

**HEARING BEYOND THE EARS PART II:  
EVALUATION AND MANAGEMENT OF CENTRAL AUDITORY PROCESSING DISORDERS  
(CAPD)  
Part 2**

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It is important to remember that auditory impairments, including CAPD, are seldom 'all or none' phenomena. Any child who frequently mishears words, misses instructions, has difficulty rapidly and accurately processing verbal information, has trouble with the prosodic or musical aspects of speech, or has noticeable difficulty hearing in background noise, should be suspected of having an auditory processing deficit and should receive a thorough evaluation.

This is especially true of children with risk factors for auditory impairments, like:

- a history of frequent or prolonged ear infections
- head trauma
- birth distress or prematurity
- craniofacial or external ear abnormalities
- meningitis or other significant peri or prenatal infections, or
- a family history of CAPD or other auditory impairments.

**BEGINNING THE AUDITORY EVALUATION**

The auditory evaluation should begin with a visit to the primary care provider for a careful physical (otoscopic) examination for evidence of external canal obstruction or middle ear problems. Tympanometry (measuring the pressure behind the ear drum) should also be performed to look for evidence of middle ear or Eustachian tube problems not apparent on direct inspection.

Next, peripheral audiometry (tone test) should be performed to detect problems with the ears and auditory nerves. It is important to remember that the accuracy of peripheral audiometry is highly dependent upon the age and cooperation of the child being tested. For children younger than age 5, audiometry often detects only fairly severe bilateral hearing impairments. Even significant unilateral hearing loss can be missed.

One audiometric finding that is not often discussed but which we have found significant is *hyperacusis*, or hearing thresholds below normal levels. We have found that hyperacusis often accompanies CAPDs. When very low hearing thresholds correlate with symptoms like auditory overloading or significant sound sensitivity they should be regarded as significant.

Once the results of peripheral audiometry are obtained, it must be decided whether they are sufficient to account for the child's presenting problems. If they appear to be, then the next step is to initiate appropriate management. If not, further evaluation is required.

This evaluation should begin with a careful search for disorders of receptive language and memory. Language evaluation is especially important if the child has difficulty comprehending both written and spoken language, or if the child appears to have difficulty comprehending auditory information even given ideal acoustical conditions and sufficient processing time.

If both peripheral audiometry and receptive language appear intact, the child should, if possible, be evaluated with a thorough CAPD battery.

## **THE CAPD BATTERY**

CAPD testing is as much an art as a science, and the quality of a CAPD test battery is highly operator dependent. The choice of tests employed varies greatly among examiners, and it is important to verify that the test battery chosen is comprehensive enough to identify or exclude the full range of deficits that could account for the child's symptoms. Some centres that offer 'CAPD testing' actually only perform a limited battery of tests known as the SCAN-C. However, the SCAN-C detects only about 45% of children with CAPD, so by itself it is far from adequate as an evaluation for CAPD. (Bellis, 2003)

We haven't space in this paper to discuss all the tests available to evaluate central auditory processing. Those interested in learning more about such tests should read the article 'CAPD Tests' in the Spring 2004 edition of our on-line newsletter, <http://www.neurolearning.com/newspring04.htm>. In general, though, we would agree with audiologist Teri Bellis' recommendations that a truly comprehensive CAPD battery should include at least one test aimed at evaluating function in each of the following categories:

- Auditory pattern temporal ordering;
- Monaural separation/Auditory closure;
- Binaural separation;
- Binaural integration;
- Binaural interaction;
- Temporal gap detection; and
- Physiologic measures of auditory function, such as auditory brainstem response, middle latency response, or late event-related potentials (Bellis, 2003).

While CAPD testing can be useful for many children, it is not for everyone. CAPD testing is very rigorous and places considerable demands on the child for focused attention, physical and mental endurance, and the ability to process complex linguistic information. In addition, because the auditory system undergoes considerable development in the first decade of life, developing assessment norms for the various tests has proven difficult. For these reasons, many audiologists feel it is not possible to administer a truly comprehensive CAPD battery to a child younger than 8 years old, or in special cases 7. However, some audiologists will administer CAPD tests to children as young as 5. In our practice, we have generally found that testing children younger than age 8 is unrewarding, and we typically base our treatment of children under this age on history, clinical exam, and neuropsychological testing, deferring rigorous auditory testing until children reach the age of 8 or 9.

Finally, it is important to realise that while CAPD testing is relatively sensitive and specific, it is not perfect. A negative or 'normal' result does not mean that a child definitely does not have CAPD. When a child's symptoms are sufficiently compelling to create high level of suspicion, it may still be reasonable to enact some of the measures below, even in the presence of a negative test battery.

## **GENERAL PRINCIPLES OF CAPD THERAPY**

The last decade has seen an explosion in research into the brain-based mechanisms that process sound. This research has clearly demonstrated that the brain is amazingly 'plastic' - that it has an extraordinary capacity for reorganisation in response to sound. Some of the earliest studies documenting this plasticity used musicians as subjects. In one study, violinists were shown to have larger cortical representations for their left (note-fingering) hands than their right (bowing) hands (Elbert and others, 1995). In another study, musicians showed larger auditory cortical responses when listening to music played on their own instrument of specialty than they did while listening to music from other instruments. (Pantev, 2001). Finally, studies on stroke subjects showed that

intensive multisensory training can improve regional blood flow in the auditory cortex, improving performance on auditory comprehension tests (Musso and others, 1999).

Despite extensive research documenting the ways that the 'hearing brain' can be reorganised through auditory training, clinical practice still lags behind theory. In the United States where we practice, there are wide variations among practitioners in the kinds of therapies recommended for patients with the various CAPD subtypes. In the rest of this article we will discuss our own approach to the treatment of children with CAPD. It is important to remember that these are general principles only, and that diagnosis and treatment of any child with hearing problems must be undertaken with a team of appropriate medical professionals.

## CATEGORIES OF CAPD MANAGEMENT

Useful interventions for children with CAPD can be divided into two broad categories.

The first category includes **interventions that act to minimise the functional problems resulting from the auditory impairments**. This category includes strategies such as sound amplification, sound filtering, classroom accommodations, and speech therapy. The second category **contains strategies that aim to relieve or even cure the impairments themselves**. This category includes primarily auditory training or brain reorganisation strategies. The strategies appropriate for an individual child depend on that child's underlying audiologic impairment.

Each of these strategies are considered below.

**Sound amplification** can be very useful for children with CAPDs that cause severe problems hearing *speech in background noise*. Many people find the notion of using sound amplification for children with normal audiograms odd, but it can dramatically benefit appropriate children by filtering out competing sounds and amplifying the desired signals. One child we saw recently in our practice was referred for attentional difficulties. Because of problems with mishearing and delayed processing we referred him for auditory evaluation. Peripheral audiometry was within normal limits, but on CAPD battery, his sustained auditory attention scores were 100% with no background noise, but dropped to 45% when background noise was added. He began using FM amplification and experienced marked improvement in sustained attention for teacher's lectures, and had improved interaction in social conversations in noisy settings like restaurants or group discussions.

**Sound filtering** is the flip side to amplification. Instead of accentuating desired frequencies, sound filters can help to minimise irrelevant frequencies. The best filters are musicians' earplugs. These can be obtained online or custom fitted ear filters that can be obtained where hearing aids are made. These filters can be useful for children whose *hyperacusis* is causing social or academic impairment. It is important to realise that sound filters must be used sparingly. There is evidence that chronic sound deprivation can actually worsen hyperacusis, so filters should be saved for circumstances where they are clearly essential.

**Classroom accommodations** are essential for any child with CAPD. The precise accommodations needed will vary depending on the nature of the child's auditory problems, and on the child's level in school. The simplest accommodations involve optimising classroom acoustics. Students with CAPD need a clear vision of the teacher's face, and should be seated near the front of the room and away from windows to minimise distractions. Such students should not be placed near sound sources like buzzing lights or heaters, blowing air ducts, or noise permeable partitions, walls, or doors. Carpeting floors and covering walls will minimise echoes and cut down on background noise.

- For a variety of reasons, children with CAPD often have significant difficulty taking notes.

- Notes should be provided from the teacher or another student, or the student should be allowed to tape record lectures.
- Also, important instructions, assignments, and due dates should be provided to them in written form.
  - Pre-learning appropriate terms and topics from textbooks or teacher's notes will also make lectures easier to follow.
  - All media used in schools should be close captioned whenever possible.
  - Teachers should provide visual or tactile cues to reinforce important auditory information, such as visual examples, hands-on learning projects, or lists of key words.
  - Waivers should be considered for exclusively oral tests, and for children with significant processing delays, timed oral conditions are inappropriate.

Sometimes, home schooling may provide a better learning environment than traditional classroom education. Online classes provide controllable acoustics, eliminate background noise, and sometimes emphasise visual learning which may be a better route of learning for certain children.

**Speech therapy** is a crucial part of therapy for many children with CAPD. For children with poor *auditory closure* skills (i.e. poor ability to fill in missing fragments of imperfectly heard messages), a programme of speech therapy designed to improve vocabulary, sound decoding abilities, and understanding of the rules of language, can often boost closure skills and result in academic and social gains.

Children with *prosodic (musical) auditory deficits* often benefit from speech therapy that improves their perception of the rhythms, inflections, and intonations of speech. These children should be given practice in:

- Listening to markedly exaggerated speech patterns, which they should then try to repeat and
- Nonverbal aspects of communication should also be stressed, including facial expressions, mouth movements, body postures, and hand gestures.

Too often children with prosodic speech deficits are herded into social skills classes where noise and other distractions prevent necessary attention to the subtle sound qualities they are trying to develop. The focus of these classes also tends to centre more on cooperative play and social interaction than on speech prosody *per se*. One-on-one training that focuses on the skills mentioned above is even more productive.

**Auditory training** strategies constitute the final class of interventions for children with CAPD.

At present there are a variety of commercially available programmes that claim to be useful for children with CAPD. The only programmes with credible scientific support for their efficacy are the computer-based programmes *Fast ForWord* and *Earobics*, which have been used primarily for children (and adults) with impairments in *phonological discrimination*.

These programmes achieve their effects by improving the brain's ability to perceive the fast changes in sound that are responsible for auditory/phonological discrimination. Over time, the gains made with these programmes have been shown to translate into real world gains in phonology and sound discrimination, reading improvements, and improvements in speech comprehension and auditory memory (Temple and others, 2003). In fact, MRI studies of persons with phonological impairments who have completed the full *Fast ForWord* course have actually shown visible evidence of improved function in the areas of the brain responsible for phonological processing (Temple and others, 2003). We have also seen improvements with these programmes in children with *auditory timing and sequencing difficulties*.

However, these programmes have several drawbacks.

They are very labour demanding, requiring a commitment of approximately one hour per day, five days per week, over a span of six weeks. They can therefore be difficult for younger children or for children with attentional difficulties. In addition, while they produce dramatic changes for many children with phonological or temporal deficits, they do not work for all children with these deficits, and at present there seems to be no clear way to predict before the fact which children they will work for and which they won't. Finally, there is also the issue of cost. In the U.S. at present, cost of a course of *Fast ForWord* costs in excess of \$1,000, while *Earobics* runs around \$300.

One other programme that has achieved significant commercial popularity is called *AIT* or *Auditory Integration Therapy*. While there are anecdotal claims supporting its efficacy, to date there are no peer-reviewed scientific studies supporting its efficacy in children with CAPD.

At present we are not aware of any commercially available programmes to help children with *difficulties balancing competing auditory inputs or localising or lateralising sound*. However, Frank Musiek, a leading CAPD researcher, has described the beneficial effects of programmes built in his lab to train selective attention and sound filtering skills (Musiek, 2003). We too have seen benefits from home-made programmes mixed on a PC using competing speech inputs of varying intensities to train selective attention and improve figure-ground recognition. The nice thing about these computer-based programmes is that the balance and intensity of the inputs can be finely controlled and modified over time as skill levels increase. It is likely that commercial programmes of this type will be available in the near future.

Lower tech versions of this strategy are fairly easy to implement. Simply have a child listen to a book on tape or to a parent reading aloud while background noise is produced by a TV or music player. Over time the background noise can be increased as the child's listening skills improve. Another good form of training is to have a child listen for the lyrics of favourite songs.

Children with *impaired sound localisation* can train these skills by practice localising a sound source such as a beeping telephone indicator, key locator, egg timer, or other hideable sound source. The classic children's game 'Marco Polo' is also a fun way to practice sound localisation. Practice should begin in a quiet, distraction free environment, then gradually progress to include increasing echoes or background noise.

## **CARING FOR CHILDREN WITH CAPD**

In closing, we would like to stress three crucial points for adults involved in the care and education of children with CAPD.

Firstly, adults must remember that variability in symptoms of children with CAPD *is the rule, not the exception*. Children with CAPD do not have a fixed level of hearing deficit that causes equal symptoms on all occasions or in all environments. Children with CAPD can experience marked variations in processing efficiency due to fatigue, ill health, emotional disturbance, variations in background noise, changes in a teacher's voice due to illness or strain, changes in the relative positions of the speaker and the listener, and countless other factors. Most children with CAPD hear easily at some times and appear functionally deaf at others. This variability often leads to accusations of poor attention, lack of effort, or willfulness in ignoring a speaker's requests or instructions. Unjust accusations of this sort can lead to confusion, resentment, hurt feelings, or despair in the child. Teachers particularly must not fall into the trap of thinking that accommodations like those listed above are unnecessary for a particular child just because that child has done well without them on certain days or because they have conversed easily with that child one-on-one after class.

Secondly, adults must realise how important a well-functioning auditory system is to essentially every aspect of a child's life. Social communication, interactive play, personal relationships, speech comprehension, and academic success are all threatened by CAPD.

Lastly, adults should remember the importance of using a child's strengths to compensate for his or her auditory weaknesses. Children with CAPD often have outstanding skills in higher order language, inference, and visual learning domains that may enable them to function well in many environments. With appropriate care and interventions, they should be able to flourish both academically, and in later life. Understanding the particular nature of their auditory difficulties, including the environments and situations that will be particularly troublesome for them as well as the strategies they can use to optimise their abilities to hear and understand, can go a long way toward helping them function well in whatever aspects of life they choose to pursue.

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