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 often 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, together with practical handouts, is 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 British Society of Audiology (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 British Society of Audiology (2018):

*Table 1: The three types of APD*

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
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<tbody>
<tr>
<td>Developmental APD</td>
<td>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</td>
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<tr>
<td>Acquired APD</td>
<td>Children with a known medical or environmental event (e.g. brain lesion, trauma, illness)</td>
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<tr>
<td>Secondary APD</td>
<td>Children who have APD that occurs together with, or as a result of either short term (e.g. glue ear) or permanent hearing impairment.</td>
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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.

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

- difficulty hearing spoken language in the background of other sounds, including 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
- difficulty hearing on the phone
- 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

Hearing difficulties in children with normal audiograms can be due to more than just APD. Other factors that can play a role are language ability, attention, memory, motivation etc. For example, a child who has difficulty following complex 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.

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. Understanding the controversy surrounding APD

Increasingly parents are demanding appropriate services when they learn of the existence of APD on the Internet and other media sources. Yet, despite this many audiologists have been reluctant to include APD assessment in their clinical practices. It helps to understand the reason why.
The reason is that APD evaluation is both a complex and controversial area. There is currently no gold standard for the tests that should be included in the test battery, or the diagnostic criteria that should be used.

Many of the ‘traditional’ audiological APD tests (e.g. dichotic digits, frequency pattern, duration pattern, masking level difference, gaps in noise etc) in use were developed in the 1970s and 1980s; before the powerful imaging (brain scan) technology that we have today. These tests were originally developed for adults with known brain tumours, lesions and illnesses. Inferences where then made that these tests could potentially also be used in adults and even children who don’t have these medical problems but report difficulty hearing. The problem is that these APD tests usually carry a high language, attention and memory load, unlike a traditional hearing test (the ‘audiogram’). So if a child has a language development delay s/he may score poorly on these tests, even if s/he doesn’t have an auditory processing disorder. There are also concerns that the skills these tests assess are not representative of real life difficulties, and also that treatment of these discrete skills is not evidence-based and does not generalise to everyday life skills. A further concern is that there is no guidance as to which tests or the number of tests that should be used. Statistically, the more tests performed, the more likely any child is to fail at least one of them. Failure rates are likely to vary greatly from test to test, as do available normative data.

Concerns have also been raised about the use of arbitrary criteria to ‘diagnose’ APD. The most commonly 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 no strong published underpinning evidence for this criterion. In a now well-known study, Wilson and Arnott (2013) showed the risk of using arbitrary criteria in a large sample of children where diagnostic rates of APD varied from 7% to 93% depending upon which criteria are applied, even when using the same traditional APD tests.

There are some newer APD tests (e.g. Listening in Spatialized Noise - Sentences (LiSN-S)) and also emerging tests (and apps) for APD. At this stage there is however not yet a gold standard. However tempting it may be 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 controversy and lack of consensus makes APD assessment a challenging area for both professionals and parents.

6. Against this background and current evidence, the British Society of Audiology (BSA, 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 interdisciplin ary 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 interdisciplin ary 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 interdisciplin ary team all working together under one roof.

5) do an audiological work-up to rule out hearing loss, middle ear dysfunction and also evaluate speech perception in quiet and noise. Separate left and right ear pure tone audiometry (250-8000Hz), with extended high frequencies if possible (up to 12000Hz) 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. Speech perception tests in quiet and noise should follow next. For example, 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. Other speech-in-noise tests such as the Digits-in-Noise (DIN) Test, Words-in-Noise (WIN) Test and the Bamford-Kowal-Bench Speech-in Noise-Test can be done to look at general speech perception in noise. It is helpful to compare speech perception in both quiet and noise on these different measures to determine the influence of language. It is also helpful to compare the results on a simple speech-in-noise test (e.g. DIN) with a more complex one (e.g. BKB Speech-in-Noise). 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 is not efficiently transferred from the ear to the brain.

6) make evidence-based decisions around administering and interpreting APD testing. Where a label of APD is necessary to secure support/funding only use tests that fulfils the criteria of functional specificity, reliability, validity, age-appropriateness and standardisation, with a clear statement of any diagnostic criteria used.

7) 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

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

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<tr>
<th>Architectural considerations and acoustic environmental modifications</th>
<th>• 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.</th>
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<td></td>
<td>• 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.</td>
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<td></td>
<td>• 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.</td>
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<td>• Provide preferential seating. Seat the student near the teacher (or primary sound source). Allow flexibility in seating to achieve the preferential seating advantage.</td>
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<td>Technology</td>
<td>• 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.</td>
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### 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-cancelling 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 *through* headphones to help block out background noise.

APD technology is *not* 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.

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<th>Auditory training programmes, computer software and apps</th>
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<td>Neuroplasticity underpins auditory training and requires that activities are sufficiently challenging (<em>i.e. at the ‘edge of competence’</em>) 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).</td>
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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.

- **Computer based auditory training not specifically developed but used for APD** includes *Fast ForWord* and *Earobics*, which were the first 2 software packages used in this way. *Fast ForWord* is designed to improve auditory, language processing and reading abilities and claims 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. *Earobics* is no longer available. *HearBuilder*, a more recent training program incorporates phonological awareness, auditory memory, sequencing, and following directions. Other software includes *Memory Booster*, designed to improve working memory and *Cogmed* designed for improving attention by increasing working memory.
• **Computer software and apps, designed for APD** typically focus on direct auditory processes, identified as poor on ‘traditional’ APD tests. Although training discrete auditory processes using computer software and apps may improve APD test scores there is limited evidence to support that these treatments generalise to improvements in everyday life.

**Computer software includes:** the *Dichotic Interaural Intensity Difference (DIID)* training (administered using customized stimuli through an audiometer or as computer based training using interaural intensity differences), *Constraint Induced Auditory Therapy (CIAT, based on the DIID)*, the *Central Auditory Processing Disorder Online Training System (CAPDOTS)* designed to train binaural integration and separation, and *Dichotic Offset Training (DOT which trains the perception of interaural time differences (ITD)).* As indicated in the above paragraph there is very limited evidence that training discrete auditory skills, identified by ‘traditional’ APD tests, generalises to real life improvement or benefit.

**Examples of apps:** The *SoundStorm* app trains spatial processing in noise and offers real-world-like signal training. There is evidence to support specifically treating Spatial Processing Disorder, which has a higher incidence in children with a history of glue ear.

Other apps include *Zoo Caper Skyscraper* (trains dichotic listening) and *Insane Earplane* (trains lateralization, non-linguistic pattern training (via pitch/frequency), interaural timing/intensity differences, and non-linguistic prosodic cues (via pitch/frequency). As indicated above, there is very limited evidence that training these discrete auditory skills, identified by ‘traditional’ APD tests, leads to real life improvement or benefit.

• **Music training and APD:** 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.
**Compensatory strategies**

- **Improving listening skills**: Developing awareness that listening is an active process involving self-regulation and monitoring, while hearing is a passive process.

- **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 focused and remember verbal information). Verbal rehearsal (either aloud or internally) can be used to commit verbal information to memory.

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**8. In summary**

As discussed APD is a complex and often controversial area. This quick guide serves to offer a snapshot of APD and current research evidence.

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, together with practical handouts, is provided in the APD MESHGuide.