Chapter 8

Auditory Processing Assessment and Management in the Paediatric Population

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'If a child cannot hear the language sound – that is, process the sound correctly through their auditory network – they cannot speak it. And if they cannot speak it, they cannot write it.'

~ Dr Anita Collins

Introduction

Auditory processing is vital for making sense of the world, as it involves not just hearing sounds but also interpreting and assigning meaning to them. A breakdown anywhere along the auditory pathway—from the ear to the brain—can disrupt this process, impacting the effective use of auditory and language information. When auditory input cannot be processed effectively, the consequences can be profound if left unaddressed.

The American Speech Hearing Association (2005) and the American Academy of Audiology (AAA, 2010) define auditory processing disorders (APDs) as a deficit in the central auditory nervous system that manages auditory information through neurobiological activity. This definition is widely accepted, but variations have been proposed by authors such as DeBonis (2015), Kraus and White-Schwoch (2015) and Moore (2013). These variations highlight ongoing controversies regarding definitions, diagnosis and intervention. The first part of this chapter aims to provide a foundation on which to build one's approach to auditory processing assessment and intervention, while the second part offers a practical approach to auditory training and management.

Auditory perception relies on the collaboration of multiple brain regions that process, integrate and interpret sound signals. The cochlea converts sound waves into electrical signals, which are refined through brainstem structures like the cochlear nuclei and superior olivary complex for localisation and contrast enhancement. These signals travel through the inferior colliculus and medial geniculate nucleus, integrating sensory inputs before reaching the auditory cortex, where pitch, volume and speech elements are analysed. Higher-level processing in the auditory association cortex, Wernicke's area and Broca's area enables speech comprehension and production, with the corpus callosum ensuring interhemispheric coordination for complex auditory tasks. Table 8.1 describes the processes underlying auditory processing skills, according to ASHA (2005) and AAA (2010).

APD frequently coexists with a range of other conditions, highlighting its complex nature and the importance of a multidisciplinary approach in diagnosis and intervention (Drosos et al. 2024; Gokula et al. 2019). The interplay between APD and these conditions emphasises the need for tailored assessment tools and interventions addressing both auditory and broader developmental challenges (see Chapter 14).

APD is linked to various developmental conditions, including language and speech disorders, learning disabilities like dyslexia and attention deficit hyperactivity disorder (ADHD), due to shared deficits in phonological processing, memory and attention. It also overlaps with autism spectrum disorder (ASD), where auditory filtering and speech comprehension challenges are common. Additionally, APD is associated with working memory and visual attention difficulties, further affecting auditory information processing.

Models of Auditory Processing

To structure an appropriate protocol for an auditory processing assessment, it is imperative that the HHPs adopts a model that will guide their assessment and intervention. Several models provide frameworks for understanding auditory processing and its disorders. Some of the more well-known models include: Erber's Model (Erber 1982), also known as the 'auditory hierarchy', which outlines stages from basic sound detection to comprehension. The Bellis/Ferre Model (2002) categorises APD into sub-profiles linked to different brain regions and emphasises targeted interventions. Katz's Buffalo Model (2019) focuses on key areas such as decoding, memory, organisation and integration, using direct auditory training. The Spatial Processing Model (Dillon and Cameron, 2011) isolates spatial processing disorder

(SPD) as a distinct subtype, highlighting the brain's ability to filter directional sound, whereas Medwetsky's Spoken Language Processing Model (2011) integrates auditory, cognitive and linguistic mechanisms with a pragmatic, real-world approach. Finally, the British Society of Audiology Approach (Moore et al. 2013) classifies APD into developmental, acquired and secondary types, recommending assessments and tailored management strategies. Each model provides a unique framework for assessing and treating APD, highlighting the importance of a comprehensive approach to address various auditory challenges. HHPs can choose and adapt these models to structure their assessment and treatment strategies effectively.

Table 8.1: Processes underlying auditory processing (ASHA 2005; AAA 2010)

Auditory Processing Skill	Sound Localization and Lateralization	Auditory Discrimination	Auditory Pattern Recognition	Temporal Aspects of Audition	Auditory Performance Decrements with Competing Signals	Auditory Performance Decrements with Degraded Signals	Amblyaudia	Spatial Processing Disorder
Description	Localization: Identifying where a sound occurs in space. Lateralization: Perceiving sound within the head (e.g. left or right side) when using headphones.	The ability to differentiate one sound from another, not limited to speech sounds.	Identifying and interpreting patterns in sounds including speech, music and environmental noises.	How we perceive and process the timing of sounds, essential for speech and music comprehension.	Challenges in understanding sounds amidst competing background noises and other sounds.	Difficulty processing incomplete, distorted or time-compressed sounds.	Neural integration disorder characterized by abnormal asymmetry between the ears during binaural integration tasks (Moncrieff and Black 2008).	A type of APD involving difficulty using spatial cues to separate sounds in noisy environments (Cameron et al. 2014).
Key Components	Crucial for navigating and interacting with the environment enabling accurate sound pinpointing and appropriate responses.	Fundamental for recognizing diverse auditory stimuli.	Processing timing, pitch, timbre and sequence for speech, music and sound differentiation. Involves memory, attention, integration and cortex.	Temporal resolution; Temporal Integration; Temporal Ordering; Temporal Masking.	Common in noisy environments; hinders focus and comprehension.	Affects understanding in situations where acoustic signals are compromised (e.g. poor phone reception or muffled speech).	Normal performance in the dominant ear. Requires consistent interaural asymmetry across two or more dichotic listening tests.	Difficulty processing sound timing and intensity differences; affects localization, separation, and speech understanding in noise.

Criteria for the Diagnosis of APD

The criteria required to make a diagnosis of APD as proposed by ASHA (2005) and espoused by AAA (2010) includes the following: APD exists when the results are two or more standard deviations (SDs) below the mean on any two tests or three SDs below the mean on any one test. Dillon, Tomlin and Kelly (2014) suggest focusing on patterns of deficits or weaknesses rather than strict cut-off scores. They argue that using a hard cut-off of -two SD below the mean can exclude children who are close to this threshold (for example, -1.92SD) from receiving services, despite showing a pattern of weakness. To address this, they recommend using a double arcsine transformation to convert scores to age-specific Z-scores that have accounted for the asymmetric distribution of the normative results to allow for a more accurate comparison.

There are certain aspects that teachers, psychologists, occupational therapists, academic support specialists, paediatricians, caregivers and others working with children can use as a checklist or indicators for APD (See Appendix 8.1). In young children, the behaviours which should raise concerns would include difficulty learning rhymes and songs, inattention to the speaker or ignoring a speaker when participating in other activities, sensitivity to sound or noise, and difficulty with complex directions. Currently, HHPs are able to assess for APD from a much younger age (three years and six months), and these warning signs could enable earlier assessment and intervention than was previously thought.

Assessment of APD

Early identification of APD is crucial. While assessment was traditionally recommended from age eight, normative data now support testing as early as three years and six months using tools such as the Auditory Skills Assessment Test (Geffner and Goldman, 2010), Staggered Spondaic Word Test (Katz 1998), SCAN-3C (Keith 2009), Phonemic Synthesis Picture Test and Phoneme Recognition Test (Katz 1998).

An individualised, evidence-based approach is essential, ensuring that HHPs have the necessary training and support to conduct evaluations effectively. The test battery should align with the patient's specific concerns, clinical framework and principles of validity, reliability and efficiency. Given the variability in APD and learning disabilities, determining test

reliability can be challenging; however, tests that successfully identify lesions remain the standard for validity. Assessments should thus incorporate tests for various auditory processes using both verbal and nonverbal stimuli with minimal linguistic bias. Even without normative data, qualitative evaluations can provide valuable insights, establish baselines and guide interventions.

Considering the individual's characteristics enhances assessment accuracy, allowing HHPs to tailor their approach for optimal comprehension and motivation. Awareness of the lowest normed test age is crucial, particularly for electrophysiologic measures, where understanding primary pathway development—especially middle latency responses —is vital. Standardised protocols should be followed, with documented modifications as needed, and session duration should be monitored for patient well-being. Collaboration with other professionals can enhance the assessment process, leading to appropriate referrals for suspected additional deficits.

An effective APD assessment should integrate test results with case history and observations to tailor interventions. The primary goals should include confirming the disorder, identifying patterns of deficits and establishing a differential diagnosis by linking auditory challenges to real-world functional difficulties. Diagnostic accuracy depends on intra- and inter-test pattern analysis across auditory and multidisciplinary evaluations and ensures ecologically valid, individualised intervention plans. Inconsistencies in test results, such as differing ear advantages on dichotic tests or uniformly poor performance, should prompt a review of test specifics and potential confounding factors, including attention, motivation, cognitive abilities or language deficits.

Tools available for APD assessment

The assessment process depends on the chosen model, with each providing theoretical support for test selection, evaluation areas and result interpretation. The HHP is responsible for investigating these foundational elements. Research emphasises the importance of evaluating the influence of cognitive factors, such as memory, attention and intelligence on auditory processing. These variables should be accounted for when analysing the relationship between auditory processing abilities and functional performance in real-world contexts to ensure accurate interpretation and application of findings (Seeto, Tomlin and Dillon 2021). Every clinician, clinic and practice should develop a context-specific protocol tailored to its

demographic, patient age group, co-morbid conditions, referral reasons and approach to auditory processing. Below is a suggested framework:

Screening APD assessment

Referral sources such as speech-language therapists, psychologists, teachers, academic support staff and HHPs might use screening tools to justify a diagnostic, person-centred assessment. Appendix 8.1 lists 'red flags' for referrals. Before auditory processing screening, at least a basic hearing test should be done, and ideally a full diagnostic hearing assessment. Age-appropriate, culturally relevant tests should be selected (see Table 8.2), considering administration time and proper training for accurate interpretation. If a child scores below the expected range, a comprehensive auditory processing assessment by an HHP is recommended to delve deeper into specific auditory skills and formulate individualised intervention plans.

Table 8.2: Screening tools available for APD

Test Name	SCAN-3 (Child)	Auditory Skills Assessment (ASA)	Differential Screening Test for Processing (DSTP)
Subtests	• Filtered Words • Auditory Figure Ground (SNR + 8dB) • Competing Words • Competing Sentences • Gap Detection • Time Compressed Sentences • Competing Words Free Recall • Auditory Figure Ground (SNR +0dB and +12dB)	Speech Discrimination Domain: • Speech discrimination in noise • Mimicry Phonological Awareness Domain: • Blending • Rhyming Nonspeech Processing Domain: • Tonal Discrimination • Tonal Patterning	Level One – Acoustic Subtests: • Dichotic Digits • Temporal Patterning • Auditory Discrimination Level Two – Acoustic Linguistic Subtest: • Phonemic Manipulation • Phonic Manipulation Level Three – Linguistic Subtests • Antonyms • Prosodic Interpretation • Language Organization
Age	5.00 – 50.11 years	3.6 – 3.11 years	6 - 12 years
Areas Assessed	Differentiation of auditory processing disorder from auditory attention and auditory comprehension difficulties.	• Speech Discrimination • Phonological Awareness • Nonspeech auditory processing"	Acoustic Processing Acoustic-Linguistic Processing Linguistic Processing

Test Name	SCAN-3 (Child)	Auditory Skills Assessment (ASA)	Differential Screening Test for Processing (DSTP)
Comments	The SCAN-3 includes screening and diagnostic tests. Screening takes 10-15 mins and diagnostics take 30-45 mins. Not all tests are required. Filtered Words and Auditory Figure Ground tests may be less sensitive. Competing Words and Sentences tests assess attention, binaural integration and separation.	The ASA is a criterion-referenced screening tool that identifies young children at risk for APD. It takes 5-15 mins to administer depending on the child's age and ability and yields a single age-based cut score. It is also useful for monitoring progress in young children.	The DSTP uses a processing continuum from auditory to language processing. It is a screening test only and should not be used for diagnostic purposes. The Pass/ Fail criteria are already one standard deviation below the mean.

The assessment should include pre-assessment, an intake interview and an in-person or online clinical assessment. Each sub-section of the assessment is described below.

Pre-assessment

a) Case History

Caregivers, teachers or the patient should complete a detailed case history form. This will serve as a valuable starting point for discussions during the intake interview. Any available reports (for example, from educators and medical professionals) should be collected to build a comprehensive understanding of the patient's challenges. Having relevant professionals and family members complete questionnaires provides insight into their perception of the areas of difficulty. Commonly used questionnaires include the Buffalo Model Questionnaire (Katz et al. 2019), The Fisher's Checklist (Fisher 1976), eClips (Barry et al. 2015), CHAPPS (Smoski, Brunt and Tanahil 1998) and the Auditory Processing Domains Questionnaire (O'Hara and Mealings 2018).

b) Intake interview

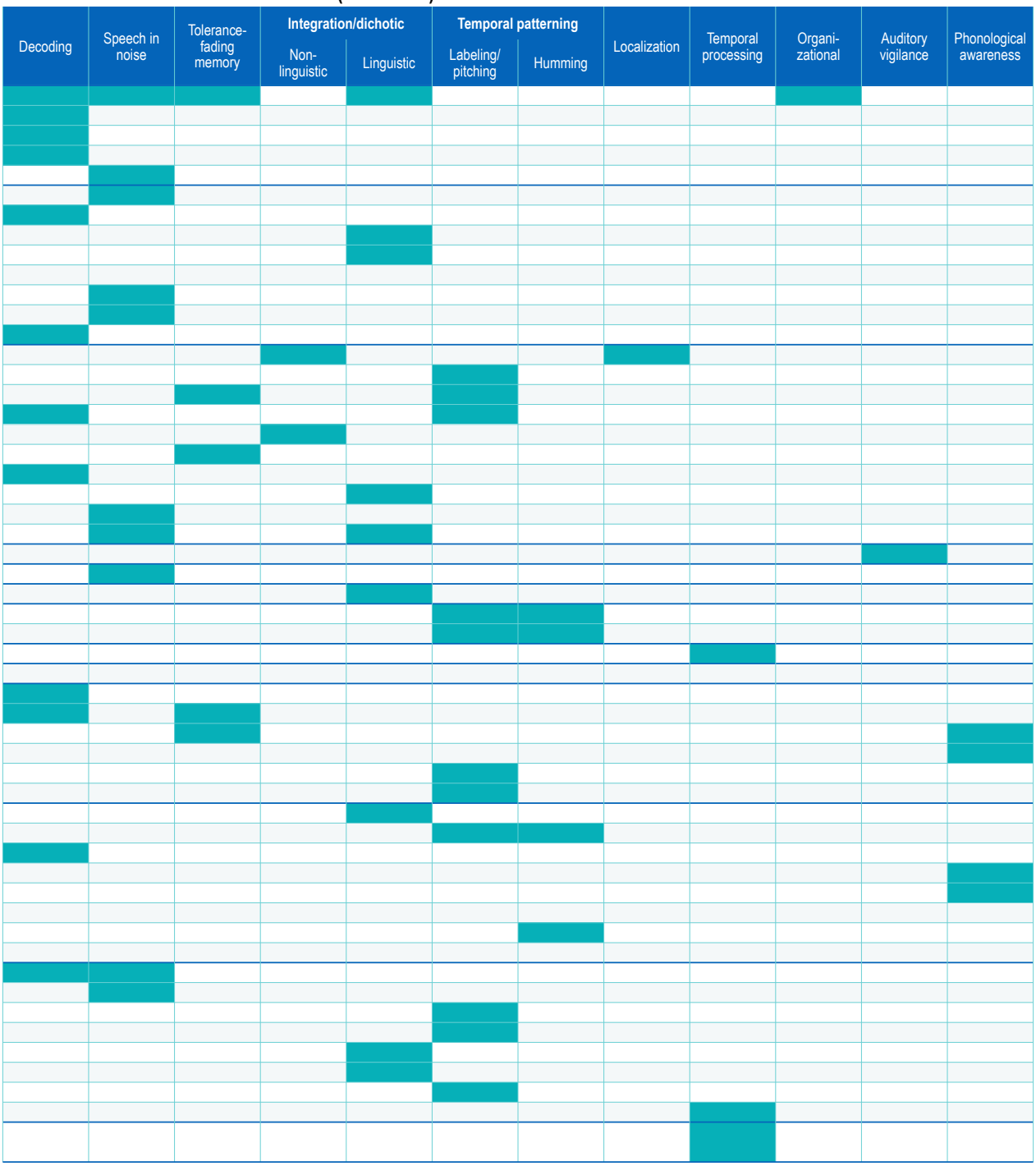
There are various factors to consider when scheduling and preparing for an auditory process-ingassessment as these factors will modify the assessment process. These considerations include the age of the child, time and length of assessment, presenting concerns, cognitive status, emotional and psychological well-being and language and hearing status. An interview with the caregivers (without the child present) should be conducted to encourage open discussion. If resources allow, peripheral hearing assessments should be conducted in parallel by another clinician. The hearing assessment should include pure tone audiometry, speech audiometry, immittance measures and otoacoustic emissions.

The assessment tools selected need to be appropriate to the child as well as to the social and economic environment in which the testing occurs. Not all assessment tools are affordable or appropriate in every situation. In many countries, there is limited access to audiological services for peripheral hearing difficulties, let alone for APD. HHPs working in areas where access to appropriate auditory processing assessment tools is not readily available should not limit their investigation, but should instead use available tools to collect information that will guide intervention. Table 8.3 provides an introduction to some of the auditory processing assessment tools available. More extensive information is available in Appendix 8.2.

APD ASSESSMENT TESTS SUMMARY

TEST	SUBTEST	SUPPLIER	AGE
Central Test Battery	Staggered Spondaic Word Test	Precision Acoustics	5 and above
	Phonemic Synthesis Test		6 and above
	Phoneme Recognition Test		All
	Phonemic Synthesis Test with Pictures		4–7 years
	W-22 in Noise and Quiet		5 and above
SCAN-3	Auditory Figure-Ground +8	Pearson	6 and above
	Filtered Words		
	Competing Words		
	Competing Sentences		
	Competing Words Free Recall		
	Auditory Figure-Ground +12		
	Auditory Figure-Ground 0		
	Time Compressed Speech		
Feather Squadron	Hearing Screening and Lateralisation	Acoustic Pioneer	5 and above
	Tonal Pattern Temporal Processing		
	Tonal Pattern Memory		
	Rapid Tones		
	Dichotic Sounds/Double Sounds		
	Word Memory		
	Rapid Speech		
	Dichotic Double Sounds		
	Speech in Noise (Without Localisation Cues)		
	Speech in Noise (With Localisation Cues)		
Auditory Continuous Performance Test		Auditec	6.0–11.11years
Listening in Spatial Noise –S/U		Soundstorm	6 and above
Dichotic Digits Test		Auditec of St Louis	7 and above
Temporal Patterning Tests	Frequency Patterning	Auditec of St Louis	7 and above
	Duration Patterning		7 and above
Gaps in Noise Test		Auditec	7 and above
Random Gap Detection Test		Auditec	5 and above
Auditory Skills Assessment	Speech Discrimination in Noise	Pearson	3.6–6.11 years
	Mimicry		
	Blending		
	Rhyming		
	Tonal Discrimination		
	Tonal Patterning		
Differential Screening Test for Processing	Dichotic Digits	LinguiSystems	6.0–12.11 years
	Temporal Patterning		
	Auditory Discrimination		
	Phonemic Manipulation		
	Phonic Manipulation		
	Antonyms (Language)		
	Prosodic Interpretation		
	Language Organization (Language)		
Multiple Auditory Processing Assessment	Monaural-Selective Attention Test	Academic Therapy Publication	8 and above
	Speech in Noise for Children		
	TAP Test		
	Pitch Pattern Test		
	Dichotic Digits		
	Competing Sentences		
	Duration Pattern Test		
	Gap Detection		
Frequency FollowingResponse	Experimental		

APD ASSESSMENT TESTS SUMMARY (continued)



Post-assessment

a) Feedback session

A follow-up visit should be scheduled to review findings with caregivers and discuss recommended auditory training and management strategies. To support caregiver understanding and engagement, structured feedback materials (for example, a feedback book or PowerPoint presentation) may be used to guide the session, ensuring that complex audiological information is communicated in clear, accessible language appropriate for non-specialist audiences.

b) Analysis and interpretation

Results should be interpreted in the context of the case history, accompanying reports, observations and assessment outcomes. No assessment task should be considered in isolation; instead, a pattern of responses should be identified to understand what each task assesses. Interventions must be process-based, targeting specific auditory processes identified as areas of deficit (see Table 8.4). These may include auditory training, compensatory strategies and environmental modifications. When patterns are unclear, a broader scope of interventions addressing both auditory and non-auditory factors should be considered to comprehensively support the child.

Table 8.4: Patterns of responses

Test	Deficit	Underlying Process
Staggered Spondaic Word Test	"Decoding Tolerance Fading Memory"	Decoding
Feather Squadron	"Rapid Speech Speech in Noise"	
Scan- 3 (Child)	"Filtered Words Auditory Figure Ground Time Compressed Speech"	

Test	Deficit	Underlying Process
Feather Squadron	"Dichotic Sounds Dichotic Words"	Integration
Scan- 3 (Child)	"Competing Words Competing Sentences"	
Dichotic Digits	Dichotic Digits	
Feather Squadron	Temporal Pattern Temporal processing	"Temporal Patterning (Prosodic)"
Temporal Patterning	Frequency Patterning	
Gaps in Noise	Temporal Resolution	

c) Recommendations

Recommendations should be person-centred and tailored to the specific needs of the child rather than relying on generic suggestions (Chapter 15). Training recommendations must be directly based on assessment findings to ensure targeted and effective intervention. While generalised strategies are not encouraged, certain activities have been shown to enhance auditory processing skills, such as learning to play a musical instrument, listening to audio-books and engaging with songs and rhymes.

d) Referrals

An educational psychologist or paediatrician might be consulted for cognitive, memory and attention difficulties, while an occupational therapist can assist with sensory integration issues beyond auditory challenges. A psychologist may be involved to address anxiety or behavioural concerns, and a speech-language therapist can provide intervention for language-based difficulties. By following this structured and adaptable approach, clinicians can ensure assessments are thorough and person-centred, and lead to actionable insights for intervention and support.

Electrophysiological Assessment

The Frequency Following Response (FFR) is a neurophonic auditory evoked potential that reflects how efficiently speech sounds are encoded. FFR uses the complex syllable /da/ to evoke auditory brainstem response (ABR), which is mainly used to analyse the neural activity of the brainstem to speech stimulus. The FFR is disrupted in various speech and language disorders, making it a valuable tool for testing auditory processing abilities across different languages. Unlike the click-evoked ABR, which identifies hearing loss or auditory neuropathy, the FFR detects real-world auditory processing deficits. For instance, individuals with concussions may have normal ABRs, yet the FFR can reveal subtle deficits with high accuracy (95% sensitivity and 90% specificity). The FFR also shows promise as a potential biomarker for literacy. In children with normal ABRs, atypical FFR results may predict a higher risk for language development issues, making it a valuable diagnostic tool. Although currently expensive, it represents a significant advancement and is likely to shape the future of APD assessment. Its value in countries where English is not the first language will be paramount, as assessment will not be limited to non-linguistic or low-linguistically loaded assessment tools.

Intervention for APD

Intervention for APD should cover three areas (Bellis 2011): a) direct auditory training (changing the individual), b) environmental modifications (changing the world of the individual) and c) compensatory strategies (helping the individual to change their world).

Direct auditory training for APD is grounded in several key principles, as highlighted by leading experts in the field (Barker and Hicks 2020; Bigras et al. 2024; Geffner and Ross-Swain 2026a; Weihing et al. 2015). Tailoring auditory training programmes to address the specific deficits of each patient is crucial. This personalised approach ensures that interventions target the unique auditory challenges faced by the person, leading to more effective outcomes. Auditory training typically incorporates both bottom-up and top-down processing approaches. Bottom-up training focuses on strengthening the neural encoding of acoustic features such as frequency, intensity and temporal cues, whereas top-down strategies engage higher-order cognitive processes, including attention, memory and linguistic knowledge, to support sound interpretation. Integrating these complementary approaches allows

for more comprehensive improvement in auditory processing abilities, particularly in complex listening environments.

Implementing adaptive training methods that adjust the difficulty level based on an individual's performance helps maintain engagement and propels continuous improvement in auditory skills. Additionally, incorporating multisensory elements, such as visual aids or tactile feedback, enhances learning by engaging multiple sensory pathways, thereby reinforcing auditory processing skills. Continuous assessment of progress allows for modifications to training programmes, ensuring that interventions remain effective over time and evolve with the individual's needs. By adhering to these principles, clinicians can design and implement auditory training programmes that effectively address the specific needs of individuals with APD, improving their auditory processing capabilities and overall quality of life.

There has been a resurgence in interest in providing direct, person-centred and evidence-based auditory training for individuals with APD, with a move away from generic recommendations (Katz et al. 2019). The following are commonly used auditory training models:

- Buffalo Model of Auditory Training (BMAT) is aimed at addressing auditory-related deficits in a gradual or incremental manner to change the unformed or incorrect representations imprinted on the auditory cortex. Given the challenges in sub-Saharan Africa related to affordability, geography, language, culture and accessibility, the BMAT (Katz et al. 2019) offers a practical, low-tech solution for addressing auditory processing deficits. The BMAT is designed to gradually reshape incorrect or underdeveloped auditory representations in the auditory cortex through structured training over twelve to fourteen sessions, each lasting 45–60 minutes. While the programme follows a structured framework, it can be adapted to an individual's language without compromising its effectiveness. This bottom-up approach builds foundational auditory processing skills, focusing on phoneme recognition in quiet and noise, phonemic synthesis, words-in-noise training, and short-term auditory memory development. Dichotic offset training further enhances dichotic listening skills. Essential materials include phoneme cards, phonemic synthesis exercises (which can be purchased or created by the clinician), short-term memory tasks and pre-recorded words-in-noise training tracks. By targeting key auditory skills, the BMAT enhances speech perception, auditory memory and overall listening abilities, ultimately improving communication and

learning outcomes for individuals with APD. Additionally, the programme can be adapted for online training, expanding access to those unable to attend in-person sessions while still benefiting from structured auditory intervention. The BMAT should be considered a sound auditory training approach for providing auditory training services that may not previously have been available. Clear, step-by-step guidance to evaluate APDs has been provided by Alexander and Abbas (2026), and the same steps can be used for providing online auditory training.

- Auditory Rehabilitation for Interaural Asymmetry (ARIA) was developed in 2000 (Moncrieff and Black 2008) to address interaural asymmetries identified in children during tests of dichotic listening. The term 'amblyaudia' was coined to refer to these asymmetries. Specific, hands-on training is provided to learn how to administer the ARIA. The ARIA is a training programme presented over four weeks for 25 minutes per session. Materials required to administer the training include an audiometer with two channel capabilities, the ARIA software played through a computer or tablet and normal audiological equipment such as high-quality headphones, a quiet environment and a means for the individual to provide feedback. Despite its reported efficacy in addressing dichotic listening difficulty, the range of materials needed limits its use to more clinical environments.

Numerous computer and tablet applications are available for direct auditory training. However, it is essential to recognise that these programmes cannot replace clinician-driven intervention. Instead, they serve as valuable supplementary tools that can enhance direct intervention or provide an alternative when direct intervention is not feasible. The HHP remains responsible for overseeing the training process, monitoring progress and offering support as needed to ensure effective outcomes. The professional grade auditory training programmes that should be considered include the following:

- *ZooCaper SkyScraper* (Barker and Bellis 2018; Barker and Hicks 2020) is a tablet- or computer-based therapy programme designed to develop dichotic listening skills. It is engaging for all ages and structured for completion over approximately 12 weeks, with two-to-three sessions of 20 minutes per week. The HHP can monitor progress remotely and provide guidance as needed.
- *Insane Earpanes* (Barker and Bellis 2018; Barker and Hicks 2020) is another tablet- or computer-based training programme that strengthens auditory processing skills, including lateralisation, pitch pattern recognition, pitch sweeps

and interaural timing and intensity differences. It incrementally builds these skills based on AAA and ASHA recommendations and is suitable for all ages. Like ZooCaper SkyScraper, it is designed to be engaging and manageable within a structured timeframe.

- *Elephant Memory Training* (Barker and Bourland-Hicks, 2020) is a top-down training programme that is conducted four times per week over an eight-week period. Working memory is a critical component in a dynamic processing system that includes auditory processing as well as language and literacy, and relates to the storage and manipulation of information.
- *Sound Storm* (formerly LiSN & Learn) (Cameron and Dillon 2008) is an auditory training programme designed to assist children with SPD with managing classroom listening challenges. By enhancing their ability to suppress background noise and focus on target auditory stimuli, the programme aims to improve speech perception in noisy environments. The programme creates a three-dimensional auditory experience through headphones on an iPad. The training is structured around an engaging space-fantasy narrative, guiding users through ten progressive levels across nine distinct galactic worlds, making the intervention immersive.
- *CAPDOTS* (Lucker et al. 2021) is a web-based AT programme designed to address binaural auditory integration deficits, commonly referred to as dichotic listening difficulties. The programme requires a stable internet connection and high-quality headphones and can be administered in a clinical setting, school or home environment. According to its developers, CAPDOTS enhances skills such as following multi-step directions, maintaining listening attention in background noise, improving inferential listening, understanding group instructions and strengthening auditory memory. It is also reported to support academic performance, particularly in reading comprehension and spelling. While this auditory training tool allows access for those unable to travel to in-person therapy, it requires the support of a capable adult to assist the individual during training. In addition to these professional-grade auditory training programmes, there are useful applications to support and enhance in-person auditory training (see Table 8.5).

In school settings, educators can make use of a number of environmental modifications, including the use of assistive listening devices (Chapter 10) as well as compensatory strategies (Chapter 13).

Table 8.5: Applications to support auditory training

APP	Broad Area	Specific Area	Link
LACE AI: Listening and Communication Enhancement	Direct Remediation	Figure-ground training; auditory separation; temporal integration; auditory working memory	*https://www.laceauditorytraining.com/*
Functional Listening App	Listening in Noise	Figure-ground listening	*https://apps.apple.com/us/app/functional-listening/id1100839826*
Hear Beyond		Listening in noise; sound localization; sound sequencing; pitch patterning; working memory	*https://www.hearbeyond.world/*
Hearapp/ HearappKids	Listening in noise	Word and phrase identification; identification of words and phrases in quiet and noise	*https://apps.apple.com/us/app/hearapp-kids/id1010536075*
Clearly Audiobooks	Speech discrimination; listening in noise		*https://clearlyaudiobooks.com/*
I-Angel Sounds	Sound discrimination and identification	Sound and speech identification; temporal patterning	*http://iangelsound.emilyfufoundation.org/*

APP	Broad Area	Specific Area	Link
ReDi	Temporal patterning	Sound sequencing	
SpeechBanana	Phoneme/speech discrimination task		*http://speechbanana.jhu.edu/*
Heroes	Sound identification	Environmental sounds; introduction to words; single vowels; common consonants; understanding sentences	*https://www.hearoes.com/*
Listening Adventures	Development of listening and language skills		*https://apps.apple.com/us/app/ab-listening-adventures/id898695069*
Auditory Training App		Dichotic digits; alternated dichotic; non-verbal sound; temporal patterns	*https://apps.apple.com/us/app/auditory-training/id1637321202*
Pocket Phonics/ Pocket Phonics Stories	Phonological awareness and processing	Phoneme recognition and identification	*https://www.readingrockets.org/resources/literacy-apps/pocketphonics*
CVC Train	Phoneme-to-grapheme skills	Letter recognition and sound blending	*https://wordwall.net/en-us/community/cvc-train*

Conclusion

Children with APD often struggle with following verbal instructions, listening in noisy environments and completing language-related tasks. These difficulties can overlap with conditions like ADHD or language disorders, makinan g accurate diagnosis through multidisciplinary assessment essential. Without intervention, APD can hinder academic success and social development, leading to frustration and low self-esteem. Early identification and targeted support equip children with the necessary skills to navigate their challenges, promoting confidence, independence and long-term success. While further research in APD is needed, access to services should not be denied based on research thresholds alone. Addressing APD is not just about mitigating auditory challenges; it is about empowering children with strategies and support to reach their full potential in all areas of life.

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Appendix 8.1: Red flags and concerning behaviours for APD

- Poor listening skills.
- Difficulty learning through the auditory modality; does better with visual stimuli.
- Difficulty following auditory instructions, especially multi-step instructions or instructions embedded in other information.
- Short-term and auditory memory span deficiencies; trouble retaining sequences or retelling stories.
- Difficulty understanding speech in background noise, reverberant environments, or when speech is distorted or rapid.
- Frequently says "what?" or "huh?" and often requests repetition.
- Mishearing or misunderstanding spoken words or messages.
- Delayed or slowed response to verbal stimuli.
- Poor auditory attention and fatigue with prolonged listening tasks.
- Easily distracted by environmental sounds; hears background noise more prominently than the speaker.
- Reduced tolerance to loud environments or hypersensitivity to sound.
- Deficits in auditory integration, including sound blending, auditory closure, phonological awareness, rhyming, and phonic skills.
- Inability to detect subtle acoustic differences and changes in prosody, such as sarcasm or humour.
- Difficulty with speech recognition in noise; figure-ground discrimination deficits.
- Problems understanding and retaining orally presented information, including stories and classroom discussions.
- Problems with spelling, reading, and written language.
- Difficulty with foreign language learning.
- Cannot write accurately from dictation.
- Cryptic or insignificant notetaking; misses key points or facts.
- Struggles with mathematical word problems.

- Takes longer to process and respond to questions or instructions.
- Poor singing ability, music appreciation, or musical memory ("poor ear for music").
- Tinnitus, especially perceived in the head.
- Academic underperformance or learning difficulties.
- History of middle ear infections (otitis media).
- Fidgety or uncomfortable in noisy settings, such as the cafeteria or gym.
- Avoids participating in class discussions or group learning tasks.

Appendix 8.2: Summary of auditory processing assessment tools

Test	Link
Central Test Battery (CTB) (Katz 1998)	*https://precisionacoustics.org/products/central-test-battery-kit*
Feather Squadron (Barker 2017)	*https://acousticpioneer.com/*
Auditory Continuous Performance Test (Keith 1994)	*https://auditec.com/2015/10/26/auditory-continuous-performance-test-acpt/*
Listening in Spatial Noise – U (Cameron & Dillon 2008)	*https://www.soundscouts.com/*
Dichotic Digits Test	*https://auditec.com/2015/10/01/dichotic-digits/*
Temporal Patterning Tests: Frequency Patterning; Duration Patterning	*https://auditec.com/category/temporal/*
Gaps in Noise Test (Musiek 2005)	*https://auditec.com/2015/09/22/gaps-in-noise-gin/*
Multiple Auditory Processing Assessment (MAPA-2)	*https://assessments.academictherapy.com/sku/2211-8*
(Cameron & Dillon 2008)	*https://www.soundscouts.com/*
Dichotic Digits Test	*https://auditec.com/2015/10/01/dichotic-digits/*
Temporal Patterning Tests: Frequency Patterning Duration Patterning	*https://auditec.com/category/temporal/*
Gaps in Noise Test (Musiek 2005)	*https://auditec.com/2015/09/22/gaps-in-noise-gin/*
Multiple Auditory Processing Assessment	*https://assessments.academictherapy.com/i/multiple-auditory-processing-assessment-mapa-2*