Recognizing and Treating Children with Central Auditory Processing Disorders

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What is CAPD?

Children and adults who have central auditory processing disorder (CAPD) are a heterogeneous group of people who have difficulty using auditory information to communicate and learn. CAPD is not a specific problem or disease; rather it is a set of problems that occur in different kinds of listening tasks. Often children with CAPD are first diagnosed with attention deficit hyperactivity disorder (ADHD) or learning disabilities. Later, an audiologist may render a diagnosis of CAPD. To audiologists, CAPD includes problems with one or more of the following auditory tasks (ASHA CAPD Task Force, 1996):

- Sound localization and lateralization
- Auditory discrimination
- Auditory pattern recognition
- Temporal aspects of audition (resolution, masking, integration, ordering)
- Auditory performance decrements with competing acoustic signals
- Auditory performance with degraded acoustic signals

Audiologists make the diagnosis using standardized tests of these skills administered in carefully controlled acoustic environments with very sophisticated calibrated equipment. Because the American Speech Language Hearing Association has determined that diagnosis of CAPD falls under the scope of practice of audiology, it is important to understand what the audiological diagnosis means.

Sound localization and lateralization refers to the ability of a child or adult to know where a sound has occurred in space. This is an important survival skill; localization is used to identify a source of sound, like a moving vehicle or barking dog.

Auditory discrimination refers to the ability to distinguish one sound from another. The term is most often used for distinguishing speech sounds, such as phoneme /p/ from phoneme /b/.

Auditory pattern recognition refers to the ability to determine similarities and differences in patterns of sounds.

Temporal aspects of auditory processing refers to the ability to sequence sounds, integrate a sequence of sounds into words or other meaningful combinations, and perceive sounds as separate when they quickly follow one another.

Auditory performance decrements refers to the ability to perceive speech or other sounds when another signal is present. The other signal might be noise or another similar speech signal, and the competing signal might be soft or loud.

Auditory performance with degraded acoustic signals refers to the ability to perceive a signal in which some of the information is missing. A degraded signal might be one where parts of the sound spectrum have been deleted, the highest or lowest frequency components of the sound are removed, or where the sound is compressed in time.

As can be seen from the above descriptions, these auditory tasks are not easily compared to what a teacher or parent might observe in the classroom or at home. A teacher might observe that a child cannot "listen" well when there is a lot of noise in the room. A parent might observe that the child is easily distracted when two people are talking to him or her at once. Because these functional "real life" behaviors are difficult to test objectively, and because they may be symptomatic of other problems not related to the auditory system, the audiologist must use more objective measures that may or may not directly correspond to these observable behaviors.

How does CAPD differ from "auditory processing disorders" described by other professionals?

CAPD is clearly recognized as a problem for many children and adults—as it affects language learning and contributes to reading disorder and dyslexia—and is well documented in research.

Often children diagnosed with CAPD may have received another diagnosis before being seen by an audiologist. The disorder can be confusing for parents, educators, and other professionals working with these children. For this reason, Dr. Jay Hall has stated that identifying the CAPD population requires the combined efforts of speech-language pathologists and audiologists. Often psychologists, physicians, and educators need to be included in the assessment and treatment team as well.

In previous diagnoses, speech-language pathologists may have referred to auditory- or language-processing disorders, which often have to do with weaknesses in auditory sequencing, auditory memory, and auditory closure. Some speech-language pathologists use the terms "receptive language disorder" and "abnormal auditory perception" synonymously. In this context, these disorders usually refer to specific language impairment where the child exhibits, as part of the language problem, difficulties with auditory tasks such as retaining sequences of numbers or following auditory directions. The speech-language pathologist may have also tested skills like phoneme discrimination, but it is important to determine whether this testing was done with calibrated equipment. Research has shown that auditory testing can result in quite variable results if the testing is not administered under well-controlled acoustic conditions.

Psychologists and educators recognize symptoms of CAPD as "poor listening comprehension," "difficulty following oral directions," or problems with "short-term auditory memory." A psychologist may ascertain that a child has an auditory-processing problem if the child scores disproportionately lower on auditory subsections of standardized tests than on visual-spatial subsections.

Incidence and etiology of CAPD

According to Chermak and Musiek (1998), the incidence of CAPD has been estimated to be as high as 3 to 5 percent and is more common than the incidence of hearing loss. Gravel, Wallace, and Ruben reported a study in 1996 in which they followed children with and without early ear infections (otitis media) from the first year of life through nine years of age. They found that these children, who experienced the mild, fluctuating hearing loss associated with otitis media, had long-term problems with

higher-order auditory-processing skills and learning. Thus, not only do many more children have auditory learning impairment from CAPD than from hearing loss, but the former may be a more "hidden" deficit because hearing impairment is usually recognized more easily and associated more directly with a marked effect on speech and language.

There is also a high occurrence of CAPD with other disorders of language and learning, such as attention deficit disorder (ADHD). Recent contributions from neuroscience have indicated that some language disorders and dyslexia may be secondary to deficits in the central auditory processes (Stark, R.E., & Tallal, 1988; Keith, R.W., & Novak, K.K., 1984; Musiek, F.E., Gollegly, K., & Ross, M., 1985; Young, M.L., & Protti-Patterson, E., 1984).

Because of the high incidence of CAPD and the resulting language and learning problems, researchers have been trying to determine the etiology. Some processing problems are thought to be genetic; sometimes other members of a family may exhibit similar processing weaknesses. Some processing problems may be caused by birth trauma or common childhood problems such as otitis media, as discussed above. Both maturational delays and idiosyncrasies in the central nervous system (CNS) are posited as causing CAPD. While the etiology of CAPD is not well understood, its devastating impact on children's ability to learn language and its negative effect on educational performance—particularly learning to read—has concerned parents, professionals, and educators for some time.

Distinguishing CAPD from ADHD

Conditions that may occur with CAPD include attention deficit disorder, dyslexia, language disorders, and various childhood syndromes such as autism. Gail Chermak and her colleagues, Jay Hall and Frank Musiek (1998, 1999), have conducted research that enables them to distinguish between behavioral manifestations of ADHD and symptoms of CAPD. By asking professionals to rank behavioral disorders observed in children diagnosed with CAPD versus ADHD, these researchers have provided a comparison list that can assist professionals in their behavioral assessments. The list is summarized below:

ADHD behaviors seen most often include:

- Inattention
- Distractibility
- Hyperactivity
- Restlessness
- Impulsivity
- Interruption/intrusion

CAPD behaviors seen most often include:

- Difficulty hearing in background noise
- Difficulty following directions
- Poor listening skills
- Academic difficulties
- Poor auditory association skills
- Distractibility
- Inattentiveness

CAPD and other neurological conditions

There are many adult populations that may also experience CAPD. Adults who have aphasia have been shown to have a high incidence of central auditory nervous system involvement, as have individuals who have certain neurological diseases. Among the latter population are those with multiple sclerosis and Parkinson's disease. Individuals who have received closed head trauma often have central and/or peripheral auditory involvement. While CAPD is most commonly identified in individuals with normal hearing, individuals with sensorineural (nerve-related) hearing loss can also experience CAPD. An individual who does poorly on auditory tests even with amplification may have a central component to their disability. Significant word-discrimination difficulty, when serious pathology has been ruled out, may also signal a processing deficit.

More recently, research has identified populations of individuals who have less well-understood but handicapping CAPD disorders. Obscure Auditory Dysfunction (OAD) refers to those individuals who have normal hearing thresholds, but who complain primarily about having problems hearing speech in noise. Many of these individuals demonstrate CAPD. Recently, researchers have identified a rare but severe form of CAPD called auditory neuropathy. Individuals with auditory neuropathy have normal cochlear function, usually identified by otoacoustic emission tests, but have abnormal auditory brainstem responses. Misunderstood as deaf, this population may not respond to amplification because the cochlea is not impaired, but they have marked speech and language impairment, significant learning disorder, and experience a very handicapping form of CAPD.

Audiological identification of CAPD

Because standard and traditional audiological tests were not sensitive to CAPD, researchers have developed behavioral tests that appear to be able to identify these disorders of the central auditory nervous system. As discussed earlier, these tests include those composed of low redundancy stimuli, such as filtered speech, time-compressed speech, and speech in noise. Other measures of CAPD include tests of sound localization, binaural fusion, masking level differences, and dichotic tasks. Tasks of temporal ordering and sequencing are also used. With advances in technology, more sophisticated tests have emerged, such as Auditory Brainstem Response, middle latencies (MLR), late latency and event-related responses (P300, mismatch negativity MNN), and fMRI. These neuroaudiological and radiological tests assess the integrity of the central auditory nervous system. Audiologists use a wide range of tests, including those that require a

behavioral response and those that are objective electrophysiological measures of central auditory nervous system integrity.

CAPD, language processing, and learning disability

Language can be reduced to a set of distinct sound components called phonemes. These are the smallest units of a language that distinguish words from one another and signal a change in meaning. Phonemes can indicate grammatical changes, as when /s/ is added to the noun "cat" to make it plural, or when /kt/ is added to the verb "walk," denoting past tense. A child who does not consistently process the consonant sounds that denote grammatical changes in words may become a child who exhibits an expressive language problem. This same child may also have such difficulty processing spoken language that understanding everyday oral communication is challenging enough to cause a receptive language deficit.

Because speech is a highly complex acoustic event that takes place over time, much research has tried to identify the acoustic attributes that must be processed for perception of phonemes to occur (Pisoni, 1984). Tallal and Newcombe (1978) indicated that temporal challenges involving the perception of rapidly changing speech signals (frequency formants) influence phoneme perception and possibly larger units of language. This led Tallal (1980) to propose that the processing of these rapidly changing acoustic events is a challenge to the central auditory processing of speech for normal individuals. In 1981, Tallal and Stark studied language-impaired children and identified auditory-processing difficulties involving syllables containing consonants. For the child with CAPD, processing speech in a classroom, where there may be varying levels of ambient noise, is challenging. Thus CAPD puts these children at risk for having learning disabilities and/or specific language impairments (Sloan, 1980; Leonard, 1999).

Those in the field of education and learning disabilities have long been aware of the impact of CAPD on academic performance and learning. It has been identified as one of the primary deficits that comprises learning disability. In 1967 the National Advisory Committee on Handicapped Children described specific learning disability as "…a disorder…which may manifest itself in an imperfect ability to listen, think, speak, read, write, spell, or to do mathematical calculation." In 1981 the National Joint Committee for Learning Disabilities revised the definition for learning disability to be "…a generic term that refers to the heterogeneous group of disorders manifested by significant difficulties in the acquisition and use of listening, speaking, reading, writing, reasoning, or mathematical abilities." Difficulty with listening ability (or auditory-processing problems) is clearly recognized as being a significant part of learning disability. With the growing body of literature on how children learn to read, and the knowledge that phonemic and phonological awareness—auditory components of reading—are the fundamental skills used when learning to read, the importance of auditory processing has taken on new significance.

Behavioral indications of CAPD in children

Infancy and early childhood

CAPD in children can manifest itself in early childhood. Parents whose children are identified as having CAPD often report that as infants, they did not readily alert or respond to voices and seemed to "tune out" even in the crib. At the other end of the spectrum are those infants who alert and attend to sounds in a manner that makes them appear to be hypersensitive. The latter population often develops difficulty with sound sensitivities and problems understanding speech in noise, which interferes with peer socialization, group function, and learning in large classes. As these infants approach 12 months, they may be seen by parents as talking less than peers, and parents may then begin asking pediatricians about having their child's hearing tested. It is not uncommon to hear parents say that their child has had numerous hearing tests, which have shown normal results. Yet for children who experience recurrent otitis media, poor listening and auditory-attending ability is attributed to residual effects of ear infections. Because 30 percent of children have at least one episode of otitis media during their first year of life, listening problems may be attributed to "a little fluid" or "stiff middle ear systems" when, in fact, listening problems may be a red flag signaling a developing processing problem. With the emergence of research that shows that 4- to 5-year-old children (Gunarson & Finitzo, 1991) with recurrent childhood otitis media have abnormal responses on auditory brainstem tests, the relationship between otitis media and CAPD is clear.

Preschool

As children enter nursery school, they begin to learn nursery rhymes and childhood songs. Children with CAPD may like music but appear to have difficulty learning the words. In nursery school, teachers identify these toddlers as ones who have difficulty sitting for story time or who require repetition of oral directions and need tactile or visual cues to attend when spoken to. Terms such as "daydreamer" or "selective listener" are attributed to the child with CAPD even in the prekindergarten years. Parents find that these youngsters often do not like to be read to and that they prefer puzzles or watching videos and television to listening to books. It is not uncommon for parents and educators to perceive the child with CAPD as one who frequently "tunes out" or who seems to be "in a world of his/her own." The children who appear to be hypersensitive to noise, covering their ears or avoiding noisy situations such as birthday parties or loud, unstructured play activities, are easier to spot but are often misidentified as seeking attention or being immature. Yet others appear to be so over-focused on television or visual activities that it is difficult to get their attention by calling to them. Because of the different and varying behaviors of children with CAPD, these characteristics are often misinterpreted as behavior problems, adjustment difficulties, and immaturity. While some maturational delays do exist, CAPD can be recognized and identified in young children and may be treated with the use of the Scientific Learning training programs: Fast ForWord, 4wd, and Step 4word.

Kindergarten

In kindergarten, children must learn to follow longer and more linguistically complex oral directions. Pre-reading skills are taught, and the children learn letter names and, more importantly, the sounds associated with letters. Phonemic-awareness skills—such as knowing that /t/ and /p/ are different sounds and knowing that the word *cat* is composed of the sounds /k/ /a/ /t/—require the accurate discrimination of individual phonemes. Phonological-awareness tasks—such as identifying the beginning, middle, and ending sounds of words—are tasks that children in kindergarten usually learn without difficulty. These skills create the foundation for learning to read (Lyon, 1994), but it is these very important pre-reading skills that, for the child who does not auditorally process phonemes with accuracy, are extremely difficult to master. Thus at the start of school and in the beginning stages of learning to read, the child with CAPD is identified as having problems. Unlike his or her peers, the child with CAPD may begin to struggle with pre-reading tasks and fall behind in academic progress.

Grade school

Some children make it through the preschool years without their listening or auditory-attending difficulties being noticed. They use compensating skills such as being alert to visual cues, picking up on body language, and anticipating what will be said. Because these children have to exert more energy to listen and are so visually alert, they are sometimes mistakenly thought to be "better listeners" than other students. Children with CAPD may also have difficulty carrying on telephone conversations, hearing announcements over loudspeakers, or understanding tape-recorded speech because of the lack of visual cues and the mild distortion unique to such speech transmission. They prefer videos to audiotapes and action games to listening to stories. First grade may be the first time these children are educated in large classrooms where oral instruction is one of the primary means of teaching. When phonics are introduced, and words must be separated into their individual phonemes, the child with CAPD may be slower than others but may mask their difficulty with eagerness to please and supplemental work at school or home. By the end of first grade, a child who experiences substantial CAPD may begin falling behind, misinterpret oral directions, and fail to master sound-symbol relationships. Difficulty with learning to read and mounting frustration usually helps these children get noticed so that they are identified at this time.

For other children, the years between first and third grade are a "grace period," when they manage to slide by with eagerness to please and attention to nonverbal cues and gestures. Although they appear to be slow to catch on, they watch other students when they have not heard what is said, and so their difficulties go unnoticed. Their "listening" problems are attributed to such notions as "boys are like that" or "she seems to be listening when she wants to." When a child cannot filter out background speech and noise, they may be seen as "hearing everything but what they are supposed to hear." The redundancy of elementary teaching techniques helps hide their CAPD until they enter the middle school years, at which point listening demands accelerate significantly and picture cues are dropped from textbooks. In the early grades, teachers can do a number of things that help the child with CAPD difficulty. Teachers can insert pauses in between

statements, repeat things frequently, use visual cues and aids routinely in instruction, and seat the child in the front of the class, all of which can help the child with CAPD. Reading skills, however, lag behind, but children with CAPD excel at math until word math problems appear. As the pace of oral instruction increases, CAPD surfaces and becomes recognized.

If the CAPD is significant, the child can become frustrated, which contributes to lowered self esteem, feelings of helplessness, and fear of failure, coupled with beginning to feel he or she is "dumb." Learning problems are often signaled by inconsistencies, and the same is true of CAPD. While children with CAPD are seen by educators and parents as "not being strong auditory learners," their inconsistent listening and auditory-attending abilities make them seem willful in their listening habits. Several factors contribute to this phenomenon. Fluctuations of ambient noise levels in the classroom vary considerably, causing children with CAPD to appear more easily distracted at some times compared to others. Teacher's voices may range from being 20 decibels louder or softer than the noise of the classroom, and the child's ability to hear instructions is complicated by factors such as the distance between child and teacher and the amount of reverberation in the room. The latter depends on the size of the room and the number of reverberating surfaces, such as hard floors, walls, and the flat surfaces of desks and chalkboards. Other factors that contribute to degradation of the speech presented in the classroom include: the pace and pitch of the teacher's voice; the direction the teacher faces when talking; the number of children in the room whose bodies absorb sound; the proximity of a classroom to noisy areas such as a hallway, the playground, or cafeteria; and the placement of the child in that room. For the child with normal auditory-processing abilities, the central nervous system beautifully fills in the missing parts, and there is little difficulty learning. The child with CAPD struggles to just listen and attend, using coping and compensating skills. These techniques require a lot of energy, which appears to cause some children with CAPD to fatigue easily. Fatigue further adds to their processing dilemmas and increases frustration. When children with CAPD feel lost or overwhelmed, they may lose interest and divert their attention, making them look as if they have ADHD. Children who experience CAPD may appear to be less able to process spoken language when they are tired, stressed, excited, or in transitions such as changing class or moving from one subject to another. With the numerous variables and the fluctuations that take place within each child and in the child's learning environment, it is not difficult to see how CAPD might affect a child's education, particularly learning to read.

Remediation of CAPD

Gail Chermak, Frank Musiek, and Jay Hall have written extensively on various techniques and procedures for clinical management of CAPD. Dr. Hall (2000) has emphasized the importance of classroom modifications for children diagnosed with CAPD. Some of Dr. Hall's recommendations include:

- Education of teachers and other school personnel about teaching strategies, modification of environment, and recognizing at-risk children
- Preferential seating so the child can see the teacher as he or she speaks, see the board easily, and have some distance from distracting noises

- Documentation and, when possible, reduction of classroom noise levels and echoes
- Reduction of noise, when possible, by use of acoustic ceiling tile, soft furniture, wall panels, and so on

Specialists may also recommend assistive listening devices (ALDs) in some cases. These devices slightly amplify an instructor's voice for the child. The child will customarily wear a receiver, and the teacher will use a microphone. ALDs vary in cost from $75 to $1600.

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The Scientific Learning training programs in remediation of CAPD

Battin, Young, and Burns (2000) reported data on 15 clinical cases randomly selected from a group of more than 50 children who had participated in the Fast ForWord program subsequent to audiological diagnosis of CAPD. In all cases, the audiologist/speech-language pathologist who administered the Fast ForWord program was the same professional who had initially diagnosed CAPD. In most cases the children had been referred for audiological testing because of academic and/or reading difficulties. Seven of the children, also diagnosed with language disorders, were analyzed for changes in language scores. Because the investigation was preliminary in nature, the authors opted for a retrospective study to determine whether further, more experimentally controlled investigation of CAPD and temporal processing/language training would be warranted.

All of the children had normal puretone thresholds except one female, who had recurrent otitis media with effusion since her first year of life: PTA 22dB, SRT 20 dB (air-bone gap not greater than 10 dB). Another female child had a 92% word-discrimination score for the left ear and 88% word-discrimination score for the right ear on initial testing but was re-tested two days later and received 100% bilaterally. That child had been diagnosed as "mildly aphasic."

Portions of the Test of Language Development (TOLD) were administered to those children for whom language testing was deemed appropriate. All seven language-impaired children received three subtests of the TOLD that will be reported here: oral vocabulary, grammatical understanding, and sentence imitation. Several CAPD batteries were administered, but the one used consistently with all 15 children was the SCAN, A Screening Test for Auditory Processing Disorders (Keith, 1986), so those data were reported.

Despite the small group, the children showed significant increases on all subtests of the SCAN. They averaged more than a 5-point standard-score increase on the Filtered Words subtest, $t=7.375$, $p<.0005$. On the Auditory Figure Ground subtest, the 15 children in this study showed an average 4.5-point standard-score increase after Fast ForWord, $t=5.315$; $p<.0005$. Finally, on the Competing Words subtest, the 15 subjects in this study made almost a 4-point standard-score increase after Fast ForWord, $t=4.375$; $p<.0005$.

Language post-test scores also showed large increases for the seven children for whom TOLD testing was conducted. The changes were reported as standard scores. On the Oral Vocabulary subtest of the TOLD, the children averaged more than a 4-point standard-score increase. On the Grammatical Understanding subtest, the children showed an average 3-point standard-score increase. Finally, on the Sentence Imitation subtest, the children averaged slightly more than a 2-point standard-score increase. No statistical

comparisons were made because this sample contained fewer than 10 language-impaired children; however, the results were consistent with those reported in the Fast ForWord National Field Trial, which was conducted with more than 500 children nationwide.

What to do if you think your child has CAPD

If your child fits the CAPD profile discussed here, the first step is to have your child's hearing tested. Fluctuations in hearing caused by middle-ear pathology and the possibility of sensorineural hearing loss needs to be ruled out first. If your child's hearing is normal, many audiologists have checklists that can help screen for CAPD. Consistent difficulty with listening in groups, ease of distraction by background noise, needing repetitions, frequently asking "huh?" or "what?", difficulty understanding what is said in noisy environments, and delayed responses when spoken to, are all behaviors suggesting that an audiological evaluation needs to be done, including testing for central auditory processing problems. Once CAPD has been identified, auditory training programs such as Fast ForWord, 4wd, and Step 4word are appropriate steps in the remediation process. Additional support from speech-language pathologists, teachers, and tutors may also be needed. Research in neuroplasticity (the ability to change how the brain functions with appropriate stimulation) indicates that brain function can be improved by the appropriate stimulation. These improvements are made possible by the research-based, auditory-language training programs developed by the neuroscientists at Scientific Learning Corporation. At last we have some help for the difficulty that CAPD can impose on children.

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