

## **Central Auditory Processing Disorder**

A central auditory processing disorder (CAPD) is a condition in which one has difficulty processing or interpreting auditory information when presented in a less than optimal listening environment.

Typically, individuals with a central auditory disorder have normal hearing when taking a traditional pure tone and speech hearing test but are unable to interpret or process speech when in an environment which is less than quiet. The vast majority of children and adults that have been evaluated at the Center for Central Auditory Research at Colorado State University (CSU) can hear even the faintest of sounds, but are unable to process verbal stimuli in an effective manner in their everyday listening situations. Environments such as a classroom setting, the work place, community gatherings, and church are often seen as threatening because of this auditory difficulty.

Individuals who have a CAPD have particular difficulty concentrating when in an environment which is not perfectly quiet or has some "controlled" noise in the background. Understanding a verbal message will also be a problem when trying to listen to a speaker and someone else is talking or ambient noise is present in the background. These individuals often have to work harder than others just trying to receive auditory information in a meaningful manner. It is a very frustrating situation for individuals when they can hear "perfectly" but can not process auditory speech information in a meaningful way.

Central Auditory Nervous System Function A thorough understanding of the function of the central auditory nervous system (CANS) is critical so that proper diagnosis and management can be implemented. Each of the human senses have special areas of representation in the brainstem and brain. The auditory system provides perhaps the most important of those sensory systems since it affords us with a means of verbal communication.

The mature, normal central auditory system allows us to assign priority to certain sounds, words, and sound/word combinations that are useful to us. It is the brain's function to assign meaning to auditory stimuli which the ears receive. This occurs while the system also suppresses and/or blocks undesirable or unwanted auditory stimuli. This process prevents all sounds from running-together which results in a "listening chaos." Think how confusing it would be if one minute you can understand auditory messages and the next moment words and sentences are totally incomprehensible!

The inability to communicate effectively hinders our academic function, our work efficiency and accuracy, social and emotional status, and overall well-being. Throughout our studies, we are continually made aware of life disruptions that occur in individuals with central auditory processing dysfunction. School failure, emotional upheavals, work difficulties, unemployment, and school drop-out situations are just a few of the disruptions we observe as being conditions associated with a CAPD.

## **Behavioral Characteristics of a Central Auditory Processing Disorder**

The study of central auditory processing in children is a complex task requiring basic knowledge of the anatomy and physiology of the peripheral hearing mechanism, the CANS, developmental milestones, speech and language function, academic requirements, and emotional and behavioral growth. Our research has led us in the area of defining classic characteristics which may be associated with children with CAPD (Willeford & Billger, 1978). Identifying behaviors can aid us in recognizing children who may be at-risk for CAPD.

Characteristics which we have seen to be especially common in children diagnosed as having a CAPD include inconsistent awareness of sound which manifests itself by an inability to be alerted by new auditory information in a way in which are most children. These children may also demonstrate a short attention span and slow or delayed responses to auditory stimuli. It appears that in an effort to "buy time" to process incomplete auditory information in a logical manner, a slowed auditory response is observed. Perhaps many of their perceived auditory signals are degraded enough so that they need more time to adequately process or integrate incomplete auditory information into a meaningful message. At-risk children for CAPD also include those who are observed to be distractible, have difficulty starting and/or completing assignments, are easily flustered or confused in noisy environments, are sensitive to loud sounds, and demonstrate difficulty with following verbal directions.

Children with central auditory processing disorders often perform below their potential in school. They are many times classified as "underachievers" by their teachers and parents. A number of our referrals for a central auditory processing evaluation come from psychologists who observe that a child's performance on an intelligence test did not compare favorably with the child's performance on

measures such as the Wide Range Achievement Test (WRAT). This means that the child's aptitude or innate ability is superior to or better than the child's actual performance or achievement in school.

In large part, children with CAPD do not demonstrate an observable physical health problem. Both general medical and neurological examinations are typically unremarkable. Occasionally, a child with central auditory processing difficulties exhibits an abnormal EEG, but that is likely due to difficulties due to seizure activity, head trauma, or some other neurological manifestation. The vast majority of children referred to this Center for evaluation show negative physical difficulties. However, studies utilizing neurophysiological measures, specifically the mismatch negativity or MMN, may show promise for identifying some children with central auditory processing problems (Kraus & McGee, 1994; Kraus et al. 1993).

Apart from the above listed manifestations, children with CAPD may also exhibit some social behaviors that are atypical in nature. A number of these children are described as having high activity levels especially when they are in confusing listening environments. They may also be labeled as having attention deficit disorder (ADD). Willeford and Burleigh (1985) hypothesize that some of these children are having trouble coping with their auditory world and "act up" because of extreme frustration and confusion. In others, their emotional state may combine with subtle organic disturbances to result in high activity levels. In some children, their activity levels may increase because they have to expend much more energy than average children in order to pay attention and understand what is being taught in school.

Other children with CAPD exhibit lower-than-normal activity levels (hypoactivity). These children do not act up in the classroom; in fact, they appear to be either lethargic, passive, or reserved. Often parents report that these children are very fatigued after school. They are probably expending a significant amount of energy just trying to receive auditory information in a meaningful manner.

A number of children that we see are classified by their parents and teachers as being "slow starters" or as having difficulty completing assigned tasks. From our research we have determined that 50% of children with known CAPD have difficulty with this area of performance. When analyzing case history information from 111 children with CAPD, our statistics indicate that 72% are easily frustrated, 77% are easily distracted, 60% are forgetful, and 78% have difficulty following verbal directions.

## **Auditory Maturation**

When accumulating data during the norming of the Willeford Central Auditory Test Battery (Willeford, 1977), it was observed that the CANS matures with age. Therefore, using age appropriate tests and age-rated normative data is very important for valid testing of the CANS. The system typically functions at its adult level by ten-to-eleven years of age. As individuals continue to age into their fifties-and-sixties, the CANS integrity appears to change and more difficulties in noisy environments are noticed.

Children with CAPD may actually grow out of this problem. According to Burleigh, Skinner, and Norris (1982), approximately 60% of children initially identified for central auditory difficulties will "outgrow" this condition. However, that leaves a significant number of children who still have difficulties processing auditory information in later years. Further, in Burleigh, Skinner, and Norris' 1982 study, the majority of children continued to demonstrate immature central auditory function several years following the initial diagnosis. In the meantime, they are experiencing communication difficulties which may impact their academic, emotional, and social functioning. Therefore, it is of utmost importance to identify this disorder early and implement an appropriate management program.

## **Central Auditory Test Battery**

The central auditory test battery is very different from those used during traditional audiometric testing. Most tests of central auditory function involve speech stimuli that have been modified in some fashion to make their understanding more challenging. The goal in all evaluations is to identify a lack of ability in the processing of auditory information which would account for the individual's communication problems in his/her everyday listening environment.

Early tests for CANS function were used primarily with adults for site-of-lesion testing. Such tests are now used with children and adults to assess the "functional proficiency" of their CANS and with concerns as to their communicative, academic, employment, and social function. Thus, the goal for

testing is to administer a battery of tests which will uniquely stress the auditory mechanism at various levels of CANS function to identify inefficient neural processing. Such stress is created by special test design that requires more complex responses in the higher auditory centers than are necessary for pure tone identification and the repeating of single-syllable words in quiet. Even a grossly inefficient CANS can process such stimuli easily.

A variety of central auditory processing tests are now available. Most central auditory processing tests fall into four classifications: (1) monotonic tests (stimuli are presented to one ear at a time in differing formats which may be frequency limited, compressed, ipsilateral competing messages, or pattern recognition); (2) dichotic tests (different signals presented to the two ears at the same time); (3) binaural interaction tests (tests which require the individuals to sequence or sum complementary signals at the same time); and (4) electrophysiological (an objectively measured physiologic response) (Willeford and Burleigh, 1985).

## **Management of a Central Auditory Processing Disorder**

There are many different opinions concerning the management of CAPD in children and adults. While some clinicians feel that therapy programs alone will help a child with CAPD, others recommend both therapy techniques and parent-teacher management guidelines to aid the child or adult. From our research, we advocate the implementation of compensatory management that has been shown to be helpful for children and adults with CAPD.

In an effort to aid children and adults with CAPD, we have designed a compensatory management program which targets the adult's or child's primary difficulties in their academic, work, and social environments. Inappropriate structure, incomprehensible commands, and tasks which continually stress the CANS will lead to failure. However, with compensatory management, the child and adult will be better able to cope with the various auditory demands placed upon them at home, at school, and at work.

Our research has led us to believe that it is very important to identify the relative strength of the CANS. In other words, one must try to determine if one ear is stronger than another for interpreting auditory information in difficult listening situations. When this occurs, special management should be implemented. If both ears are equally decreased, then compensatory management should be individualized to meet that individual's needs. Management should also be centered around the individual's personal listening challenges. Management protocol, then, will vary depending upon the auditory profile of the child or adult.

Another important management tool is the use of FM auditory systems. Individualized and speaker FM systems have been used successfully with children and adults with auditory difficulties including central auditory processing disorders. The use of such units has shown good improvement in classroom performance for a number of children at the Center for Central Auditory Research. Furthermore, we have fit FM units for college students who have had great difficulty processing auditory information in large lecture halls. The use of a FM system allows them to receive instruction on practically a one-on-one basis. Again, their classroom performance is improved along with a decrease in the amount of energy they are expending just trying to understand confusing auditory input. These units are being utilized for students with a variety of auditory challenges (Flexer, 1994).

New technology is on the horizon for assisting children and adults with central auditory processing difficulties. The discussion of management protocols would not be complete without mention of our work with colleagues in the Department of Electrical Engineering at CSU and the University of Texas-Pan American. Advances in digital signal processing (DSP) have created exciting opportunities for enhancing the understanding of speech stimuli. Preliminary results show promise and we are very excited about the potential benefits of this research (Wenndt, Burleigh, & Thompson, 1996).

## **Summary**

Central auditory processing function is an important consideration in the communication process. Efficient processing of auditory information is critical for academic and work performance, social and emotional status, and overall well-being. Identifying and managing children and adults with this auditory challenge can further enrich their overall function.

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