



## Hearing and Auditory Processing Basics

**Dr Chyrisse Heine**  
Speech Pathologist and Audiologist

### Key points

- The auditory system is divided into four parts, the Outer ear (OE); the Middle ear (ME); the Inner ear (IE) and the Central Auditory Nervous System (CANS).
- Hearing tests for children include Otoscopic examination; Immittance testing; Pure-tone tests; Otoacoustic emissions (OAE) or Auditory Brainstem Response (ABR) and Central Auditory Processing Disorder (CAPD).
- Children with CAPD often have language, learning including Short-Term Auditory Memory (STAM) and literacy difficulties.
- Intervention may include Direct work, Environmental modifications and Child-focussed strategies

### The Auditory System

The auditory system is divided into four parts:

1. **Outer ear (OE)** – consists of the pinna and external auditory canal (meatus) which is responsible for hair cell secretion of cerumen (wax). The OE is responsible for localization and funnelling sound into the ear. Earwax protects foreign objects from entering the ear. Common diseases of the OE are malformed pinnae or wax occlusion.
2. **Middle ear (ME)** - consists of the Tympanic Membrane (TM) (eardrum) and three joined bones (malleus, incus and stapes). When sound enters the ear, it causes the TM to vibrate and the lever action of the ossicles act as an impedance matching device moving the sound through the bones to the inner ear. The Eustachian tube also feeds into the ear from the nose and throat and is responsible for the equalization of pressure. Common diseases of the ME are otitis media (middle ear infection) or TM perforation.
3. **Inner ear (IE)** - is responsible for sound analysis (via the cochlea) and balance (via the vestibular system). The cochlea analyses and filters the sound (for example into frequency and intensity), converting it into neural impulses which feed into the Central Auditory Nervous System (CANS). Common diseases of the IE are presbycusis (hearing loss associated with age) and noise-induced hearing loss.

4. **Central Auditory Nervous System (CANS)** – consists of nerve fibres and structures that are responsible for sound localization, discrimination, temporal processing (tonal, rate and speed cues), filtering, binaural integration and separation. From the CANS, sound is interpreted in the brain (auditory cortex of the temporal lobe). Common diseases/ disorders of the CANS are Central Auditory Processing Disorder (CAPD) or tumors.

### Hearing tests for children

Aim: To identify whether a child has normal hearing or a hearing deficit and locate the site-of-lesion of the disorder. Tests may be conducted in the clinic (comprehensive testing) or at school (screening to identify the need for referral).

Hearing tests are important since there is an established link between hearing impairments, auditory processing, speech or language delay, learning difficulties and other associated developmental disabilities.

Tests include:

- **Otoscopic examination** – observation of the external ear canal and the TM. If any significant deviations (eg. excessive wax) are noted, the child may be referred to their General Practitioner (GP).
- **Immittance testing** – evaluates the status of the ME and evaluation of the movement of the TM in response to changes in air pressure. Deviations suggest a ME disorder possibly due to increased mass in the ME (e.g. due to an OM) or substantial negative ME pressure (e.g. due to Eustachian Tube dysfunction). A child who fails this test may be referred to the GP or Ear, Nose and Throat (ENT) specialist, or use nasal spray to open the Eustachian tube. This test identifies conductive hearing loss.
- **Pure-tone tests** – determines a child's ability to hear high and low frequency sounds presented at quiet listening levels. A child with normal hearing would be expected to hear at a low level of sound production (25dB or less) throughout the frequency range (250-8000Hz). A child who fails the air conduction testing would require further testing (such as bone conduction testing) to determine the site-of-lesion (conductive or sensorineural hearing loss). The child may be referred to an ENT for further evaluation if necessary.
- **Otoacoustic emissions (OAE) or Auditory Brainstem Response (ABR)** – These

the ABR assesses the integrity of the CANS and auditory cortex. These tests identify sensorineural hearing loss.

- **CAPD tests** – include tests of speech discrimination (in quiet and noise or when there is reverberation), auditory closure, binaural integration and separation (evaluate how the ears work together or separate information e.g. when there are two sets of stimuli heard at the same time e.g. dichotic listening) and temporal processing (e.g. pitch pattern perception). In addition, auditory reception, phonological awareness and STAM may be evaluated.

## Central Auditory Processing Disorder

The ability to process information develops with age and maturity of the CANS.

The CANS is responsible for processing and interpreting auditory information. Children with CAPD often have language, learning including Short-Term Auditory Memory (STAM) and literacy difficulties. Children with CAPD often have difficulty with understanding speech in noisy or reverberant environments which cannot be accounted for by peripheral auditory dysfunction, reduced auditory attention or concentration span, increased distractibility, intolerance to loud noise, difficulty remembering information or following instructions, discriminating auditory stimuli, localizing the sound source, difficulty with conversations.

## Intervention

A diagnosis of CAPD is made once all tests have been scored and compared to normative data (a specific score indicative of expected performance or according to the child's age or year at school). Management is planned based on deficit areas. The rationale for intervention is derived from studies that have investigated neural firing before and after intervention. Results support that auditory training leads to faster and more accurate firing.

Intervention may include:

- **Direct work:**
  - Auditory training– E.g. train active listening whilst using low level background noise as a distractor; or train auditory tracking to improve accuracy and speed of processing;
  - Dichotic listening (multi-task listening) – E.g. train directed attention to improve the ability to separate or integrate dichotic information;
  - Temporal processing – E.g. train pitch discrimination to improve the ability to

- Auditory closure – improve the ability to fill in gaps of missing information; and
- Literacy (phonological awareness and phonics) and language.
- **Environmental modifications**
  - Seating – in a circle of arms to enhance visual cues; seated away from noise in the room E.g. Buzz of fluorescent light;
  - Lighting – away from open window; or when the speaker’s face is in a shadow;
  - Use a remote microphone (FM system) if available; and
  - Apply acoustic modifications – E.g. Using acoustic tiles and carpet squares.
- **Child-focussed strategies**
  - Use visual cues and hands-on demonstrations;
  - Check child’s understanding;
  - Identify a listening buddy or allow child to observe others;
  - Provide notes;
  - Pre-teach new concepts; and
  - Use good communication strategies (speak slower/ louder/ clearer, emphasize key words, use short simple phrases, rephrase or repeat your message).