Central Auditory Processing Disorder (CAPD)*
This leaflet has been produced by CAPD Ireland. CAPD Ireland is an organisation made up of people that have an interest in CAPD.
Our members include: Audiologists, Speech and Language Therapists, Psychologists, Occupational Therapists, academics and parents.
Some of CAPD Ireland aims are: to promote a greater understanding of CAPD, to provide information on diagnosis and interventions and to lobby for a public CAPD service for the children of Ireland.
If you wish to be part of CAPD Ireland, email Lucy.OHagan@hse.ie or martin.cromb@cuh.ie
*Central Auditory Processing Disorder (CAPD) is also known as Auditory Processing Disorder (APD).

The Auditory System

The Peripheral and Central Auditory Systems
The peripheral auditory system is the part of the auditory system from the outer ear to the cochlear nerve. The central auditory system refers to the parts of the brain that process and interpret signals received from the peripheral auditory system.

How Does The Auditory System Work?
Sound occurs when a moving or vibrating object causes the air around it to move. Sound travels in invisible waves through the air.
When sound waves travel down the ear canal and hit the eardrum, the eardrum vibrates. Three bones in the middle ear link the vibrating eardrum to the cochlea in the inner ear.
The cochlea is filled with liquid that contains thousands of tiny hair cells. Movement of cochlear liquid causes the hair cells to bend and send electrical signals along the cochlear nerve to the brain.
For normal hearing to occur, the brain has to receive the signals, then process and interpret them appropriately.
**Central Auditory Processing- Definition**
Central Auditory Processing may be defined as the processing of a signal by the brain that has been received from the cochlear nerve.

**Central Auditory Processing Disorder (CAPD)- Definition**
Central Auditory Processing Disorder may be defined as impairment in the processing of a signal by the brain that has been received from the cochlear nerve.

**Central Auditory Processing- How The Brain Processes**
Electrical signals from the cochlear nerve enter the lower part of the brain, called the brainstem. Different parts of the brain carry out different functions e.g. to enable localisation of sound, before the processed signals reach the auditory cortex at the top of the brain. The auditory cortex is responsible for interpreting/giving meaning to the signals that it receives e.g. recognising a person's voice without seeing their face.

**CAPD- Impairment In How The Brain Processes**
There are a number of possible causes of CAPD. In some cases permanent impairment in the brain’s ability to process auditory information can occur following an event that:
- causes auditory processing difficulties immediately, due to direct damage to the brain or
- causes processing difficulties gradually over time, following the onset of hearing loss

In other cases people may have a CAPD or listening difficulties unrelated to either of the above.

**CAPD Following an Event**
Events such as: a stroke, head injury, brain tumour or meningitis can cause brain damage that directly impairs the brain’s auditory processing abilities. The British Society of Audiology (BSA) describes a CAPD as being “Acquired” (Category 2), when it has been caused by this type of event.

It has also been suggested that the function of brain can become permanently impaired due to persistent peripheral hearing loss. When someone has a hearing loss, an impaired signal reaches the brain from the peripheral hearing system. Most children will experience at least one episode of temporary hearing loss during childhood and although an impaired signal will reach the brain during this time, if the hearing loss is short-lived it is unlikely to result in any permanent central processing difficulty. However, some children have frequent/persistent hearing loss in childhood due to glue ear. Once the glue ear issues resolve, the signal reaching the brain returns to normal. It is thought that in some cases the brain will learn to appropriately process the normal signal again, but that for other children a permanent processing difficulty remains.

Given that the CAPD under these circumstances is the result of long term peripheral hearing loss, rather than there being an immediate consequence following direct damage to the brain, the BSA describes this type of CAPD as being “Secondary” (Category 3) CAPD.

**CAPD Unrelated to a Specific Event**
When children have a CAPD that is unrelated to an event that could plausibly explain it, the BSA describes this as being “Developmental” (Category 1) CAPD.

In many cases the reason for having an auditory processing difficulty is not known. It is possible that some people with CAPD may have tiny differences in the way that brain cells (called ‘neurons’) in certain areas of the brain are joined together, or send messages to each other. This could cause some parts of the brain to not correctly process the signal that has been received, resulting in an impaired signal being passed onwards.

This may make it hard for sounds to be passed on to the areas of the brain which help the person understand language. It is possible such brain cell differences may cause CAPD.
Difficulties that may be experienced by people with CAPD, as described in the 2011 BSA document "Practice Guidance An overview of current management of Auditory Processing Disorder (APD)". appendix B

People that have CAPD may have some but not all of the following functional difficulties:
- Difficulty localising and ‘tracking’ sounds
- Hearing when signal is not clear or ‘degraded’ (e.g. accents, telephone)
- ‘Mishears’ auditory information (e.g. lethal/legal)
- Takes longer to respond to and process auditory information
- Poor listening skills and auditory attention
- Poor auditory memory
- Music perception difficulties
- Above difficulties may be exacerbated in noisy or reverberant environments

Additionally, in children there may also be reports of:
- Delayed auditory milestones
- Difficulty with learning songs and nursery rhymes
- Difficulty with multiple auditory commands
- Possible speech & language delay/disorder
- Phonological and phonemic awareness, reading, spelling, and academic difficulties

However, some people may experience one or more of the above difficulties, even though they do not have CAPD or when CAPD is not their only problem. It is important that a multidisciplinary approach is used so that the primary reason/s for an individual's difficulties are identified and so that the most appropriate management is chosen (see diagnosis and management section)

Diagnosis of CAPD and Management of CAPD

There are many different approaches being used to diagnose CAPD and there are a wide range of interventions available.

In 2012, Wilson and Arnott examined the files of 150 children that had had CAPD testing. When the scores from the tests were analysed using nine different criteria, the percentage of children that were considered to have an abnormal result ranged from 7.3% to 96%.

The BSA explored the lack of consensus for diagnosing CAPD in their 2011 document "Practice Guidance An overview of current management of Auditory Processing Disorder (APD)". The executive summary states:
"At this time there is no ‘gold standard’ for diagnosing APD. Without such a ‘gold standard’, the best methods for identifying and managing APD remain elusive. Data specifically addressing the efficacy of interventions for APD are lacking".

Despite there not being a "gold standard" for diagnosing CAPD, the BSA have given recommendations for assessing children that have suspected CAPD or listening difficulties.

As noted earlier a multidisciplinary team approach is required, so that the primary reason/s for an individual's difficulties are identified and so that the most appropriate management is chosen.

The diagnostic process may be broken into the following components:
1) Assessment of the peripheral hearing system, to establish if there is a problem with the outer ear, middle ear, inner ear or nerve.
2) A screening language and cognitive assessment (including tests for auditory memory- and attention- and assessments of nonverbal ability, language and literacy
3) Running tests that are designed to assess the brain’s auditory processing ability. Most diagnostic behavioural tests for CAPD require a minimum age of 7 years and the BSA recommends that CAPD testing should include at least 1 non-speech test procedure. Administering CAPD tests in isolation, without completing 1) and 2) may result in misdiagnosis and delays in the appropriate management of individuals with co-existing disorders.
Problems identified following part 1) or 2) of the diagnostic process may explain the CAPD-like functional difficulties that a person experiences. If this is the case, it may not always be necessary/appropriate to run a CAPD test battery.

For example, if a child is diagnosed with a permanent hearing loss, fitting of hearing aids, a soundfield system for the classroom and input from the visiting teacher service may be the appropriate management for this child. Running the CAPD test battery may not provide any additional benefit. Another example may be when a child has been identified as having attention difficulties. The diagnostic behavioural tests are often lengthy and poorer results will be achieved if a child does not maintain their attention throughout each test. It may not add anything by running the CAPD tests when children have significant attention problems, as it is likely that an abnormal result will be obtained whether a CAPD exists or not.

The intention of diagnostic assessments is to identify an issue so that appropriate interventions can put in place to address the consequences of the disorder.

In general, the BSA's view is that "reliability, validity, sensitivity, and specificity is lacking for most commonly used behavioural tests of auditory processing and this shortcoming needs to be addressed."

Some, such as Teri Bellis, believe that the CAPD test battery can be designed based on neuroscience and that the part of the brain where the auditory processing disorder occurs can be identified. Many of the behavioural tests used to diagnose CAPD that Teri Bellis recommends were developed following studies on adults that had auditory processing difficulties due to events that caused direct damage to the brain.

Teri Bellis’s approach is for an appropriate intervention to be given, based on whether the processing difficulty occurs in the left hemisphere, right hemisphere or corpus callosum. For example, if the test battery indicated that a child had a left hemisphere problem and if the child complained about problems hearing in background noise, then an FM system could be used in the classroom, so that the teacher could be heard above the background noise.

Another school of thought is that a formal diagnosis of CAPD is not needed and that interventions can be based on the functional difficulties that people have. So, if a child had completed parts 1) and 2) of the diagnostic process and had no issues identified or whose issues were not considered likely to be significant enough to explain the CAPD-like functional difficulties, but there were problems hearing in background noise, then it could be argued that an FM system would be appropriate without any CAPD tests being performed. However, it may be difficult to get resources for interventions, without the diagnosis of a distinct disorder.

A large number of interventions are available for those that have listening or CAPD difficulties. The BSA drafted a Position Statement and Practice Guidance document in April 2017 which listed the examples of interventions in the below table.

**Examples of CAPD interventions**

<table>
<thead>
<tr>
<th>Modifying the listening environment</th>
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<tbody>
<tr>
<td>Room acoustics</td>
<td>Architectural interventions and acoustic treatments of the environment</td>
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<tr>
<td>Assistive listening devices (also known as Remote Microphone Technology or Wireless Communication Devices)</td>
<td>Wireless devices that deliver input from a remote microphone to the ear. They reduce the impact of background noise and reverberation.</td>
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<tr>
<td>Teacher and speaker adaptations</td>
<td>Teachers and speakers are advised to secure attention first, use clear speech and regularly check on the comprehension.</td>
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### Auditory training

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<tr>
<th>Interactive training programs</th>
<th>Computer software can provide automated training using game-like formats, for example, LiSN &amp; Learn specifically targets and improves Spatial Processing Disorder, Memory Booster targets working memory and memory strategies, Earobics and Fast ForWord target phonological awareness, phonics, auditory attention and language. The evidence base for these programs is mixed.</th>
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</thead>
<tbody>
<tr>
<td>Musical Training</td>
<td>The evidence base for music training is mixed.</td>
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<tr>
<td>Compensatory Strategies</td>
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<td>Improving listening skills</td>
<td>Developing awareness that listening is an active process involving self-regulation and monitoring, while hearing is a passive process</td>
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<tr>
<td>Metacognitive and meta-linguistic strategies</td>
<td>Training in self-regulation, problem solving and strategies such as visual imagery and/or ‘chunking’ to remember and recall verbal information, writing information down to stay focussed and remember information, mindmapping and verbal rehearsal. These strategies, though widely advocated, have not been rigorously tested.</td>
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Evidence for the success of the interventions is weak. A thorough review was carried out by the BSA in 2011 and can be accessed by the link below.


**An overview of current management of auditory processing …**

[www.thebsa.org.uk](http://www.thebsa.org.uk)

Practice Guidance An overview of current management of auditory processing disorder (APD) Date of this version: 1st August 2011 Minor corrections: 17th October 2011