

Tutorial

It Is Time to Rethink Central Auditory Processing Disorder Protocols for School-Aged Children

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Purpose: The purpose of this article is to review the literature that pertains to ongoing concerns regarding the central auditory processing construct among school-aged children and to assess whether the degree of uncertainty surrounding central auditory processing disorder (CAPD) warrants a change in current protocols.

Method: Methodology on this topic included a review of relevant and recent literature through electronic search tools (e.g., ComDisDome, PsycINFO, Medline, and Cochrane databases); published texts; as well as published articles from the *Journal of the American Academy of Audiology*; the *American Journal of Audiology*; the *Journal of Speech, Language, and Hearing Research*; and *Language, Speech, and Hearing Services in Schools*.

Results: This review revealed strong support for the following: (a) Current testing of CAPD is highly influenced by nonauditory factors, including memory, attention, language, and executive function; (b) the lack of agreement regarding the performance criteria for diagnosis is concerning; (c) the contribution of auditory processing abilities to language, reading, and academic and listening abilities, as assessed by current measures, is not significant; and (d) the effectiveness of auditory interventions for improving communication abilities has not been established.

Conclusions: Routine use of CAPD test protocols cannot be supported, and strong consideration should be given to redirecting focus on assessing overall listening abilities. Also, intervention needs to be contextualized and functional. A suggested protocol is provided for consideration. All of these issues warrant ongoing research.

After many years of discussion, the reality of central auditory processing disorder (CAPD) as a diagnostic construct is still far from any scenario that would put an end to the ongoing questioning of both its existence and its value. The concept of CAPD as a unique diagnostic entity that could be assessed and treated in school-aged children continues to engender controversy. Cacace and McFarland (2005) described the current status of CAPD construct as stalled; Cowan, Rosen, and Moore (2009) referred to the auditory processing-related research as “stagnating” (p. 188); and even proponents of CAPD have admitted that the persistent lack of evidence validating the nature of the disorder and the most appropriate test protocol threatens its viability as a diagnostic entity (Bellis, 2002; Dawes & Bishop, 2009; DeBonis & Moncrieff, 2008).

The purpose of this article is to review the literature that pertains to ongoing concerns regarding the central auditory processing construct among school-aged children and to assess whether the degree of uncertainty surrounding CAPD warrants a change in current protocols.

CAPD and Auditory Processing Disorder (APD)

It may be helpful to first clarify the use of the terms *central auditory processing disorder* and *auditory processing disorder*. CAPD was the original diagnostic term used for individuals who were believed to “exhibit sensory processing deficits that are more pronounced in the auditory modality” (American Speech-Language-Hearing Association [ASHA], 2005, p. 2). Jerger and Musiek (2000), working with 14 scientists and clinicians, recommended use of the latter term in an effort to avoid attachment of specific anatomic loci to the disorder and to better reflect peripheral and central contributions to the auditory difficulties. Although ASHA (2005) continued to support the use of the CAPD terminology, they also conceded that the terms could be used

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interchangeably. In view of this history, some authors use the acronym (C)APD in their writing. In this article I use the acronym CAPD.

Definition of CAPD

The ASHA (2005) technical report stated that CAPDs refer to difficulties in the perceptual processing of auditory information in the central nervous system as demonstrated by poor performance in one or more of the following areas: auditory discrimination, auditory pattern recognition, temporal aspects of audition, auditory performance in competing acoustic signals, and auditory performance with degraded acoustic signals. Jerger and Musiek (2000) 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,” which may underlie problems in understanding speech in the presence of noise, in degraded speech, and in direction following (p. 467). Although ASHA agrees that individuals who have CAPD exhibit deficits in processing that are more substantial in the auditory modality, it also admits that sensory processing involves multiple modalities as well as support from cognitive and language systems, making complete modality specificity unlikely. Medwetsky (2011) agreed that pure auditory processing is unlikely, stating that “the processing of spoken language entails the intertwining of auditory, cognitive and language mechanisms that are often engaged simultaneously” (p. 291).

Traditional CAPD Testing

Both the American Academy of Audiology (AAA, 2010) and ASHA (2005) described the CAPD test process as one that involves the following: (a) ruling out cognitive or language deficits through speech-language and psycho-educational testing, (b) ruling out peripheral deficits through hearing and immittance testing, (c) gathering case history information, (d) performing tests of auditory processing, (e) interpreting test results, and (f) developing and implementing a management plan in conjunction with other professionals. The types of tests recommended in the battery include (a) temporal processes and pattern recognition; (b) dichotic listening; (c) monaural low-redundancy speech perception; (d) localization, lateralization, and binaural interaction; (e) auditory discrimination; (f) electroacoustic tests; and (g) electrophysiological measures. The traditional testing process supports the view that CAPD is primarily due to reduced function of the bottom-up aspects of the auditory system. Once testing is completed, the audiologist must determine which of a number of pass-fail criteria to use in order to determine whether a diagnosis will be made. If a diagnosis is made, both ASHA and AAA stated that recommendations should include bottom-up (i.e., auditory training) and top-down (e.g., language intervention, strategy instruction) activities to address the fundamental auditory deficits and related communication difficulties. Although

the traditional CAPD test protocol appears reasonable, the literature suggests otherwise.

Testing Issues

Dichotic Listening Tasks

Tests of auditory processing have included dichotic tests for more than four decades on the basis of Kimura’s (1967) model of ipsilateral and contralateral auditory pathways, the role of the left hemisphere in processing language, the role of the corpus callosum in communication between hemispheres, and the resulting right-ear advantage commonly found in young children or individuals with corpus callosum impairment (Jerger, 2007). 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. Rather, she attributed this pattern to the presence of an auditory-specific deficit in processing speech during binaural listening.

However, research has now established that performance on dichotic listening tasks is greatly influenced by allocation of attentional resources, which is different when the listening mode is one of divided attention (listeners repeat back everything heard in both ears) versus directed attention (listeners repeat back only what is heard in one of the two ears). The size of the performance difference by ear is affected by the listening mode (i.e., the difference is greater when attention is divided), and, according to Martin, Jerger, and Mehta (2007), this difference shows up on both behavioral and event-related potential measures. The researchers also suggested that performance differences between ears on dichotic tasks may be minimized when memory is controlled.

Hugdahl (2003) suggested that although a right-ear advantage on a directed-left task could suggest underdevelopment or impairment of the corpus callosum, it also could reflect executive function deficits. Lawfield, McFarland, and Cacace (2011) found that the magnitude of the right-ear advantage noted on dichotic digits testing was greatest when three-digit pairs were used in conjunction with verbal reproduction as a means of responding, suggesting the influence of nonperceptual factors of response mode and working memory. Consistent with this, Maerlender, Wallis, and Isquith (2004), on the basis of correlations noted between performance on dichotic digits and the Digit Span Test of the Wechsler Intelligence Scale for Children—Fourth Edition (Wechsler, 2004), suggested that tests of auditory working memory would be more sensitive to auditory processing disorders. Kelly, Purdy, and Sharma (2009) did not find correlations between scores on a dichotic digits task and memory but did find correlations between dichotic digits and sustained attention. Loo, Bamiou, and Rosen (2013) described competing sentence tasks as tapping short-term auditory memory and language processing skills. McFarland and Cacace (2009) concluded that dichotic

measures “are not well suited and, for that matter, are less than optimal for studying disorders of auditory perception” (p. 97).

Speech-in-Noise and Low-Pass Filtered Speech Testing

Anderson and Kraus (2010), in describing the processes that allow a listener to identify a “target” speaker from noise, stated that one’s first task is to form an auditory object, which is required for stream segregation and allows the listener to extract meaning from a noisy environment. Fundamental frequency and second harmonics support a process of “auditory grouping,” which allows the listener to attach an identity to a speaker’s voice. Further, speech onsets, offsets, and phoneme transitions allow the listener to target speech from background noise. Although the role of the brainstem in encoding pitch and temporal cues to provide the cortex with a “sharply tuned and stable representation of the stimulus” (p. 582) is crucial, these processes are mediated by attention and memory. As Anderson and Kraus noted, auditory attention is required to extract the relevant aspects of the signal from the noise; these signal features are then stored in working memory. Such higher level cognitive skills can alter brainstem responses to speech, thereby influencing speech understanding.

In contrast, Kidd, Watson, and Gygi (2007) reported that speech understanding scores are not correlated with measures of spectral or temporal acuity and concluded that a specialized ability to recognize familiar sound, which is independent of general cognitive ability and spectral–temporal acuity, may be most relevant to speech-in-noise performance.

Tamati, Gilbert, and Pisoni (2013) investigated the sensory, perceptual, and neurocognitive differences between young listeners with good hearing and those with poor hearing using the Perceptually Robust English Sentence Test (Gilbert, Tamati, & Pisoni, 2013). The researchers found that listeners with good hearing outperformed listeners with poor hearing on measures of short-term and working memory, vocabulary, and executive functions. Further, Rudner, Ronnberg, and Lunner (2011) found that the crucial factor in a listener’s ability to understand speech in noise was working memory.

Ferguson, Hall, Moore, and Riley (2011) found high correlations between scores for the Attention and Noise sections of the Children’s Auditory Processing Performance Scale (Smoski, Brunt, & Tannahill, 1992) for listeners with CAPD ($r = .75$) and hypothesized that attention is the underlying deficit in these listeners and that this becomes apparent in adverse listening conditions. The researchers noted that this is consistent with data from Moore, Ferguson, Edmondson-Jones, Ratib, and Riley (2010) indicating that speech-in-noise, communication, and listening abilities are better predicted by measures of attention than by sensory processing or psychoacoustic testing. Citing research by Schmithorst, Holland, and Plante (2011) that showed that low-pass filtered speech test results correlate with white matter

in brain regions related to working memory for speech as well as the genu of the corpus callosum, Ferguson et al. concluded that low-pass filtered speech testing assesses linguistic competence rather than auditory processing.

The Listening in Spatialized Noise–Sentences Test (LISN-S; Cameron & Dillon, 2007) creates a three-dimensional environment, allowing examiners to measure an individual’s threshold for sentences in the presence of multitalker noise as well as the influence of vocal pitch cues, spatial cues, or both on sentence understanding. By manipulating the maskers’ location in space and altering whether the speaker’s vocal quality is the same as or different from that of the target speaker, this test can help identify not only whether a listener has an auditory streaming segregation disorder but, more specifically, whether the disorder is of a spatial or vocal nature. In this way, the test can identify the reason for reduced performance on the basis of the type of cues that are not being used effectively by the listener. If, as Cameron and Dillon (2008) suggested, the test can separate out those with learning and attention issues and those with auditory stream segmentation difficulties, it could represent an impressive new test for children with listening challenges.

Temporal Processing Tests

McFarland and Cacace (2009), in a brief discussion of temporal processing tests, noted that because of the similarity that exists between perceptual motor tasks found in the psychology literature and certain tests of auditory processing, data collected from the former are helpful to the understanding of CAPD tasks. The researchers added that such perceptual motor tasks use both visual and auditory stimuli and that correlations exist between performance on such tasks and intelligence, suggesting that they assess “more than just modality-specific processes” (p. 101). Other research by McFarland, Cacace, and Setzen (1998) found differences in performance on temporal order tasks in the auditory and visual modalities, highlighting the role of perceptual mechanisms. McFarland and Cacace (2009) concluded that temporal processing tests assess “both modality-specific abilities and more generalized amodal abilities” (p. 101).

Kelly et al. (2009) found that in a sample of 49 children who were diagnosed with auditory processing disorders, 82% failed a frequency pattern task bilaterally. The researchers noted that the challenging demands of the task, such as attending to the directions, discriminating the tone frequencies, remembering the auditory sequence, and then labeling it, may affect performance. Loo et al. (2013) found that performance on gap detection tests was worse in listeners who had a language-related deficit. The researchers hypothesized that this reflects the underlying reduced attention in those with language or reading difficulties.

Concerns Across Tests

Wallach (2011), making a strong case for the critical role of language in speech perception, suggested that although current CAPD testing may be sensitive to reduced abilities

of some sort, the results are not confined to auditory skill areas and reflect broader underlying problems in language comprehension and metalinguistic awareness. Consistent with this, Dawes and Bishop (2009) compared children with a CAPD diagnosis to children diagnosed with dyslexia and found similarly elevated instances of attention, reading, and language deficits in both groups. Further, Kelly et al. (2009) found that 76% of a sample of 68 children with suspected auditory processing disorder also had language impairment. More than half (53%) demonstrated reduced sustained auditory attention, and 59% demonstrated decreased auditory memory. It is interesting that Sutcliffe and Bishop (2002) found that initial significant correlations between test scores for auditory processing, language, reading, and attention of 6- and 7-year-old children were no longer noted when attention effects were controlled. Acknowledging the similarities they found among children with language impairment, children with auditory processing disorders, and typical learners on parental reports of communication, listening, and behavioral skills as well as cognitive and language abilities, Ferguson et al. (2011) concluded that “the current labels of CAPD and SLI [specific language impairment] may, for all practical purposes, be indistinguishable” (p. 225).

Wallach (2011) concluded that children diagnosed with CAPD likely have disorders of a broader nature that would best be assessed by a multidisciplinary team. The researcher suggested that CAPD test findings represent the “tip of the iceberg” and that abnormal performance will always require further testing in order to reveal the true nature of a student’s difficulties. B. U. Watson and Miller (1993) noted that reduced performance on challenging psychophysical tasks could be an indicator that cognitive deficits are present (Hautus, Setchell, Waldie, & Kirk, 2003; Zaidan & Baran, 2013). The British Society of Audiology (BSA, 2011a), in its position statement on auditory processing disorders, concluded that auditory processing disorder is “closely associated with impaired top-down, cognitive function” and that there is “no evidence that it is produced by a primary, sensory disability” (p. 6).

Test Psychometrics

Test reliability and validity have long been issues in any discussion of CAPD. One approach to establishing test validity is to use individuals who have lesions of the central nervous system on the premise that a test that has 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 CAPD (AAA, 2010; ASHA, 2005). However, Cacace and McFarland (2005) expressed concern with this approach because brain lesions do not often affect auditory areas alone, and Bellis (2003) questioned the soundness of using data collected from adults with brain lesions to draw conclusions about test validity for children who do not have such lesions. The BSA (2011a) criticized this neurologic approach to establishing validity, and Dillon, Cameron, Glyde, Wilson, and Tomlin (2012) described this

approach as an “unnecessary restriction on the development of useful tests” (p. 98) because there is no reason to believe that sensitivity and specificity data collected from lesion studies (on the basis of the availability of a “gold standard” in the form of some sort of brain image) would apply to children whose listening difficulties were of a different nature. Further, because there is no “gold standard” allowing definitive confirmation of the CAPD diagnosis, sensitivity and specificity data cannot be collected. Keith (2009) pointed out the irony in consensus statements that urge the use of norm-referenced tests of central auditory function even though few such tests exist and there is no agreed-upon definition of the disorder.

Electrophysiological Testing

It had been hoped that at this point in the history of the CAPD construct the use of electrophysiological measures would provide audiologists with a nonbehavioral CAPD assessment alternative to resolve some of the previously noted testing issues. In fact, more than a decade ago, Jerger and Musiek (2000) recommended that behavioral measures be supplemented with otoacoustic emissions and auditory evoked response testing, but others, including Katz et al. (2002), disagreed on the basis of a lack of research supporting the value of such tests for assessing CAPD in school-aged children.

The AAA (2010) cautioned that there are no widely supported criteria for when auditory evoked testing should be included in the CAPD battery, no accepted measurement procedures for cortical-related auditory evoked responses and no normative data across the life span. Cacace and McFarland (2013) suggested that (a) scalp electrodes may not be able to detect some relevant potentials; (b) the biophysics involved in using scalp electrodes makes interpretation of results challenging; (c) responses may not all be from modality-specific structures, particularly for longer latency potentials, which would most likely be of greater value; and (d) reliability issues may reduce the value of speech evoked auditory brainstem testing and mismatched negativity. The AAA also reported limited availability of advanced equipment with the capability to perform speech evoked auditory responses and predicted that additional research and clinical use will be needed before such techniques might be useful in the assessment of CAPD.

Criteria for Making the Diagnosis

The AAA’s (2010) guidelines on CAPD testing suggested that scores of 2 *SDs* below the mean in at least one ear on at least two different behavioral tests of CAPD determine the presence of the disorder. ASHA (2005) stated that the diagnosis of CAPD requires performance deficits of 2 *SDs* below the mean on two or more tests in a given battery. However, diagnosis may also be made if performance on any one test is 3 *SDs* below the mean or if 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 problematic. Rates of misdiagnosis are likely to increase in cases where test reliabilities are low, multiple tests are used, and reduced performance on a small number of tests is considered evidence of the disorder (McFarland & Cacace, 2006).

W. J. Wilson and Arnott (2013), noting that some audiologists make diagnostic decisions on the basis of recommendations provided by individual researchers (e.g., Bellis, 2003; Dawes & Bishop, 2009), found that in a sample of records of 150 school-aged children who had completed at least four CAPD tests, rates of diagnosis ranged from 7.3% to 96% depending on the criteria used. Given this, the researchers suggested that the use of CAPD as a global label be discontinued.

Candidacy

Both the AAA (2010) and ASHA (2005) suggested that audiologists require potential candidates for tests of auditory processing to first have language and psycho-educational testing performed in order to rule out listening and learning difficulties that stem from broader deficits in cognition, attention, memory, or language comprehension. However, this does not consistently occur in day-to-day clinical practice. One possible reason is that some parents find that attributing a child's difficulties to an auditory processing disorder is less stigmatizing and easier to communicate than other diagnoses; this creates a strong motivation for CAPD testing and a weak motivation for pursuing cognitive testing prior to the CAPD assessment (Cowan et al., 2009; Kamhi, 2004).

Another possible reason for the popularity of the CAPD construct is the appealing and widely held but unsupported notion that CAPD is the underlying cause of a range of complex language and literacy deficits that can be remediated indirectly by targeting isolated auditory processing skills (Kamhi, 2004). From the perspective of a parent or professional who adheres to this line of reasoning, testing for CAPD should be done first in the diagnostic process rather than last. Cowan et al. (2009) summarized this situation by stating that "the primacy given to auditory processing abilities has resulted at times in neglect of other cognitive factors" (p. 192).

Another obstacle to fully ruling out global deficits prior to CAPD testing occurs when the audiologist receives incomplete speech and language assessments that tap only areas of basic language knowledge and not information about the student's higher level cognitive-linguistic skills or ability to use these skills to succeed academically (Medwetsky, 2011; Richard, 2011). This may be due to a lack of training among speech-language pathologists (Blood, Blood, Gordon, & Mamett, 2010), a tendency among clinicians to rely on a limited number of familiar tests of language (Caesar & Kohler, 2009), a lack of time to conduct more detailed assessments (Blenkarn, Fallon, Katz, Maag, & Smith, 2010), or a shortage of school speech-language clinicians (Edgar & Rosa-Lugo, 2007). Whatever the reason, the combination

of a highly popular construct that is (incorrectly) believed to be the key to unlocking the true nature of a child's listening and academic difficulties with obstacles that make it harder for parents to obtain data about their child's cognitive and language abilities has very likely increased the chances that the testing and subsequent assignment of a CAPD diagnosis occurs in children whose true deficits involve language, memory, or attention.

Contribution of Auditory Processing to School-Related Skills

CAPD and Language and Reading Abilities

Despite Tallal and Piercy's (1973, 1974) findings that children with reduced phonological processing have temporal processing deficits, the literature has consistently suggested that the presence of a CAPD is not the cause of language or reading difficulties. Mody, Studdert-Kennedy, and Brady (1997) found that when children with reading difficulties were asked to discriminate tones on the basis of acoustic transitions and then consonant-vowel syllable pairs on the basis of articulatory features, readers with less skill performed similarly to readers with more skill when relying on acoustic features but more poorly when using phonetic features. The researchers concluded that the underlying deficit in reading difficulties is linguistic, not auditory.

Others have also failed to support differences in performance between individuals who are good readers and individuals who are poor readers on auditory temporal discrimination tasks (McAnally, Castles, & Bannister, 2004). Halliday and Bishop (2006) found that although a group of children with dyslexia did have poorer frequency discrimination, the perceptual deficit could not be explained on the basis of processing of temporal cues because deficits were noted at frequencies where temporal cues are not available. Hazan, Messaoud-Galusi, Nouwens, Rosen, and Shakespeare (2009), comparing the performance of adults diagnosed with dyslexia and adults who are average readers on speech perception tasks, found little support for an underlying speech perception deficit in dyslexia. The researchers suggested that some of the poor performances noted were due to non-sensory factors, such as attention.

C. S. Watson and Kidd (2009) noted that data collected by Thurstone (1938, 1947) support "independent auditory abilities for speech recognition and for auditory spectral-temporal acuity" (p. 226). C. S. Watson et al. (2003), studying the extent to which certain sensory, cognitive, and linguistic factors were associated with performance in the first years of school, found low correlations between auditory processing skills and both reading achievement and language abilities.

CAPD and Listening Ability

What about the presumed relationship between listening abilities and auditory processing skills? Moore (2011) and Moore et al. (2010) found that initial significant correlations between auditory processing and caregiver reports

of listening and communication abilities were greatly reduced once the contribution of cognitive abilities (i.e., attention and working memory) was removed from task performance. The researchers concluded from their studies conducted over an 8-year period that children with listening deficits have underlying auditory cognitive deficits in the areas of working memory and attention that will most likely not be identified by tests of auditory processing. They recommended that research and clinical work related to auditory processing be based on an understanding of the disorder as one primarily involving impaired attention. Sharma, Dhamani, Leung, and Carlile (2014) found children with listening-in-noise difficulties to be slower in their ability to switch their auditory attention and demonstrate behavioral inhibition.

Kamhi (2011) viewed “auditory perceptual deficits as a processing problem that may occur with common developmental, language, and reading disabilities rather than as a distinct clinical entity” (p. 266). Cowan et al. (2009) summarized the current state of affairs regarding the importance of central auditory processing abilities by stating that such impairments have not been shown to uniquely contribute to a clearly defined condition that would warrant its inclusion in any of the major disease classification systems, such as the *Diagnostic and Statistical Manual of Mental Disorders* (5th ed.; American Psychiatric Association, 2013) or the *International Classification of Functioning, Disability and Health* (World Health Organization, 2001).

Attention-Deficit/Hyperactivity Disorder (ADHD)

Given that attention, memory, and executive functions are all noted in the literature as being associated with listening abilities as well as the frequency with which one or all of these skill areas are compromised in individuals with ADHD, at least brief mention should be made of this disorder.

ADHD is considered the most common behavioral disorder of childhood (Barkley, 1997). Individuals with this disorder frequently exhibit impulsivity (Barkley, 1997; Schachar, Tannock, & Logan, 1993); hyperactivity (Barkley & Cunningham, 1979); inconsistent task performance (Douglas, 1972); and academic (August & Garfinkel, 1990), social (Cunningham & Siegel, 1987), and emotional (Szatmari, Offord, & Boyle, 1989) challenges.

Currently viewed as a disorder of behavioral inhibition that interferes with executive functions such as working memory and self-regulation (Barkley, 1997; Clark & Kinsella, 2000), this construct enjoys research support found in studies of brain structure (Hynd, Semrud-Clikeman, Lorys, Novey, & Elopulos, 1990) and brain function (Zametkin et al., 1990) and in the behavioral neuropsychological literature (Berlin, Bohlin, Nyberg, & Olof, 2004). Psychostimulants have been the most extensively investigated and most effective drug intervention for ADHD (Scheffler et al., 2009), presumably because of their effect on the availability of certain brain chemicals that stimulate the frontal lobes and executive function brain centers (Volkow et al.,

2007). Any effort to improve assessment protocols for identifying children who have listening difficulties certainly must acknowledge the important role of attention, memory, and executive functions and be flexible enough to be used with these students.

Intervention

Because the focus of this article is primarily on CAPD test protocols with school-aged children, only a brief mention of recent intervention research is provided. Fey et al. (2011), in a review of all peer-reviewed articles published between 1978 and 2008 that used auditory or language interventions with school-aged children, did not find any “compelling evidence that existing auditory interventions make any significant contributions to auditory, language, or academic outcomes of school-aged children who have been diagnosed with [C]APD” (p. 254). A systematic meta-analytic review by Strong, Torgerson, Torgerson, and Hulme (2011) led researchers to conclude that evidence does not exist to suggest that Fast ForWord is effective for remediating reading or language deficits. Loo, Bamiou, Campbell, and Luxon (2010), in a systematic review of studies that used computer-based auditory interventions in children, concluded that positive effects on language and reading are not noted. W. J. Wilson, Arnott, and Henning (2013) described the evidence that auditory training results in quantifiable electrophysiological changes in children with CAPD as limited, and Miller (2011) stated that inconsistent correlations between electrophysiological and behavior changes after intervention make conclusions about causality difficult.

Summary

Despite great efforts by many to resolve the ongoing uncertainties that surround the CAPD construct as applied to school-aged children who have no known neurological impairment, the process by which students are referred, tested, and treated continues to be viewed with skepticism. It is ironic that the popularity of the construct continues to grow on the basis of the unsupported notion that auditory processing deficits cause a range of global language and listening deficits. Research now suggests that auditory processing skills, as measured by routinely used tools, contribute very little to difficulties in reading, spelling, academic achievement, or even listening ability (Halliday & Bishop, 2006; Mody et al., 1997; C. S. Watson et al., 2003). Further, performance on commonly used tests of auditory processing have been shown to reflect general intelligence, attention, memory, language comprehension, and executive functions, thus raising serious questions about the value of such tests. Last, although certain authorities insist on the role of auditory training in reducing the negative effect of CAPD (AAA, 2010; Bellis, 2006), the lack of research supporting intervention efficacy and effectiveness raises questions about the utility of decontextualized auditory interventions for school-aged children.

Conclusions and Recommendations

As clinicians seek to provide more defensible assessment procedures and more effective support for children who have undiagnosed listening and communication difficulties, the following changes in daily clinical practice regarding CAPD in school-aged children are urged. This recommended process is summarized in Figure 1.

Assess and Treat Global Deficits

Considering that the popularity of the CAPD construct is based on ideas and associations that have not been supported by research (Fey, Kamhi, & Richard, 2012; Kamhi, 2004; Moore, 2011; C. S. Watson et al., 2003) and the rate at which auditory processing, language, reading, attention, and memory difficulties co-occur (Kelly et al., 2009), audiologists must begin a campaign to re-educate parents and other professionals regarding the critical need to pursue thorough testing of language and cognitive abilities when students present with listening and communication difficulties. On the basis of research supporting the importance of language, early literacy, attention, and memory to a child's ability to listen and learn (Bellis, Chermak, Musiek, & Weihing, 2012; C. S. Watson et al., 2003), students with undiagnosed listening challenges need to undergo tests of the peripheral auditory system, memory, executive

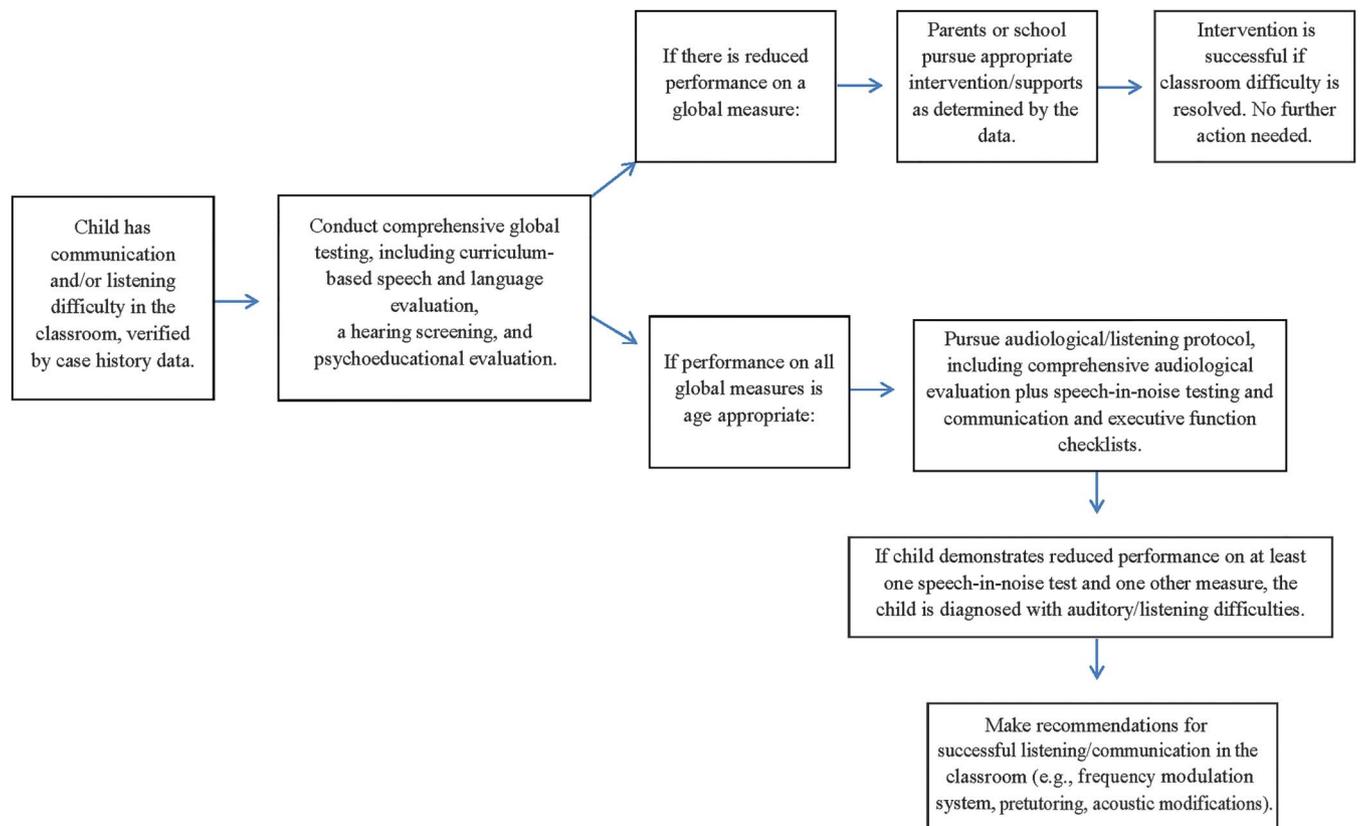
functioning, attention, and higher level language abilities before undergoing other tests.

Considering the possible challenges that parents may face in securing comprehensive assessments (Blenkarn et al., 2010; Blood et al., 2010; Caesar & Kohler, 2009; Edgar & Rosa-Lugo, 2007), it may be necessary for audiologists to establish new relationships with speech-language pathologists and psychologists who can provide thorough assessments and the data needed to advocate for appropriate intervention, academic supports, accommodations, and educational classifications when students are identified with deficits of a broader nature. For these students, further testing is unnecessary as their presenting difficulties may likely be explained by language or cognitive deficits.

Focus on Identifying Students Who Have General Listening Deficits Rather Than Auditory Processing Deficits

For those students who demonstrate little to no cognitive or language deficits but appear to exhibit communication and listening breakdown in the classroom, audiologists need to shift focus to the assessment of general listening deficits (Dillon et al., 2012). As one considers the lack of evidence that auditory processing tests truly measure auditory processing abilities and that auditory processing, as currently

Figure 1. The recommended assessment and intervention process for children with listening and communication difficulties in the classroom.



assessed, contributes significantly to one's academic and listening success in the classroom (Moore, 2011; Moore et al., 2010), this shift to directly assessing listening abilities is valid.

The conceptualization of auditory and listening difficulties used in this article is consistent with that of Medwetsky (2009), who noted that even at the most basic level, both bottom-up (e.g., analysis of acoustic signals) and top-down (e.g., language knowledge) processes merge. Medwetsky added that if clinicians' assessment goal is to "determine why individuals break down in everyday life" (where both auditory and higher level cognitive processes work together), clinicians should "adopt a view that considers all of the factors that may be involved in the normal processing of acoustic stimuli, primarily speech" (p. 588). This conceptualization is also consistent with that of Dillon et al. (2012), who recommended that audiologists focus on "identifying patients who have more than usual difficulty understanding speech in (real-life) difficult listening conditions" (p. 97), which could include disorders of "perceptual processing, sensory attention, or higher level cognition" (p. 98).

Adopt an Auditory–Listening Test Protocol

This focus on listening is accomplished through use of a protocol that includes psychometrically sound checklists sensitive to the effects of attention, memory, and executive functions that have been shown to distinguish children who do and do not have communication impairment. In addition, the protocol must include reliable and valid measures of speech-in-noise abilities suitable for use with children.

The value of speech-in-noise testing in this recommended protocol is consistent with Putter-Katz et al. (2002), who examined data on 20 children referred due to some type of listening difficulty and found that all 20 demonstrated speech-in-noise deficits. Also, high correlations reported by Ferguson et al. (2011) between behavioral checklist ratings for noise and attention suggest that the adverse condition created by speech-in-noise testing may reveal underlying attention difficulties that contribute to overall listening deficits. As noted by Schafer (2010), measuring speech perception in noise "provides individualized information regarding a child's ability to function in a noisy classroom" and, when used with teacher questionnaires, can provide "a functional assessment in the child's customary learning environment" (p. 13). Consistent with the focus of identifying general listening deficits, and as summarized by Lewis, Hoover, Choi, and Steimachowicz (2010), speech-in-noise difficulties in children can be due to cognitive (Wightman, Callahan, Lutfi, Kistler, & Oh, 2003), linguistic (Nittrouer & Boothroyd, 1990), and acoustic (Mayo, Scobbie, Hewlett, & Waters, 2003) factors.

The specific tools that compose the recommended protocol follow. All measures should be administered based on the guidelines provided by the test developers so that the appropriate norms can be applied.

Behavior Rating Inventory of Executive Function (BRIEF). The BRIEF (Gioia, Isquith, Guy, & Kenworthy, 2000) is a questionnaire for parents and teachers of children

aged 5 to 18 years that allows professionals to assess executive function behaviors. The BRIEF can be administered and scored by individuals who do not have formal training in psychology, and interpretation of the scores is supported by software. The BRIEF was standardized and validated for use with boys and girls, and the sample used to establish normative data included a "range of racial and socioeconomic backgrounds and geographic locations, including inner city, urban, suburban, and rural environments" (Gioia et al., 2000, p. 5). Reddy, Hale, and Brodzinsky (2011) reported that the BRIEF yields "high internal consistency, with correlations ranging from .80 to .98, good test–retest reliability, and has moderate interrater reliability between parents and teacher ratings for the normative group" (p. 48). The researchers found the BRIEF to be valid in assessing school-aged children and adolescents, specifically those with ADHD, compared with a control sample. They also agreed that the BRIEF could provide differential diagnosis of the type of executive function impairment in children with ADHD as well as important information as part of a comprehensive evaluation for school-aged children suspected of having ADHD.

Jarrett, Riccio, and Siekierski (2005), comparing ratings from parents using the BRIEF and a similar questionnaire, concluded that the BRIEF's greater focus on metacognition and working memory makes it more useful for "effective intervention planning" (p. 93). Mahone et al. (2002) found that groups with ADHD scored higher on the BRIEF on all scales compared with two groups without ADHD and that correlations between BRIEF scores and scores on other parent rating measures were significant, ranging from .51 to .87. The researchers concluded that the BRIEF's sensitivity to a broad range of behavioral regulation difficulties, combined with the fact that it is a theory-driven tool, makes it potentially valuable for a diverse range of diagnostic groups.

Children's Communication Checklist–Second Edition (CCC-2). The CCC-2 (Bishop, 2003) was designed to serve as a general screener of communication impairment. As described by Geurts and Embrechts (2008), the CCC-2 assesses one's formal and social language and communication and yields a general communication composite, a social interaction deviance score, and a general pragmatic score. Bishop (2003) reported that internal consistency values for this tool ranged from .66 to .88. Interrater reliability was .40 for the general communication composite and .79 for the social interaction deviance score. Geurts (2007), using the Dutch version of the tool with children with no communication impairment, found internal consistency to range from .53 to .75 and test–retest reliability to range from .49 to .77. Using children with communication impairment, the researchers found internal consistency for the general communication composite to be between .82 and .89.

Norbury, Nash, Baird, and Bishop (2004) found that the tool could distinguish children with autism from those without autism and could identify children with particularly impaired pragmatic language. Geurts and Embrechts (2008) found that the CCC-2 could also distinguish children with

specific language impairment from those with autism spectrum disorder as well as children with ADHD from children with no impairment. The researchers characterized the CCC-2 as a valid instrument for distinguishing between children with and without language-related difficulties and one that can be used as a screener for a wide range of ages. Ferguson et al. (2011) stated that although it was originally developed for assessing language disorders, the CCC-2 is “currently the best constructed and validated measure of which we are aware for selectively screening for communication impairments” (p. 224).

Words-in-Noise Test (WIN). The WIN (R. H. Wilson, 2003) was created as a tool for measuring a listener’s ability to understand monosyllabic words presented in a background of multitalker babble. McArdle and Wilson (2008) used the WIN in studying potential variables on listeners’ understanding of speech in noise and found that although acoustic and phonetic factors accounted for nearly half of the shared variance, lexical factors accounted for only 3% of it. The researchers concluded that recognition of words in noise may be more of a bottom-up process.

In 2010, R. H. Wilson, Farmer, Gandhi, Shelburne, and Weaver published normative data for the WIN that applied to children aged 6 to 12 years. On the basis of the data collected, the researchers found (a) stable performance for children aged 9 to 12 years, (b) that the largest change in word recognition occurred between 6 and 7 years of age, and (c) slightly better performance among young adults compared with older children. These findings were consistent with those of other researchers, who have noted improved auditory listening abilities with age. Also, the performance data for the young adults used in this study were very similar to those of R. H. Wilson’s (2003) study.

Bamford-Kowal-Bench Speech in Noise Test (BKB-SIN). Schafer (2010) described the BKB-SIN (Bench, Kowal, & Bamford, 1979; Etymotic Research, 2005) as a tool designed to find the signal-to-noise ratio loss of the listener, which is defined as the “increase in the signal-to-noise ratio required by a listener to obtain 50% of key words correct as compared to normative data from normal hearing listeners at the same age” (p. 6). The test consists of sentences that are presented in multitalker babble and is to be used with school-aged children no younger than 5 years of age.

Bench et al. (1979) reported a lack of correlation between linguistic ability measures and scores on the BKB-SIN sentences, supporting its validity as a speech perception test. In addition, Kirk, Diefendorf, Pisoni, and Robbins (1979) interpreted better performance on BKB-SIN sentences compared with individual BKB-SIN words as support for the test as a valid measure of connected speech. Statistically significant correlations with self-report measures have also been reported by Donaldson et al. (2009) and Schafer and Wolfe (2008). Regarding test-retest reliability, Bamford and Wilson (1979) reported an average performance difference of ± 1.29 dB over a 3-month interval. Schafer (2010) concluded that the BKB-SIN “appears to be the most viable choice for measuring speech perception in noise with

school-aged children in the sound booth or in the classroom” (p. 13).

Make a Diagnosis

In order for a student to be identified as having a listening deficit, they must perform outside of the norms on at least two of the four measures, and at least one of these measures must be a speech-in-noise test. In interpreting test results, the audiologist should openly acknowledge that reduced performance could reflect deficits in some aspect of perceptual processing, global deficits involving language or cognition, or some combination thereof. The degree to which the listening deficits are attributable to language or cognitive factors will be due, at least in part, to the quality of the initial language and cognitive assessments that were done prior to this testing. There may be cases where more thorough global testing is needed in order to gain more insight into the nature of the listening problem.

Keep Recommendations Broad and Contextualized

Consistent with Dillon et al. (2012), reduced performance could lead to some immediate recommendations, such as changes in seating, intervention to improve vocabulary or the use of context, pretutoring, or the use of frequency modulation technology. This is consistent with BSA’s (2011b) guidance document on auditory processing disorders, which states that management can be based on either functional or test-driven deficits. Other forms of management that might be considered should focus on the use of top-down approaches. Moore (2011), an advocate for the role of auditory training, cautioned that the ability of training to transfer beyond the skills that were trained is still unresolved. He added that the client’s specific areas of difficulty, including understanding spoken language and following directions, need to be addressed. The use of contextualized material that links directly with classroom demands, along with long-term work aimed at improving the child’s language, memory, and attention skills, should be prioritized.

Measure the Effects of Intervention

Follow-up consultations with students, parents, and school personnel, which could include readministration of some or all of the tools, would be important. If the interventions put in place to address the identified challenges are effective, additional tests are not necessary. The fact that this has been accomplished with minimal use of tests of auditory processing is important because the use of multiple tests increases the chances that the child will perform poorly “for reasons unrelated to the patient’s real-life communication ability” (Dillon et al., 2012, p. 100).

Use Traditional CAPD Tests Rarely

Are there cases in which traditional auditory processing tests would still be useful? On the basis of the literature reviewed, the answer to this question could easily be *no*.

However, some audiologists might use some traditional tests in cases in which the original interventions put in place are not effective or when speech-in-noise testing is not impaired but behavioral questionnaires support real-world difficulty. In order to reflect the current state of the literature, audiologists who choose to do this should view these tests not as measures of auditory processing but rather as psychoacoustic tasks that may reflect some aspects of auditory, language, and/or cognitive ability (Dawes & Bishop, 2009; Sutcliffe & Bishop, 2002). In addition, these tests may have some value in providing information about functional deficits identified by the behavioral questionnaires. For example, reduced performance on a competing sentences test might signal selective attention issues that were not identified in other more global tests, or difficulty on the dichotic digits tests may reflect unaddressed memory deficits.

Long-Term and Ongoing Research Efforts

In order to determine whether CAPD is viable and whether it is a primarily auditory disorder, ongoing research will be needed. In the meantime, it is hoped that this new protocol will motivate audiologists to participate in a research-based testing process that does not require them to navigate the confusing landscape of a weak construct or to disentangle processes that are, by definition, intertwined. Their task is simply to identify children who appear to have overall listening deficits that could stem from any number of factors. This reasonable task for audiologists could be tremendously helpful to struggling school-aged listeners.

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