

Quick Guide for parents: Understanding Auditory Processing Disorder (APD) in children

This quick guide offers a practical snapshot of APD. APD is a complex and sometimes controversial area. Understanding the controversy and how APD co-exists with other childhood developmental disorders will empower you in making the best decisions for your child.

More detail and practical handouts are offered in the full APD MESHGuide.

1. What is APD?

Auditory Processing Disorder (APD) was first described more than 60 years ago as the ‘*inability to structure the auditory world*’ (Mykelbust, 1954:158). It is said to affect 2-3% of children but prevalence is difficult to know with certainty, given that there is no universal ‘gold standard’ for defining APD. The terms APD and Central Auditory Processing Disorder are used interchangeably.

The British Society of Audiology (BSA) (2018) define APD as follows:

APD is characterised by poor perception of speech and non-speech sounds. It has its origins in impaired neural function, which may include both the afferent and efferent pathways of the central auditory nervous system (CANS), as well as other neural processing systems that provide ‘top down’ modulation of the CANS. APD impacts on everyday life mainly through a reduced ability to listen, and therefore respond appropriately to speech and other sounds. Individuals referred for APD assessment typically present at clinics reporting hearing difficulties, despite a normal audiogram in most cases.

Simply stated APD refers to difficulty processing what we hear.

2. There are three types of APD, according to the BSA (2018):

Table 1: The three types of APD

Developmental APD	Children who experience hearing difficulties even though their audiogram (standard hearing test) shows they have normal hearing. There is usually no known cause other than a possible family history. These children may retain APD into adulthood
Acquired APD	Children with a known medical or environmental event (e.g. brain lesion, trauma, illness)
Secondary APD	Children who have APD that occurs together with, or as a result of either short term (e.g. glue ear) or permanent hearing impairment.

The majority of children suspected of having APD fall into the first group.

Children can however also present with Acquired or Secondary APD. In these cases appropriate and timely audiological and medical intervention should be sought, alongside any APD assessment and management offered.

Children with a history of glue ear are reported to have a higher incidence of Spatial Processing Disorder (SPD). SPD is a specific type of APD where a child has a reduced ability to use spatial cues to hear in background noise. Spatial processing refers to how the two ears work together and with the brain. Some children without a history of glue ear may also have difficulty with spatial hearing.

3. Children with suspected APD present with 'symptoms' that may include:

- Listening difficulties and other behaviours consistent with hearing loss, despite a normal audiogram (in most cases)
- Difficulty hearing spoken language in the background of other sounds, including competing speech (the most common presenting complaint)
- Difficulty hearing in reverberant acoustic environments, or when speech is rapidly presented or degraded in some way
- Mishearing speech and similar sounding words ('shoulder' versus 'soldier')
- Responding inconsistently or inappropriately to spoken language and auditory information
- Taking longer to process spoken language and auditory information
- Frequent requests for repetition
- Poor attention to and/or memory of spoken language and instructions

There may also be reports of impaired speech, language, phonological awareness, literacy, attention, and academic performance.

4. The importance of a multi- or interdisciplinary approach

Listening difficulties in children can be due to factors other than APD. These include impairments in hearing, language ability, attention, memory, motivation etc. For example, a child who has difficulty following multiple instructions may have APD but equally it could be that the child does not yet have the language ability or memory to do so.

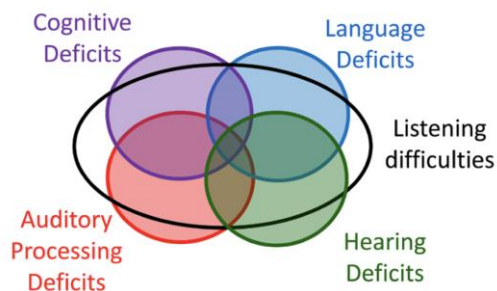


Figure 1: The different causes of listening difficulties. Cognition includes aspects such as attention and memory (From: Dillon H & Cameron, S. (2021). *Separating the Causes of Listening Difficulties in Children*. *Ear and Hearing*, 42 (5), 1097–1108)

Audiological assessment for APD should therefore *not* be done in isolation. Although the audiologist is the professional that makes the diagnosis it is essential that all aspects of a child's development be considered.

A multi- or interdisciplinary approach is thus recommended. The team typically consists of an audiologist, speech language therapist, educational audiologist/teacher of the deaf and educational psychologist but can vary, depending on the needs of the child.

5. New developments within the international arena

APD is included in the current ICD-10-CM Diagnostic Code H93.25. It is also included in the ICD-11 (Beta version) which is under development.

In 2014, The National Foundation for the Deaf in New Zealand approached the United Nations, arguing that lack of rehabilitation for New Zealand children with APD was a breach of their right to access to education and social interaction. This led to the development of the NZ APD guidance document in 2019. Many other countries also have guidance documents.

The World Report on Hearing 2021 includes a paragraph on APD. Although brief it's likely that future reports will include more information about APD.

6. Current situation: Demand versus caution

Increasingly parents are demanding APD assessment and support when they learn of the existence of APD from professionals, or on the Internet and other media sources. Although a label of an APD has the potential risk of stigmatizing, it can be helpful in ensuring that problems are not trivialized, help improve access to support/funding, and make "atypical behaviour" more acceptable, i.e., helps reduce stigma for the child and their families. Labels and fixed diagnostic criteria also help professionals, service providers and funders better understand the epidemiology of APD, i.e., the magnitude of the problem as well as the resources, service provision and funding needed.

Despite the demand for APD services some caution is expressed. It helps to understand the reasons why. Here is a summary:

- APD often co-exists with other disorders such as language, dyslexia, memory, or attention, with possible effects on the validity of APD test results. APD tests often carry a high language, attention and memory load and weaknesses in these areas can impact on the validity of APD test results, e.g., a child with a language development delay may score poorly on these tests, even if s/he doesn't have APD. This in turn has implications for the appropriateness of the support received.
- Many of the traditional tests of APD were originally developed in the 1970/80s for use with adults with neurological lesions, before the powerful imaging (brain scan) technology that we have today. Inferences were then made that these tests could potentially also be used in adults and children who don't have these medical problems but report difficulty hearing.
- Most tests of APD can only be done from the age of seven years, even though the importance of early intervention is well known.

- There is currently no universal consensus on the test battery and criteria for APD diagnosis. Statistically, the more tests done the more likely anyone is to fail a test. The most used diagnostic criterion is '*performance at or below 2 standard deviations of the mean in at least 2 tests, or 3 standard deviations below the mean on 1 test*'. There is however no strong published underpinning evidence for this criterion.
- Tests and normative data developed for one country may not necessarily apply to another. Accent and language (including country-specific vocabulary) should be considered.
- There are concerns that the discrete skills, which many APD tests assess, are not representative of everyday difficulties, and that treatment of these discrete skills may not generalise to everyday life.

On a positive note, there are now some newer APD tests and apps emerging. Although it may be tempting for professionals to simply decide on a 'new' test battery and 'new' criterion we need to be careful. The use of arbitrary test batteries and criteria in the past is unfortunately what has contributed to much of the current controversy. It's important to base decisions on good research evidence, as it unfolds.

The above aspects make APD assessment a challenging area for both professionals and parents.

7. Against this background and current evidence, the British Society of Audiology (2018) advise that it is important to:

- 1) Engage with, educate and inform stakeholders (professionals, individuals with suspected APD, parents) and funders about APD.
- 2) Determine and address the difficulties that a child is experiencing in real life (a detailed case history, validated questionnaires and professionals' reports can be used to obtain a 360° view of a child).
- 3) Understand the reported hearing difficulty against the background of a multi- or interdisciplinary assessment that considers aspects such as language, attention and memory.
- 4) Recognise that audiological assessment for APD should not be done in isolation given that aspects such as language ability, attention and memory may affect test results.

There are different multi- or interdisciplinary models that can be considered. For example, it is possible for the audiologist to request that other assessments, such as a speech and language assessment and educational psychology assessment, be done prior to referral for an APD assessment. Another approach is to have an interdisciplinary team all working together under one roof.

- 5) Do an audiological work-up to rule out hearing loss, middle ear dysfunction and evaluate speech perception in quiet and noise first.

Separate left and right ear pure tone audiometry (250-8000Hz) and immittance testing (including reflexes) are necessary to rule out hearing impairment and middle ear problems, requiring medical and/or audiological intervention. There is some evidence that contralateral acoustic reflexes can be absent for some children with APD and that oto-acoustic emissions in the presence of contralateral broadband noise may have diagnostic value.

Campbell N, Grant P, Rosen S and Moore D. 2018; updated 2021.

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Comparing speech perception (using tests with different levels of language complexity, e.g., digits, sentences, words) in quiet and noise can be helpful in determining the influence of both language and noise. For example, if a child can correctly repeat all types of stimuli in quiet but then struggles in noise that may suggest difficulty hearing in noise. Another child, however, may be unable to repeat sentences in quiet at an age-appropriate level, suggesting that language may also be playing a role.

The Listening in Spatialized Noise-Sentences test can be used to diagnose Spatial Processing Disorder (SPD). SPD is a specific type of APD where a child has a reduced ability to use spatial cues to hear in background noise. There is a higher reported prevalence in children with glue ear. Newer variations of this test include: the Listening in Spatialized Noise Universal test (which uses nonsense syllables common to most of the world's languages, in a consonant-vowel-consonant-vowel format) and the Language-Independent Speech in Noise and Reverberation test (which also assesses the impact of reverberation and considers fluctuations in attention on performance)

Finally, if there is suspicion of Auditory Neuropathy Spectrum Disorder (ANSD) further appropriate tests can be done. ANSD is a hearing disorder in which a large part of the inner ear responds appropriately to sound, but that information is not efficiently transferred from the ear to the brain.

- 6) Make evidence-based decisions around administering and interpreting traditional tests of APD. Examples of the most commonly used tests are the dichotic digits test, the frequency pattern test, the duration pattern test, the masking level difference test and the gaps-in-noise test. Audiologists should only use tests that fulfil the criteria of functional specificity, reliability, validity, age-appropriateness, and standardisation, with a clear statement of diagnostic criteria used in reports.
- 7) In children younger than 7 years of age, where traditional tests of APD are not possible, support should not be delayed. Appropriate and timely onward referral and management is important. Speech and language therapists are well placed to advise in these cases, given that APD often co-exists with speech, language, phonological awareness, attention, and memory difficulties.
- 8) Recognise the complexity and current controversy surrounding APD. The BSA, along with an increasing number of audiologists worldwide, are proposing that one way forward could be that only those audiologists with further training and accreditation by a professional academy or society be allowed to diagnose APD.

7. Intervention for APD

Linking a child's test results/needs to specific management strategies can be:

- Functionally driven: The child's difficulties in everyday life and at school are matched with corresponding management strategies, or
- Test driven: Management strategies are matched to specific/discrete test findings

The above approaches can be integrated. Management should also consider the other developmental delays/disorders that the child may have. Support should be integrated, multi-disciplinary in nature, and lead to improvements in everyday life, not only on test measures in the clinic.

Current intervention strategies can be divided into 4 main areas:

- 1) Architectural considerations and acoustic environmental modifications
- 2) Technology
- 3) Auditory training programmes, computer software and apps
- 4) Compensatory strategies

The strategies listed under areas 1 and 2 have greater supporting evidence than areas 3 and 4.

Table 2: Summary of intervention strategies

Architectural considerations and acoustic environmental modifications	• Architectural interventions to reduce reverberation and improve the signal-to-noise ratio should be considered for both new build schools and refurbishments. Signal-to-noise ratio refers to the level of a desired signal (usually the teacher's voice) in relation to background noise. Architectural interventions are primarily about blocking out sounds from outside the classroom and absorbing noise within the classroom. There are specific acoustic performance standards which schools are required to meet: - Acoustic Design of Schools: <i>Performance Standards, Building Bulletin 93, Department for Education</i> - Acoustics of Schools: <i>A Design Guide, Institute of Acoustics and the Association of Noise Consultants, 2015</i> • Acoustic treatments such as carpets, curtains, doors, seals, rubber shoes on furniture legs, and double-glazed windows help absorb and reduce noise. The installation of noise absorbent partitions or screens can also help reduce and absorb noise. • Teachers and speakers are advised to face the child, secure attention, use clear speech, alter the pacing, emphasis, and segmentation of their speech, and regularly check on the comprehension of verbal instruction. • Provide preferential seating. Seat the student near the teacher (or primary sound source). Allow flexibility in seating to achieve the preferential seating advantage.
Technology	• Remote microphone technology or personal assistive listening devices help reduce background noise and reverberation so that the child can hear the teacher's voice more clearly. The technology is specifically for children with normal hearing. The teacher wears a clip-on wireless

	microphone. The microphone transmits his/her voice directly to a child's receiver, worn on the ear. There are also other 'modes' of use, i.e., small groups conversations (when the microphone placed flat on table becomes omni-directional), focus mode (microphone held in hand and pointed in the direction of the speaker) and streaming mode (e.g., using bluetooth technology). • Sound field systems relay the teacher's voice to speakers placed at different locations in the room. This helps to distribute the teacher's voice evenly throughout the classroom, so all students can hear it well regardless of where they are seated. These types of systems are often used in lecture halls and theatres. • Noise-canceling headphones can help block out background noise when individual work needs to be done. • Headphones - if the child needs to listen to an audio recording (e.g., in second language classes) he/she can listen <i>through</i> headphones to help block out background noise. Audio material of this nature can also be streamed if remote microphone technology is used. APD technology is <i>not</i> a substitute for other intervention that may be required, e.g., speech and language support or learning support. A trial with technology is advised before final fitting to ensure benefit and acceptance. There should also be support in place to check and support the child's use of technology on a day-to-day basis.
Auditory training programmes, computer software and apps	Neuroplasticity underpins auditory training and requires that activities are sufficiently challenging (<i>i.e., at the 'edge of competence'</i>) and repeated over extended periods of time to be likely to be effective (for example, 30 minutes, 3-4 times a week for 6 weeks). There is no evidence to suggest that either formal or informal methods are better, or that more expensive methods are more effective than less expensive ones. There is some limited evidence that training discrete auditory skills, such as those identified by traditional APD tests, leads to everyday improvement or benefit.

	Computer based auditory training not specifically developed but used for APD includes <i>Fast ForWord</i> which was one of the first software packages used in this way. <i>Fast ForWord</i> is designed to improve auditory, language processing and reading abilities and purports to train the brain to process at faster rates and help modify the neural pathways. It uses both speech and non-speech stimuli that have been acoustically modified to slow and amplify transient sounds. <i>HearBuilder</i>, a more recent training program, incorporates phonological awareness, auditory memory, sequencing, and following directions. Other software includes <i>Memory Booster</i>, designed to improve working memory and <i>Cogmed</i> designed for improving attention by increasing working memory. Computer software and apps, designed for APD typically focus on direct auditory processes, identified as weak on ‘traditional’ APD tests. Computer software includes: the <i>Dichotic Interaural Intensity Difference (DIID)</i> training (administered using customised stimuli through an audiometer or as computer based training using interaural intensity differences), <i>Constraint Induced Auditory Therapy (CIAT)</i>, based on the DIID), the <i>Central Auditory Processing Disorder Online Training System (CAPDOTS)</i> designed to train binaural integration and separation, and <i>Dichotic Offset Training (DOT)</i> which trains the perception of interaural time differences (ITD) Examples of apps for improving hearing in noise and Spatial Processing Disorder: The <i>SoundStorm</i> app trains spatial processing in noise. The <i>StiNT</i> app trains hearing in noise. Other apps include: <i>Zoo Caper Skyscraper</i> (trains dichotic listening) and <i>Insane Earplane</i> (trains lateralization, non-linguistic pattern training (via pitch/frequency), interaural timing/intensity differences, and non-linguistic prosodic cues (via pitch/frequency). Additional formal training programmes, e.g., phonological awareness training programmes (often used by speech language therapists), etc. Phonological awareness is the ability to recognize and manipulate spoken parts of words and sentences. Phonemic awareness relates to specific sounds. These skills underpin reading ability.
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	• Informal activities and workbooks e.g., shared reading/reading aloud, following multiple instructions etc. • Music training: There is evidence to suggest that musicians have better auditory processing abilities than non-musicians, and that children with APD can potentially derive some benefit from playing a musical instrument/s. However, what is less clear is the nature and duration of training necessary, the expected outcomes and whether speech-in-noise ability can be improved. Music can also be used to affect mood and state of arousal/attention, e.g., ‘happy’ versus ‘sad’ music, ‘calming’ versus ‘upbeat’. This can help maintain/direct attention.
Compensatory strategies	• Improving listening skills: Developing awareness that listening is an active process involving self-regulation and monitoring, while hearing is a passive process, e.g., “Whole body listening skills” • Meta-cognitive and meta-linguistic strategies: This involves training in self-regulation and problem solving by identifying individual listening strengths and weaknesses, listening situations that are more challenging and possible solutions (e.g. move to a quieter area, use visual material, visual imagery and/or ‘chunking’ to remember and recall verbal information, write information down to stay focussed and remember verbal information). Verbal rehearsal (either aloud or internally) can be used to commit verbal information to memory.

8. In summary

APD is a complex and sometimes controversial area, despite growing international consensus.

This quick guide serves to offer a snapshot of APD and current research evidence. APD testing needs to be done as part a multi- or interdisciplinary assessment given that it is often co-exists with other delays/disorders such as language, dyslexia, memory or attention deficit disorder. The test battery, normative data and diagnostic criteria should be clearly stated in reports. Management should be evidence-based and have a functional impact, i.e., make a difference in everyday life.

Understanding the complexity of APD and how it co-exists with other childhood developmental disorders will empower you in making the best decisions for your child.