauditory effects and that testing using multiple modalities is not necessary. Similarly, Moncrieff (2006) suggested that a unilateral deficit on a dichotic listening test is not linked to a global language, attention, or cognitive disorder because the child is able to attend to and process information normally when it is presented to the dominant (usually right) ear. The researcher believed that the presence of a large interaural asymmetry during dichotic listening tests that is not present for monaural listening tests is strongly suggestive of an auditory-specific deficit in processing speech during binaural listening.

Musiek, Bellis, and Chermak (2005) also expressed concern about the use of multimodal testing and questioned whether true visual analogs could be created for auditory measures, particularly in view of differences in central integration in the visual and auditory systems. Instead, the researchers advocated the use of a multidisciplinary approach to testing using professionals from related fields (e.g., academic, speech-language, neuropsychological) who could provide supplemental information about nonauditory areas.

A second issue regarding assessment of APDs in children has to do with test validity and the lack of a "gold standard." A gold standard may be defined as an "outcome or condition that is designated as the criterion against which the test characteristics of all other measures are compared" (Stach, 2003, p. 119). An example of a gold standard in audiology would be the use of magnetic resonance imaging (MRI) in studying whether auditory brainstem response (ABR) testing is a valid tool for the identification of medium to large acoustic tumors. The gold standard against which the ABR findings would be compared would be the MRI because this would represent the definitive measure of the "truth" that is being measured. One study has linked differences in the fMRI hemodynamic response recorded from reading disabled children with a unilateral dichotic listening deficit, especially when the children were initially primed to attend to their right ears during a challenging listening task (Moncrieff, McColl, & Black, in press). Future studies of this kind could potentially provide important standards for brain activation patterns during a variety of auditory processing skills.

In the absence of a current gold standard for the identification of APD in children, several researchers have measured test validity within groups of children who are suspected of having APD. This approach is problematic because it leaves open the possibility that the participants have unidentified language, attention, or general learning disabilities. The possibility of comorbid factors interferes with the true assessment of the sensitivity and specificity of individual APD tests, as well as the efficiency of any proposed test battery (Cacace & McFarland, 2005a).

Another approach to establishing test validity is to use individuals who have been identified with lesions of the central nervous system. This is based on the premise that a test which has been shown to be valid in identifying gross abnormality of the central nervous system (e.g., a tumor) can be presumed to be valid for use with children who have APD. Musiek et al. (2005) advocated the use of this approach with individuals whose lesions are well-defined, and ASHA (2005) noted that this approach to validity is common in cognitive and neuropsychological fields. Cacace and McFarland (2005b) expressed concern with this approach because brain lesions are often not limited to auditory areas, and Bellis (2003) noted the potential problems in using data collected from adults with brain lesions to draw conclusions about test validity for children who do not have brain lesions.

There is general agreement that more information is needed about APD test reliability. Test-retest reliability has been shown to improve when clients are asked to identify the correct choice from a series of options, rather than repeating back what was heard (Voyer, 2003) and when computer-controlled adaptive test procedures are used to control floor and ceiling effects (Levitt, 1971). These methodologies would be appropriate to include in APD testing. Information obtained from future studies on the reliability of tests of auditory processing will help clinicians determine the extent to which such tests correlate with other important measures of ability in school-age children (Cacace & McFarland, 1995).

Finally, the criterion for determining the presence of APD based on test performance is a concern. ASHA (2005) stated that the diagnosis of the disorder generally requires performance deficits of 2 5Ds below the mean on two or more tests in the battery. However, the diagnosis may also be made if performance on any one test is 3 5Ds below the mean or the client is exhibiting significant functional difficulty in behaviors that are related to the auditory process in question. The fact that the diagnosis could be made on the basis of one test for which reliability and validity information is likely limited is of great concern. Rates of misdiagnosis are likely to increase in cases where test reliabilities are low, multiple tests assessing different auditory processes are used, and reduced performance on a small number of tests is considered evidence of the disorder (McFarland & Cacace, 2006).

4. Does APD Cause Specific Language and Learning Disorders?

Jerger and Musiek (2000) claimed that deficits in auditory processing likely underlie problems with understanding speech in a background of noise, understanding speech that is degraded, following orally presented instructions, and speech sound discrimination. They noted that APD may coexist with other disorders, but they did not suggest that it was causative in nature. Also, they suggested that APD should be viewed as a "discrete entity apart from other childhood problems" (Jerger & Musiek, 2002, p. 19). As a corollary, ASHA (2005) stated that 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" (p. 3). In contrast, Katz and colleagues (2002) claimed that APDs may cause speech and language impairment, dyslexia, and attention deficit disorder.

Cacace and McFarland (1998) reviewed the available empirical evidence regarding the proposition that deficits in auditory processing underlie language and learning problems and concluded that validation of this theory is nearly impossible because almost all of the research employed only acoustic stimuli. ASHA (2005) concluded from their review that because APD and learning are both complex and heterogeneous, "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" (pp. 3-4).

Other research has attempted to link one particular auditory process with weaknesses in language, learning, and reading. For example, Tallal and colleagues have asserted that the underlying impairment in children who have reduced phonological processing (and subsequent reading deficits) is one of temporal processing, which refers to perception of rapid changes in acoustic information (Tallal & Piercy, 1973, 1974). But Troia (2003) noted that the same children who demonstrated these auditory difficulties also exhibited greater difficulty with rapidly presented visual patterns and perceiving and producing rapid sequential motor movements. This suggests that the auditory deficits are part of a broader pansensory disorder. Troia added that at this point a functional relationship has not yet been established between auditory perceptual deficits and phonological processing deficits.

Also in contrast to claims by Tallal and colleagues, Studdert-Kennedy and Mody (1995) asserted that the difficulties noted in temporal processing tasks among children who have reading deficits reflect linguistic deficits that interfere with the ability to identify phonemic categories for the stimuli at hand. Mody, Studdert-Kennedy, and Brady (1997), in a study using two complex nonverbal tones, required listeners to discriminate the tones based on perception of brief transitions in format frequencies; because the tones were nonverbal, listeners were not required to create phonological representations of the stimuli. Also, these researchers assessed participants' ability to discriminate additional pairs of consonant-vowel syllables that differed on specific articulatory features. The fact that less skilled readers did not perform significantly differently in their ability to discriminate based on acoustic transitions but did perform more poorly in discriminating phonetically similar phonemes lends support to an underlying linguistic deficit in children with reading deficits, rather than an underlying auditory one. Consistent with this, Agnew, Dom, and Eden (2004) found that intensive daily intervention using a computerized program designed to improve temporal processing skills resulted in improvements on auditory duration tasks but not on phonological awareness or nonword reading.

McAnally, Castles, and Bannister (2004) compared good and delayed readers on auditory temporal pattern discrimination tasks and found that both groups were equally able to perform these tasks. Similarly, Breier, Fletcher, Foorman, Klaas, and Gray (2003), in a study examining perception of auditory temporal cues among children with reading disabilities, did not find support for fundamental deficits in auditory temporal ability. Earlier studies reported variable results when assessing temporal integration and resolution performances in children with reading disorders, suggesting that (a) many temporal resolution skills mature very early (gap detection and masking level difference), (b) some but not all children with reading disorders may demonstrate a temporal processing deficit, and (c) more evidence is needed to determine which children are most likely to have this particular difficulty (see Moncrieff, 2004b, for a review). Rosen (2003), in a review of the relationship between auditory processing deficits and specific language impairment and dyslexia, concluded that "auditory deficits do not appear to be causally related to language disorders, but only occur in association with them" (p. 521). He added that the position held by Tallal and Piercy (1973, 1974) that the auditory deficit noted in individuals diagnosed with specific language and reading impairment is related to rapid auditory processing "is no longer viable" (p. 518).

Watson and colleagues (2003) examined the degree to which various sensory, cognitive, and linguistic factors were associated with success or failure in the first years of school and found low correlations between reading achievement and measures of auditory processing. In fact, low scores on measures of APD were associated with "virtually any level of reading achievement" (p. 181) and cast doubt on the thesis that "children with auditory processing deficits have language and reading problems as a consequence of the difficulty they have in understanding spoken language, especially under difficult listening conditions" (p. 188). Musiek et al. (2005), in response to Watson's findings, stated that they do not view APD as the direct cause of academic, learning, or reading problems but rather one small but important component of listening and learning.

What all of these studies suggest is that a one-to-one correspondence between APD in general, or even a particular deficit in one type of auditory processing skill, may be difficult to link to any specific learning, language, or reading disability. One study noted that some dyslexic children demonstrated evidence of a unilateral deficit during dichotic listening tasks and that the prevalence of this deficit was much greater among the children with dyslexia than among normal controls (Moncrieff & Black, in press). This study suggested that APD may be present in children with school-based learning disabilities to a greater extent than among children without them, but additional research in this area is clearly needed.

5. What Are the ASHA-Defined Roles and Responsibilities of SLPs and Audiologists as Related to School-Age Children With APD?

Children at risk for listening, learning, and language disorders in the school are usually referred to the SLP for evaluation to determine eligibility for services. Among the tools utilized to make these determinations are a variety of language assessments that include measures related to auditory processing skills. Table 2 provides information about tests of auditory perceptual skills. When an auditory processing weakness is suggested by the results from any of these tests, the SLP may then choose to either directly refer to an audiologist for a diagnostic assessment or perform additional screening measures designed more specifically to address APD.

Although both audiologists and SLPs may screen for and treat individuals who have or are suspected of having APDs (ASHA, 2004b, 2005), only audiologists diagnose this disorder. ASHA (2005) also noted the important role of SLPs in "the differential diagnosis of language processing disorders from APD" (p. 6).

Richard (2006) noted that these definitions may not sufficiently clarify the division of responsibilities between audiologists and SLPs within this population. Both professionals are directed to provide both screening and intervention, but only the audiologist is directed to provide diagnostic services for APD. Because the SLP is directed to screen for APD, it is necessary that screening tools for this purpose be clearly identified and provided to the SLP to use in the schools. Intervention is even more complicated because under current reimbursement standards, only the SLP is entitled to reimbursement for the intervention services that are typically involved in remediating APDs in children.

6. How Are School-Age Children Screened for APD?

The ASHA (2005) technical report on APD defines screening as "systematic observation of listening behavior and/or performance on tests of auditory function to identify those individuals who are at risk for APD" (p. 5). Unfortunately, no national professional organization has yet issued a policy statement on the screening of APD in school children (Jerger & Musiek, 2000) and "there is no universally accepted method of screening for APD" (ASHA, 2005, p. 5). In fact, the latest ASHA technical report on APD dedicates only one paragraph to the topic of screening and states that "an in-depth discussion of the role of the SLP and other professionals is beyond the scope" of the report (p. 1).

Despite the lack of information on the topic of screening, the ASHA technical report (2005) does refer the reader to four sources of information about screening for APD, each of which is reviewed in this section of the article. The SCAN-C: Test for Auditory Processing Disorders in Children (Keith, 1986, 2000a, 2000b) and Children's Auditory Performance Scale (CHAPS; Smoski et al., 1992) are widely used screening tools. The other two sources, the Consensus Conference on the Diagnosis of Auditory Processing Disorders in School-Aged Children (Jerger & Musiek, 2000) and Bellis (2003) text, both provide discussions of screening approaches.

The report of the Consensus Conference (Jerger & Musiek, 2000) stated that development and validation of a screening procedure specifically for school-age children is necessary and should (a) assess the perceptual processing of complex auditory stimuli, (b) meet acceptable psychometric standards, (c) rely minimally on cognition, attention, and language, and (d) be able to be administered in a brief period of time. The participants at the Consensus Conference concluded that the screening procedure could take the form of either a questionnaire, a test, or a combination of the two.

According to the Consensus Conference (Jerger & Musiek, 2000), screening by questionnaire should assess evidence of difficulty (a) hearing/ understanding in background noise or reverberant settings, (b) understanding speech that is degraded, (c) following oral directions, and (d) identifying and discriminating speech sounds. Evidence of inconsistent auditory awareness or inconsistent responses is also included.

The CHAPS, developed by Smoski et al. (1992), is a behavioral questionnaire that is used to assess auditory function. Using a rating scale of+1 to -5, respondents are asked to rate the child on six listening conditions by comparing the child to other children of similar age and background; a rating of+1 indicates less difficulty than their age peers, and -5 indicates severe difficulty. The listening conditions are (a) noise, (b) quiet, (c) ideal, (d) multiple inputs, (e) auditory memory/sequencing, and (f) auditory attention span. Although the original respondents used in developing the tool were classroom teachers, the tool can be used by others, including parents. The test is not standardized, but the test developers state that children whose total score meets or exceeds a specified criterion are more likely to require special resource support services in school.

Regarding screening by test, the Consensus Conference (Jerger & Musiek, 2000) suggested that for children older than 6 years, the screening that is developed should include dichotic digit and gap detection measures. Neither of these tests is generally administered by the SLP, however. Furthermore, ceiling effects may interfere with the utility of a dichotic digits test utilizing double-digit pairs among children past age 9 (Moncrieff & Musiek, 2002).

The SCAN-C test (Keith, 1986,2000a, 2000b) is an available screening tool that contains subtests which assess understanding of low-pass filtered words, auditory figure-ground abilities, and dichotic listening performance with competing words and competing sentences. It can be administered by nonaudiologists in a quiet room using a CD player, although anyone administering it should be careful to monitor presentation level throughout the test. The test has demonstrated poor predictive value when used outside a sound-treated booth (Emerson, Crandall, Seikel, & Chermak, 1997, 1998), suggesting that a failure to maintain an appropriate presentation level may result in poor test results. Also, Amos and Humes (1998) investigated the reliability of the SCAN-C for first- and third-grade children using a 6-7-week retest interval. They found that for both grade levels, raw and standard scores improved significantly from the first to second test administration for the Filtered Words and Competing Words subtests, as well as for the composite score. The composite percentile rank and age-equivalent data also demonstrated significant test-retest improvement for both grades. Poor and nonsignificant test-retest correlation values were noted for the Filtered Words and Auditory Figure-Ground subtests ($r < .35$), and significant moderately strong positive correlations ($r = .7$-$.78$) were noted for both grades on the Competing Words subtest and composite score. These researchers concluded that the composite score (rather than individual subtest scores) should be used for making decisions about the need for further testing.

The Competing Words subtest of the SCAN-C, which provides information on dichotic listening performance, could be scored separately from the composite score as a screening instrument in place of or in addition to the dichotic digits test. According to Moncrieff (2006), the prevalence of disordered performance was shown to increase dramatically when the scores for the individual ears were compared in order to derive a measure of interaural asymmetry. The research suggested that this alternative scoring method may prove useful in screening for dichotic listening deficits in the school-age population (Moncrieff, 2006).

The SCAN-A: Test for Auditory Processing Disorders in Adolescents and Adults (Keith, 1994) is a modification of the SCAN-C for use with older students as well as adults. The SCAN-A is a 20-min test that includes four subtests: Filtered Words, Auditory Figure-Ground, Competing Words, and Competing Sentences. Test-retest reliability for the total test is reported by Keith to be .69. The SCAN-A can be administered by audiologists or SLPs.

One problem with the SCAN-A is that it presumes that by age 12 years, a child's performance is similar to that of an adult's. In a recent retrospective study of results obtained from adolescents, it was found that the prevalence of disordered performance increases dramatically once children are above 12 years and must be assessed with normative information obtained from adults (Eichert, Heithaus, & Brown, 2007). It is important that normative information be separately obtained from children between 12 and 18 years of age in order to adequately screen and diagnose them for an APD.

To determine whetfier the SCAN-A's total score test-retest reliability of .69 (Merz, 1998) was adequate, McFarland and Cacace (2006) simulated test performance using a simple statistical model. The researchers generated percentages of false alarms (i.e., test value is below 1 SD, but trait value is not), misses (i.e., trait value is below 1 SD, but test value is not), and hits (both values are below 1 SD). Using this model, it was determined that reliabilities approaching .80 were required in order for the rate of correct decisions to exceed the rate of errors. Keith (2000a, 2000b) reported subtest test-retest reliability correlations for the SCAN-C for 5- to 7-year-olds ranging from .65 to .82.

Bellis (2003) advocated a screening process that requires a collaborative, multidisciplinary team (e.g., audiologist, SLP, teacher, psychologist) in order to gain an understanding of the child's strengths and weaknesses and to develop an initial auditory profile. According to Bellis, this profile is necessary because of the degree of interdependency that exists between auditory processing, language, and learning. Integral to this screening process is the assessment of overall cognitive, language, and achievement abilities (prior to any decision to administer an APD test battery) in order to identify the presence of more global issues that might explain the students' presenting difficulties. Once data from the multidisciplinary team have been collected, they are examined for patterns that might support a referral for APD testing.

7. Are Some Children Poor Candidates for Diagnostic Testing for APD?

The ASHA (2005) technical report describes APD as "a deficit in neural processing of auditory stimuli that is not due to higher order language, cognitive, or related factors" (p. 2). In view of this, children whose listening/ auditory difficulties clearly stem from broader deficits in cognition, attention, memory, or language comprehension would not be good test candidates. The ASHA document specifically mentions significant intellectual impairment as an example of a comorbid diagnosis that would preclude APD testing, and Bellis (2003) noted that although normal cognitive abilities are not required for testing, the child must have the capacity to follow the test directions and respond appropriately. Bellis also included uncontrolled behavior disorder as a diagnosis that could prevent reliable testing.

According to the ASHA (2005) technical report, "task difficulty and performance variability render questionable results on behavioral tests of central auditory function" in children whose mental age is below 7 years (p. 6). Despite this, Jerger and Musiek (2000) suggested that children as young as 6 years could be tested with whatever screening tool is eventually developed. Electrophysiological measures are sometimes recommended for younger children, but research is lacking to suggest that students with APD would have auditory nerve or brainstem pathology (Katz et al., 2002). In addition, middle latency responses are variable in children (Kraus, Smith, Reed, Stein, & Cartee, 1985) and are influenced by nonauditory factors, including client age and the test protocol used (Jerger & Jerger, 1985). Finally, abnormality on electrophysiological measures yields no specific information about how the child processes incoming auditory information (Bellis, 2003).

Some disagreement exists in the literature regarding the appropriateness of performing tests of auditory processing on individuals with peripheral hearing loss. Although some authorities view APD as a disorder that, by definition, occurs in the presence of normal peripheral hearing (Jerger & Musiek, 2000), the literature does address the issue of performing these tests on individuals who have peripheral hearing loss. Although some researchers have found that hearing loss minimally affects scores on dichotic digits and pattern recognition tasks (Musiek, Baran, & Pinheiro, 1990; Speaks, Niccum, & Van Tasell, 1985), Neijenhuis, Tschur, and Snik (2004) found that performance of participants who had mild, flat, symmetrical sensorineural hearing loss was significantly poorer than that of the normal hearing participants, even for the dichotic digits and pattern recognition tasks. The researchers also noted that increasing the stimulus intensity for other auditory processing measures (e.g., words in noise, filtered speech) was not sufficient to compensate for the mild loss.

8. What Management Approaches Are Available for Children With APD and What Evidence Exists Regarding the Effectiveness of These Interventions?

Data specifically addressing the efficacy of interventions for students with APD are seriously lacking, and many of the recommendations commonly made are based on theory. In fact, Cacace and McFarland (2006) suggested that the peer reviewed literature does not contain any evidence of a validated model of APD intervention. Empirical studies have, however, documented the efficacy of interventions commonly used with students who have APD as they have been applied to other populations or other disorder areas (e.g., use of metacognitive strategies, acoustic modifications). Table 1 summarizes some common management recommendations generated from test data, as conceptualized by Bellis (2003, 2006). It is important to emphasize that the management strategies noted are largely based on theory and are not supported by outcome studies performed specifically on students diagnosed with APD.

A number of broad, guiding themes appear in the current APD intervention literature (ASHA, 2005; Bellis, 2003, 2006; Ferre, 2006). One such theme is to provide, whenever possible, early and intensive intervention in order to capitalize on the known plasticity of the central nervous system (Chermak & Musiek, 1992). Animal studies suggest that the effect of external auditory input (or lack thereof in the case of auditory deprivation) on plasticity is time-limited to some critical period (Arnold, Bottjer, Nordeen, Nordeen, & Sengelaub, 1987), the exact length of which is still unknown. Before early auditory training for children with APD can become commonplace, empirical data will have to be collected regarding the types, frequency, and duration of activities that would be effective with specific types of APDs, as well as the optimum age period for delivering therapy.

Another theme that emerges from the current APD literature is that intervention should be broad and comprehensive in order to address the potential impact the disorder may have on listening, communication, and academic functioning. "Bottom-up" approaches to intervention address the listener's ability to receive and analyze the acoustic signal, whereas "top-down" approaches address the listener's ability to understand the message and attach meaning to it (ASHA, 2005; Richard, 2006).

An example of a bottom-up remediation approach is dichotic listening training, described by Bellis (2003). This intervention involves systematic variation of the relative intensity levels of signals presented to each ear as clients are asked to either integrate or separate incoming information. Although controlled study of this type of intervention is very limited, Moncrieff (2004a) recently found considerably improved performance for the weaker ear in children with a unilateral deficit in dichotic listening. Broader improvements in listening and language skills following the dichotic training exercises were also reported.

Research involving auditory training activities designed to produce physiological and behavioral changes in children represent another type of bottom-up intervention and may have promise for determining both the existence of APDs and treatment effectiveness. This type of research typically involves a between-groups research design with (a) pretreatment measures of auditory behaviors and electrophysiological data, (b) intervention targeting discrete auditory skill areas, and (c) posttesting of auditory behaviors and electrophysiological measures. For example, a study by Hayes, Warrier, Nicol, Zecker, and Kraus (2003) compared two groups of students who had learning disabilities, one of which received computer-based auditory training and a control group that did not receive any remediation. Researchers assessed (a) speech- and click-evoked ABRs in quiet, (b) speech-evoked cortical responses in both quiet and noise, and (c) standardized measures of academic achievement and cognitive skills. Postintervention measures revealed cortical responses that were more resistant to degradation in noise and positive behavioral changes in the auditory processing abilities of the experimental group; no such changes were noted in the control group.

Other bottom-up auditory training activities are described by Bellis (2002) and Chermak and Musiek (2002) and use tones and simple speech in activities designed to remediate "basic auditory skills or processes" that are presumed to serve as the foundation for "more complex listening, learning, and communication abilities" (Bellis, 2002, p. 287). Importantly, although Bellis advocated use of such activities, she also noted that a lack of evidence currently exists to support the assumptions that (a) basic auditory processes do, in fact, underlie more complex listening, learning, and communication abilities (p. 287), (b) such processes can be identified with current tests, and (c) remediation of the deficient processes will result in functional improvements in listening and communication.

In addition to attempts at direct remediation of APD, the ASHA (2005) technical report on APD addressed two other broad components of intervention: compensatory strategies and environmental modifications. Compensatory strategies training, classified as a top-down approach, attempts to develop cognitive, metacognitive, linguistic, and metalinguistic skills to support overall listening and communication and to reduce the functional deficits imposed by the APD (Bellis, 2003; Chermak & Musiek, 1997). Such metacognitive instruction approaches have a long and rich history in developmental and cognitive psychology and have been shown to be effective for a variety of children with various, learning difficulties, including attention deficits (Meichenbaum, 1977) and reading comprehension difficulties (Palincsar & Brown, 1984). One specific metalinguistic/metacognitive strategy for students with APD provided by Chermak and Musiek (1997) is to teach students to identify linguistic structures that connect related ideas into complex messages. For example, in the sentence "Joe saw the bird," opportunities for understanding are increased if the student understands the role of pronouns and that this message may become "He saw it." Instruction in the use of content schema is another strategy recommended by Chermak and Musiek to support understanding among students with APD. By considering what they already know about a particular experience (e.g., attending a birthday party), students are able to use this already established structure to facilitate spoken language comprehension. A third example of a compensatory strategy noted by Chermak and Musiek is building students' skills in using context cues to increase understanding. This involves teaching the student to analyze incoming spoken language and deduce a missed word from the parts of the message that have been successfully received. A final example of a compensatory strategy comes from Bellis (2003), who suggests teaching whole body listening. This child is instructed not only to position himself so that his attention is toward the teacher, but also to instruct himself to maintain his attention and avoid distraction.

Environmental modifications may be either bottom-up or top-down in nature and are made to improve the listener's access to incoming auditory information. According to ASHA (2005), these may include (a) preferential seating, (b) use of visual aids, (c) control of background noise, and (d) use of communication repair strategies. Bottom-up environmental modifications are typically preceded by an analysis of the listener's acoustic environment, followed by specific modifications designed to bring noise and reverberation levels to acceptable standards (American National Standards Institute, 2002; ASHA, 2002a). These may include decreasing reverberation by covering hard surfaces, strategically placing acoustic dividers, and using absorption materials in open spaces. Also, ASHA (2005) notes that FM technology is useful for some students diagnosed with APD. Although empirical documentation exists regarding the benefits of FM technology for improving literacy and academic achievement (Loven, Fisk, & Johnson, 2003; McCarty & Gertel, 2003), speech recognition (Prendergast, 2001; Updike & Connor, 2003), and attending/listening (Loven et al., 2003; Rosenberg et al, 1999), a comprehensive review of the literature on sound field amplification by Rosenberg (2005) did not reveal any studies done specifically with students diagnosed with APD.

Although computer-delivered interventions have become popular in recent years, the literature support for such approaches is being questioned. We noted previously that work by Tallal and Piercy (1973, 1974) suggested a causal link between academic differences and impairment in the temporal aspect of sound recognition. Based on this finding, Scientific Learning Corporation (Tallal & Merzenich, 1997) developed Fast ForWord, a popular computerized training program in which the listener is exposed to sounds and words that have been electronically lengthened. The theory involved here is that the manner of speech modification and massed-practice learning trials incorporated into the program will result in changes in neural pathways so as to improve language learning.

Although initial research data by the program developers (Merzenich et al., 1996; Tallal et al., 1996) were impressive (i.e., 1.5- to 3-year gains in language over a 6-week period), subsequent analysis of these studies revealed a number of methodological concerns, summarized by Gillam (1999). These included (a) outcome measures that were very similar to training activities, (b) lack of control for regression to the mean, (c) use of examiners to deliver the intervention, and (d) failure to measure language in authentic contexts. Hook, Macaruso, and Jones (2001) used a between-groups design with three groups: one received FastForWord, one received the Orton-Gillingham reading program, and one received no treatment. The researchers found that both treatment groups made equivalent gains in phonological awareness, but neither group made statistically significant gains in word recognition. The Orton-Gillingham group scored higher on the decoding tasks compared with the group receiving Fast ForWord. Also, although children in the Fast ForWord group made gains in producing oral language, gains in comprehending the language and production were not noted upon a 2-year follow up. Other studies using Fast ForWord reported some language improvements on standardized measures, but clinically significant changes in spontaneous language were not found (Friel-Patti, DesBarres, & Thibodeau, 2001; Loeb, Stokes, & Fey, 2001).

Brief mention should be made of auditory integration training (AIT; Berard, 1993) because anecdotal reports have suggested that it improves attending and auditory comprehension, two common signs of APD. Also, the majority of the AIT practitioners in the United States and Canada are SLPs or audiologists (ASHA, 2004a). As described by Berard (1993), AIT is based on the idea that the underlying cause of autism spectrum disorders, learning disabilities, and aggressive behaviors, for example, is the presence of auditory distortions. These auditory distortions are revealed as "peaks and valleys" on the client's audiogram and are created when the threshold of adjacent audiometric frequencies differ by 5 dB or more. According to Berard, in order to reduce these distortions, the audiogram must be flattened by having the client listen to specifically modulated and filtered music twice daily for 30 min over a 10-day period.

ASHA (2004a), in its most recent technical report, addressed the value of AIT in treating various "communication, behavioral, emotional, and learning disorders" (p. 7) and concluded that "despite approximately one decade of practice in this country, this method has not met scientific standards for efficacy and safety that would justify its inclusion as a mainstream treatment for these disorders" (p. 7). ASHA also pointed out that this is the same conclusion reached by the American Academy of Audiology (1993), American Academy of Pediatrics (1998), and Educational Audiology Association (1997).

Summary and Recommendations

At this point in our discussion, it should be clear that APD is a topic of great controversy and one that is perplexing to SLPs seeking to find their role in working with students who are suspected of having or are diagnosed with the disorder. Not only have different researchers collected contradictory data regarding APD, different authorities in the field have drawn different conclusions from the same data. This is likely related to the fact that individuals interpret data based on their own mindset, experiences, and roles. For example, researchers are more likely to require overwhelming empirical evidence before endorsing new ideas or paradigms; clinicians, however, are more likely to consider other factors in making such decisions (Kamhi, 1999). For these reasons, "the translation of evidence into recommendations is not straightforward" (Burgers & van Everdingen, 2004, p. 392).

In view of the above, we conclude this article with our own personal views of the need for future research and conclusions about the role of the SLP with respect to APD.

Recommendations for Future Research

1. Modality specificity is an important concept and should be further explored, in conjunction with adaptive test procedures, to reduce misdiagnosis and improve reliability. This will also help to determine if there truly are students whose reduced performance on auditory tasks

represents a fundamental auditory deficit rather than a broader, nonperceptual problem.

2. The use of auditory training to produce physiological and/or auditory behavioral change could one day provide important information about the existence of APD and treatment efficacy. Measuring both behavioral and physiological changes (rather than just physiological) is important and should be continued. Additional research of this type should include functional measures of listening and long-term follow-up testing.

3. Development of a valid screening tool for APD in school-age children should be a priority. Also, we agree with the conclusion of the report of the Consensus Conference on the Diagnosis of Auditory Processing Disorders in School-Aged Children (Jerger & Musiek, 2000) that some type of screening tool for children younger than 6 years needs to be developed. This is particularly important because parents and teachers often note listening difficulties in younger children, and early testing may provide important initial information that can be used to establish baseline measures for later diagnostic testing. This will also be very difficult to achieve because the issues that make reliable and valid testing of APD so challenging (e.g., the influence of maturation, motivation, language ability, attending) will be even greater in younger children.

4. Research that establishes correlations between auditory processing skills and other measures of learning, language, and listening (Watson et al., 2003) is important and should be encouraged. However, a lack of association does not mean that the construct is unimportant because the relevance of APD as a diagnostic entity does not hinge solely on school performance in the younger grades or on any one particular learning, language, or listening skill. For some children, it is not until the later grades (even as late as middle school or high school) that difficulties in auditory processing become apparent. What is needed is evidence of the prevalence of auditory processing difficulties within the population of school-age children, from which measures of the associated sequelae can ultimately be derived.

5. Randomized clinical trials represent a powerful method of controlled study, and clearly more such research needs to be pursued if a validated model of treating APD is to be established.

6. Other forms of research should also be encouraged, including those that can be performed by SLPs in schools. One important example is single-subject designs. Although frequently viewed as a lesser form of evidence of treatment efficacy, these designs can be very useful in justifying clinical

decisions for individual clients when they are based on well-documented trial therapy (Kamhi, 2006; Ylvisaker et al., 2002).

7. Both ASHA and the American Academy of Audiology should explore the use of specific criteria for all practice guidelines that are published. According to Grilli, Magrini, Penna, Mura, and Liberati (2000), these criteria should include a description of the types of professionals involved in creating the guidelines, the specific strategy used in searching for primary evidence, and a grading of all recommendations to inform the reader of the quality of the evidence used and to clarify the degree to which expert panel recommendations are consistent with the literature and free of conflicts of interest.

Recommendations Regarding the Role of the SLP

Given the current state of the literature on APD, SLPs appear to have two choices: to reject the use of APD screening and diagnostic measures or to engage cautiously in a process of screening, which in some cases will lead to diagnosis (by an audiologist) and then intervention. In considering these two options, think about the following case example. Michael is an 8-year-old student exhibiting difficulties in the classroom that include poor direction following, reduced speech understanding (particularly in noise), and a need for spoken information to be repeated. These difficulties are believed to be related to reduced academic performance and have led to concerns about Michael's confidence in the classroom and anxiety about school. Speechlanguage testing reveals age-appropriate language skills, and psychoeducational testing reveals normal cognitive abilities, including good memory and attending skills. No significant social-emotional difficulties are observed.

The SLP involved in this case adds to the data that have already been collected on Michael and, using the CHAPS, finds Michael to have significantly more difficulty (compared with his classmates) understanding speech when background noise is present. Also, on the Competing Words subtest of the SCAN-C, Michael demonstrates an age-appropriate number of errors on the right ear and a significant number of errors on the left ear. Finally, on the Listening Test, Michael demonstrates reduced performance. Based on the resulting profile, Michael is referred to an audiologist for tests of auditory processing and is found to have reduced speech understanding in noise and reduced dichotic listening skills. Based on these findings, a series of recommendations are made that include (a) an analysis of the sources of noise within the classroom and recommendations to reduce that noise, (b) use of a sound-field FM system to improve the signal-to-noise ratio, and (c) language therapy, designed in collaboration with the classroom teacher, to increase Michael's familiarity with new vocabulary used in class and to promote his ability to use contextual cues to support comprehension.

Consider now the sequence of events had the SLP decided not to engage in a process of screening with Michael. On what basis would Michael have received the additional support that he needed to succeed in the classroom? More broadly, if no initial screening process is in place, on what basis are students with APD brought to the attention of school personnel so that they can receive necessary instructional accommodations and modifications? Doesn't an assessment of the potential costs of intervening versus the potential risk of not intervening strongly support intervention?

Our conclusions regarding APD and the role of SLPs are as follows:

First, we agree with ASHA (2005) that current evidence is sufficient to support the existence of APD as a diagnostic entity. We also agree with Bellis (2002) that until data are obtained to validate the nature of the disorder, the best testing protocols, and the most effective intervention, "the clinical utility of the APD diagnosis will remain limited" (p. 294).

Second, despite the limitations inherent in working with an evolving construct, the process of identifying school-age children with APD and providing management recommendations can, if done cautiously, be valuable. This is not unlike the situation that currently exists in diagnosing a number of complex, incompletely understood disorders that affect children (e.g., autism).

Third, although no universally accepted screening approach for school-age children exists, the literature does provide some guidance to SLPs interested in determining whether a given student who is exhibiting specific classroom difficulties (e.g., reduced speech understanding in noise, frequent need for spoken information to be repeated) might benefit from diagnostic tests of APD. Consistent with the approach described by ASHA (2005) and Bellis (2003), screenings should be multidisciplinary and should begin with assessment of cognitive, psychoeducational, and language skills. By starting the process with these more global measures, school personnel can determine whether one of these broad areas is contributing to the student's classroom difficulties. If deficits are noted, appropriate intervention can be planned and tests of APD would likely not be necessary. If, on the other hand, these broad measures do not reveal deficits, the SLP could explore the student's auditory abilities further by analyzing, for example, results from the SCAN-C combined with ratings on the CHAPS and/or performance on selected tests of auditory perceptual skills (see Table 2). The SLP with evidence of auditory deficits based on these measures would be making a significant case that further testing for APD was warranted.

Fourth, current test protocols for auditory processing diagnosis, although flawed, should not be abandoned. Careful audiologic testing that uses all available methods to control for the influence of language, attention, and motivation, combined with data from other professionals, can yield a meaningful diagnosis. We understand that use of an interdisciplinary testing process is not a substitute for developing better testing protocols, but there is a steady and growing demand for clinicians to assist parents and teachers with identification of APD, and this demand cannot be put on hold until more exact clinical protocols are in place.

Fifth, despite pressure to do so, SLPs should avoid referring students who are not good candidates for APD testing. This includes students with significant intellectual impairment, uncontrolled behavior disorders, and significant sensorineural hearing loss. Attention, language ability, and motivation must also be considered. Adherence to selection criteria that are consistent with the literature reviewed in this article will reduce the likelihood of misdiagnosis as well as the misuse of an APD diagnosis as a substitute for a more accurate but less acceptable label, (e.g., reduced cognitive ability, attention deficit).

Sixth, although we encourage the badly needed research in the area of treatment for APD, we also acknowledge that validation of a treatment is typically a time-consuming process (Dawes, 1994), and clinicians are unlikely to have students in need of services and support wait until a critical mass of research is available. Also, based on the current disagreements in the literature, it is uncertain that consensus would develop regarding whether adequate evidence had been collected on which to base treatment decisions.

In the absence of treatments that have been validated specifically for students with APD, clinicians should make every attempt to use approaches that have been validated with other populations. Consistent with evidence-based practice, clinicians should also make use of their clinical insights and the specific needs and preferences of their clients in making decisions about treatment. It is important to note that in many fields, including medicine, empirical evidence is infrequently the only factor used in clinical decision making (Sackett, Richardson, Rosenberg, & Haynes, 1997; Wulff, 1986). In fact, Raine et al. (2004), in an investigation of the degree to which physicians' recommendations for treating patients with specific conditions agreed with the research evidence, found that no greater than 60% of the group ratings agreed with the data provided. Qualitative follow-up interviews revealed that factors such as client preference, clinical judgment, and an unwillingness to do nothing influenced the physicians' judgments. Malterud (2001) not only acknowledged the importance of physicians' clinical insights in making decisions, but recommended that these insights be studied using qualitative research in order to systematize such knowledge for "description and analysis" (p. 398).

We agree with Gillam (1999), who noted that "the best any parent, clinician, or educator can do is make treatment decisions that are based on careful consideration of the data that are presently available" (p. 364). It should be noted that the fathers of the evidence-based practice movement in medicine make this same point about decision making in the presence of inadequate research evidence (Sackett, Rosenberg, Gray, Haynes, & Richardson, 1996).

Seventh, although theoretically, a team approach involving the audiologist and the SLP in remediating APDs seems to logically provide a combination of bottom-up and top-down methodologies, SLPs should be aware of the lack of data supporting the use of popular bottom-up tools, such as FastForWord and AIT. Also, less well-known bottom-up approaches described in the literature by Bellis (2002) and Chermak and Musiek (2002) are largely theoretical and in our view would be difficult to justify to a school district pressed to find the time and money to provide services to students. Recommending therapy that uses noncontextualized, nonspeech tasks in the hopes of targeting an isolated auditory process that may or may not positively affect functional understanding of language is difficult to justify when more global and empirically validated approaches exist. Based on this, management should focus on the types of topdown approaches discussed previously that are designed to support overall comprehension and functional communication. These approaches, along with improvements in the acoustic environment, can be very useful.

Our eighth and final conclusion is that, as Kamhi (1999) noted, clinicians are trained professionals "educated to make informed decisions concerning clinical practice" (p. 97). They are, as Hedge (1994) noted, systematic problem solvers who cautiously implement solutions to clients' challenges. While important research is ongoing, and always mindful of the limitations inherent in a construct that is still under investigation, we hope that clinicians will carefully use their considerable skills for the benefit of their students and families.

[Reference] » View reference page with links

References

Agnew, J., Dorn, C, & Eden, G. (2004). Effect of intensive training on auditory processing and read
American Academy of Audiology. (1993). Position statement: Auditory integration training. Audiolog
American Academy of Pediatrics. (1998). Auditory integrations training and facultative communicati
American National Standards Institute. (2002). Acoustical performance criteria, design requirement
American Speech-Language-Hearing Association. (2001). Scope of practice in speech-language p
American Speech-Language-Hearing Association. (2002a). Appropriate school facilities for student www.asha. org/policy.
American Speech-Language-Hearing Association. (2002b). 2002 omnibus survey caseload report:
American Speech-Language-Hearing Association. (2004a). Auditory integration training [Technical
American Speech-Language-Hearing Association. (2004b). Scope of practice in audiology [Scope
American Speech-Language-Hearing Association. (2004c). 2004 schools survey: Caseload charac
American Speech-Language-Hearing Association. (2005). (Central) auditory processing disorders
Amos, N., & Humes, L. (1998). SCAN test-retest reliability for first- and third-grade children. Journa
Arnold, A. P., Bottjer, S. W., Nordeen, E. J., Nordeen, K. W., & Sengelaub, D. R. (1987). Hormones Rauschecker & P. Marler (Eds.), Imprinting and cortical plasticity (pp. 55-67). New York: Wiley.
Bellis, T. J. (2002). Developing deficit-specific intervention plans for individuals with APD. Seminars
Bellis, T. J. (2003). Assessment and management of central auditory processing disorders in the ed Learning.
Bellis, T. J. (2006). Interpretation of APD test results. In T. K. Parthasarathy (Ed.), An introduction to Erlbaum.
Berard, G. (1993). Hearing equals behavior. New Cannan, CT: Keats.
Breier, J., Fletcher, J., Foorman, B., Klaus, P., & Gray, L. (2003). Auditory temporal processing in cl deficit/hyperactivity disorder. Journal of Speech, Language, and Hearing Research, 46, 31-42.
Burgers, J., & van Everdingen, J. (2004). Beyond the evidence in clinical guidelines. The Lancet, 3
Cacace, A. T., & McFarland, D. J. (1995). Opening Pandora's box: The reliability of CAPD tests. Am
Cacace, A. T., & McFarland, D. J. (1998). Central auditory processing disorder in school aged child 41, 355-373.
Cacace, A. T., & McFarland, D. J. (2005a). The importance of modality specificity in diagnosing cen 123.
Cacace, A. T., & McFarland, D. J. (2005b). Response to Katz and Tillery (2005), Musiek, Bellis, and 143-150.
Cacace, A. T., & McFarland, D. J. (2006). Delineating auditory processing disorder (APD) and atten practical framework. In T. K. Parthasarathy (Ed.), An introduction to auditory processing disorders i
Chermak, G. D., & Musiek, F. E. (1992). Managing central auditory processing disorders in childrer
Chermak, G. D., & Musiek, F. E. (1997). Central auditory processing disorders: New perspectives.
Chermak, G. D., & Musiek, F. E. (2002). Auditory training: Principles and approaches for remediatin 297-308.
Dawes, R. M. (1994). House of cards: Psychology and psychotherapy built on myth. New York: Fre
Educational Audiology Association. (1997). Auditory integration training: Educational audiology pos
Kichert, S., Heithaus, D., & Brown, D. (2007, April). SCAN-A: Are adolescents being mislabeled? P of Audiology, Denver, CO.
Emanuel, D. C. (2002). The auditory processing battery: Survey of common practices. Journal of th
Emerson, M. F., C randall. K. K., Seikel, J. A., & Chermak, G. D. (1997). Observations on the use th Language, Speech, and Hearing Services in Schools, 28, 43-49.

Emerson, M. F., Crandall, K. K., Seikel, J. A., & Chermak, G. (1998). The use of SCAN to identify c
Hearing Services in Schools, 29, 118-119.
Ferre, J. M. (2006). Management strategies for APD. In T. K. Parthasarathy (Ed.), An introduction to
Erlbaum.
Friel-Patti, S. (1999). Clinical decision-making in the assessment and intervention of central auditor
Schools, 30, 345-352.
Friel-Patti, S., DesBarres, K., & Thibodeau, L. (2001). Case studies of children using Fast ForWord
Gillam, R. (1999). Computer-assisted language intervention using Fast ForWord: Theoretical and e
Hearing Services in Schools, 30, 363-370.
Grilli, R., Magrini, N., Penna, A., Mura, G., & Liberati, A. (2000). Practice guidelines developed by s
Hayes, E., Warrier, C, Nicol, T., Zecker, S., & Kraus, N. (2003). Neural plasticity following auditory t
673-684.
Hedge, M. N. (1994). Clinical research in communication disorders (2nd ed.). Boston: College-Hill
Hook, P., Macaruso, P., & Jones, S. (2001). Efficacy of Fast ForWord training on facilitating acquisit
Annals of Dyslexia, 51, 75-96.
Hugdahl, K. (1995). Dichotic listening: Probing temporal lobe functional integrity. In R. J. Davidson
Press.
Jerger, S., & Jerger, J. (1985). Audiological applications of early, middle, and late auditory evoked p
Jerger, J., & Musiek, F. (2000). Report of the Consensus Conference on the Diagnosis of Auditory I
Academy of Audiology, 11, 467-474.
Jerger, J., & Musiek, F. (2002). On the diagnosis of auditory processing disorder: A reply to "Clinica
recommendations." Audiology Today, 14(2), 19-21.
Jerger, J., Thibodeau, L., Martin, J., Mehta, J., Tillman, G., Greenwald, R., et al. (2002). Behavioral
study. Journal of the American Academy of Audiology, 13, 438-460.
Kamhi, A. G. (1999). To use or not to use: Factors that influence the selection of new treatment app
Kamhi, A. G. (2006). Treatment decisions for children with speech-sound disorders. Language, Spe
Katz, J. (1986). SSW test user's manual. Vancouver, WA: Precision Acoustics.
Katz, J., Johnson, C. D., Brandner, S., Delagange, T., Ferre, J., King, J., et al. (2002). Clinical and r
recommendations. Audiology Today, 14(2), 14-17.
Katz, J., & Tillery, K. (2005). Can central auditory processing tests resist supramodal influences? A
Keith, R. (1986). SCAN: A Screening Test for Auditory Processing Disorders. San Diego, CA: The P
Keith, R. (1994). SCAN-A: Test for Auditory Processing Disorders in Adolescents and Adults. San A
Keith, R. (2000a). Development and standardization of SCAN-C Test for Auditory Processing Disor
445.
Keith, R. (2000b). SCAN-C: Test for Auditory Processing Disorders in Children-Revised. San Anton
Kraus, N., Smith, D., Reed, N., Stein, L., & Cartee, C. (1985). Auditory middle latency responses in
and Clinical Neurophysiology, 62, 343-351.
Levitt, H. (1971). Transformed up-down method in psychoacoustics. Journal of the Acoustical Socie
Loeb, D., Stokes, C, & Fey, M. (2001). Language changes associated with Fast ForWord: Evidence
216-230.
Loven, F., Fisk, K., & Johnson, S. (2003, November). Classroom amplification systems on early aca
Convention of the American Speech-Language-Hearing Association, Chicago.
Malterud, K. (2001). The art and science of clinical knowledge: Evidence beyond measures and nu
McAnally, K. L, Castles, A., & Bannister, S. (2004). Auditory temporal pattern discrimination and rea
1243.
McCarty, P., & Gertel, S. (2003, September). Designing the best learning environments to maximize

Educational Facility Planners International, Chicago.
McFarland, D., & Cacace, T. (2006). Current controversies in CAPD: From Procrustes bed to Pand
disorders in children (pp. 247-263). Mahwah, NJ: Erlbaum.
Meichenbaum, D. (1977). Cognitive behavior modification. New York: Plenum.
Merz, W. (1998). Review of SCAN-A: A test for auditory processing disorders in adolescents and a
measurement yearbook: Buros Institute of Mental Measurement (pp. 870-871). Lincoln: University
Merzenich, M., Jenkins, W., Johnston, P., Schreiner, C, Miller, S., & Tallal, P. (1996). Temporal proc
training. Science, 271, 77-81.
Mody, M., Studdert-Kennedy, M., & Brady, S. (1997). Speech perception deficits in poor readers: A
Psychology, 64, 199-231.
Moncrieff, D. (2004a, November). New tests of auditory processing. Presentation at the Annual Co
Philadelphia.
Moncrieff, D. (2004b, February). Temporal processing deficits in children with dyslexia. Audiology O
www.audiologyonline.com/articles/article_detail. asp?article_id=725.
Moncrieff, D. (2006). Identification of binaural integration deficits in children with the Competing Wo
Journal of Audiology, 45, 545-558.
Moncrieff, D. W., & Black, J. R. (in press). Dichotic listening deficits in children with dyslexia. Dysle
Moncrieff, D., Jerger, J., Wambacq, I., Greenwald, R., & Black, J. (2004). ERP evidence of a dichot
of Audiology, 15, 518-534.
Moncrieff, D. W., McColl, R. W., & Black, J. R. (in press). Hemodynamic differences in children with
cued listening task. Journal of the American Academy of Audiology.
Moncrieff, D., & Musiek, F. (2002). Interaural asymmetries revealed by dichotic listening tests in no
13, 428-437.
Musiek, F. E., Baran, J. A., & Pinheiro, M. L. (1990). Duration pattern recognition in normal subjects
Musiek, F., Bellis, T., & Chermak, G. (2005). Non-modularity of the central auditory nervous system
Audiology, 14, 128-138.
Neijenhuis, K., Tschur, H., & Snik, A. (2004). The effects of mild hearing impairment on auditory pro
Palincsar, A. S., & Brown, A. L. (1984). Reciprocal teaching of comprehension-fostering and monito
Prendergast, S. (2001). A comparison of performance of classroom amplification with traditional an
Raine, R., Sanderson, C, Hutchings, A., Carter, S., Larkin, K., & Black, N. (2004). An experimental
Lancet, 364, 429-437.
Richard, G. J. (2006). Language-based assessment and intervention of APD. In T. K. Parthasarathy
108). Mahwah, NJ: Erlbaum.
Rosen, S. (2003). Auditory processing in dyslexia and specific language impairment: Is there a defi
4), 509-527.
Rosenberg, G. (2005). Sound field amplification: A comprehensive literature review. In C. Crandell,
speech perception and classroom acoustics (pp. 72-111). New York: Thomson Learning.
Rosenberg, G., Blake-Rahter, P., Heavner, J., Allen, L., Redmond, B., Phillips, J., & Stigers, K. (199
amplification study. Journal of Educational Audiology, 7, 8-28.
Sackett, D. L., Richardson, W., Rosenberg, W., & Haynes, R. (1997). Evidence-based medicine: H
Sackett, D. L., Rosenberg, W. M. C, Gray, J. M., Haynes, R. B., & Richardson, W. S. (1996). Evide
71-72.
Smoski, W. J., Brunt, M. A., & Tannahill, J. C. (1992). Listening characteristics of children with centr
in Schools, 23, 145-149.
Speaks, C, Niccum, N., & Van Tasell, D. (1985). Effects of stimulus material on the dichotic listening
and Hearing Research, 28, 16-25.

Stach, B. (2003). Comprehensive dictionary of audiology illustrated. Delmar, NY: Thomson Learnin
Studdert-Kennedy, M., & Mody, M. (1995). Auditory processing deficits in the reading impaired: A cr
Tallal, P., & Merzenich, M. (1997, November). Fast ForWord training for children with language-lear
Convention of the American Speech-Language-Hearing Association, Boston.
Tallal, P., Miller, S., Bedi, G., Byma, G., Wang, X., Nagarajan, S., et al. (1996). Language compreh
modified speech. Science, 682, 27-47.
Tallal, P., & Piercy, M. (1973). Defects of non-verbal auditory perception in children with developme
Tallal, P., & Piercy, M. (1974). Developmental aphasia: Rate of auditory processing and selective in
Troia, G. (2003). Auditory perceptual impairments and learning disabilities: Theoretical and empiric
Updike, C, & Connor, K. (2003, November). Classroom amplification and its impact on auditory disc
American Speech-Language-Hearing Association, Chicago.
Voyer, D. (2003). Reliability and magnitude of perceptual asymmetries in a dichotic word recognitio
Watson, C, Kidd, G., Horner, D., Connell, P., Lowther, A., Eddins, D., et al. (2003). Sensory, cogniti
school children: The Benton-IU Project. Journal of Learning Disabilities, 36(2), 165-197.
Wulff, H. R. (1986). Rational diagnosis and treatment. Journal of Medical Philosophy, 11, 123-124.
Ylvisaker, M., Coelho, C, Kennedy, M., Sohlberg, M. M., Turkstra, L., Avery, J., & Yorkston, K. (200
making. Journal of Medical Speech-Language Pathology, 70(3), xxv-xxxiii.

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Received July 12, 2006
Revision received January 1, 2007
Accepted August 9, 2007
DOI: 10.1044/1058-0360(2008/002)
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