When the brain doesn't hear: Auditory processing disorder in children

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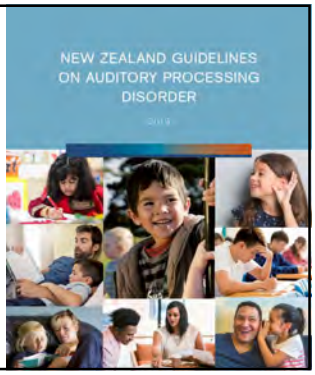
Online seminar for
Institute of Educational and Developmental Psychology
May 2020



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Affiliations and funding

Affiliations

- Owner of SoundSkills APD Clinic
- Research Fellow/Honorary Academic, University of Auckland
- Member, Eisdell Moore Hearing Research Centre

Funding

- Oticon (now William Demant) Foundation, Denmark
- Sonova AG, Switzerland
- Hearing Research Foundation/Eisdell Moore Centre
- Lottery Health Research

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Definition of APD - NZ

Auditory processing disorder is a generic term for hearing disorders that result from atypical processing of auditory information in the brain. Auditory processing disorder is characterised by persistent limitations in the performance of auditory activities and has significant consequences for participation.

2016 ICD-10-CM Diagnosis Code H93.25

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What does APD sound like?

https://www.soundskills.co.nz/_literature_104671/Click_to_listen_to_an_Audio_Simulation_of_APD.mp3

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Impact

- "She just sat in the toilets at school all day crying. The teachers said it was bad behaviour."
- "He sits a lot with his hands over his ears in class."
- "The worst thing was he lost all his confidence and friends. The best thing we did was take him out of school. For all those years he thought he was dumb. It took ages for him to get his confidence and self-esteem back."

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Causes

- hereditary developmental abnormalities
- maturational delay
- antenatal, perinatal and postnatal factors including prematurity and low birth weight, prenatal anoxia, prenatal exposure to cigarette smoke or alcohol, hyperbilirubinemia
- diseases, toxins and neurological conditions affecting the brain including space-occupying lesions; Moyamoya disease and other cerebrovascular disorders; multiple sclerosis and other neurodegenerative diseases; bacterial meningitis; herpes simplex encephalitis; Landau Kleffner Syndrome and other seizure disorders; Lyme disease; metabolic disease; heavy metal exposure; solvent exposure
- traumatic brain injury
- blast injury
- auditory deprivation e.g., from otitis media in early childhood
- aging

(Bamiou, Musiek, & Luxon, 2001; AAA, 2010, p. 13; Witton, 2010)

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Prevalence in children

- we estimate at least 6% overall in NZ (Sapere Report on APD in NZ)
- high in some populations
  - the Pacific Island Families Study - 34%
  - youth offenders 27% (Lount, Purdy & Hand, 2017)
- 3-7% of all children (Chermak & Musiek 2007; Bamiou, 2001)
- ~10% in some studies (Skarzynski et al, 2015; Moloudi et al, 2018)
- 10% estimated taking into account presence with comorbidities (Brewer et al, 2016)
- estimates depend very much on diagnostic criteria and method

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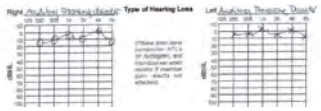
How do you detect APD?

- an audiogram is NOT enough
  - normal audiograms give false reassurance that there is no hearing problem



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Refer for APD assessment when there are symptoms of hearing or listening problems inconsistent with the results of basic hearing assessment

Symptoms

- difficulty following spoken directions unless brief and simple
- difficulty attending to and remembering spoken information
- slowness in processing spoken information
- difficulty understanding in the presence of other sounds
- being overwhelmed by complex or "busy" auditory environments e.g., classrooms, shopping malls
- undue sensitivity to loud sounds or noise
- poor listening skills
- preference for loud television volume
- insensitivity to tone of voice or other nuances of speech

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Consider referral for APD assessment when there are frequently associated conditions or factors

Frequently associated conditions or factors

- brain injury
- neurological disorders affecting the brain
- history of frequent or persistent middle ear disease
- dyslexia, difficulty with reading or spelling
- language disorder (SLI) or delay
- autism spectrum disorder.

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Dyslexia and APD

- …. There is considerable research supporting the hypothesis that the underlying core deficit of developmental dyslexia is a phonological processing deficit.
- …there is substantial research on the specific neurologic links between APD and dyslexia

Geffner D, Ross-Swain, D. (2013) Auditory Processing Disorders: Assessment, Management, and Treatment. 2nd edn Plural Publishing 301-317
Chapter 13. Auditory Processing Disorders and Literacy. Martha S Burns

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ASD and APD

- people with ASD commonly have central auditory processing deficits
- auditory training, RMHA systems and language therapy can improve hearing and learning, reduce stress, and help with social skills

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AD(H)D and APD

- APD and AD(H)D present differently and appear to be separate morbidities

Table 1
Top Four Characteristics of ADHD and APD in Rank Order of Occurrence

ADHD	APD
Inattentive	Asks for things to be repeated
Academic difficulties	Poor listening skills
Daydreams	Difficulty following instructions given orally
Distracted	Difficulty hearing in background/ambient noise

Note. From Chermak, Tucker, & Seikel, 2002.

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Diagnosis

- APD is diagnosed by audiologists using a battery of tests that stress the auditory system, for example:
  - speech in noise
  - distorted speech (filtered, time-compressed)
  - recognition of brief acoustic events (<20msec)
  - dichotic tests: competing (simultaneous) speech messages to the two ears

test results must be considered in the context of comorbid conditions and cognitive and language ability levels

automated testing apps are not endorsed in NZ Guidelines on APD

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Pre-assessment is vitally important

"Because of the cognitive and language requirements necessary to complete an APD test battery, and because of the possibility of coexisting disorders, APD cannot be diagnosed accurately in isolation from knowledge of other developmental ability levels" *NZ Guidelines on APD*

- pre-assessment of related developmental capacities – cognition, language, phonological awareness, teacher observations
  - summary appreciated if evaluation is detailed
  - General Ability, oral comprehension, language, phonological awareness, auditory memory, processing speed

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Diagnostic tests

Dichotic Digits Test

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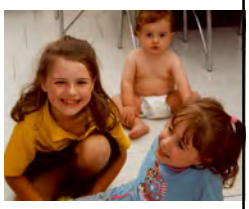
How young can we diagnose and treat?

EARLY DETECTION

- *Early detection of and intervention for auditory processing difficulties are recommended.*

Tests suitable for use with younger children by audiologists in New Zealand are shown in Table 4 and include SCAN-3:C from 5 years of age and the ASA and CELF Pre-School 2 (User Level B) if below 5 years.



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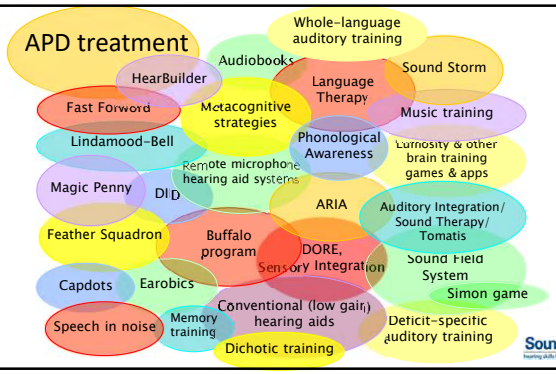

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A suggested treatment approach

- auditory training
- amplification

Audiologist +
Education Adviser in school

- language therapy
  incl phoneme recognition and discrimination, phonemic awareness, phonological awareness, phonics, prosody, language

SLT, Teachers…

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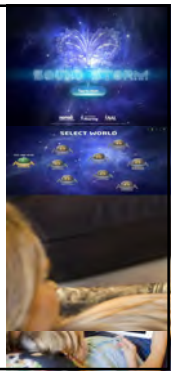
Sound Storm auditory training game

- improves hearing in noise
- developed by Australian Government research group



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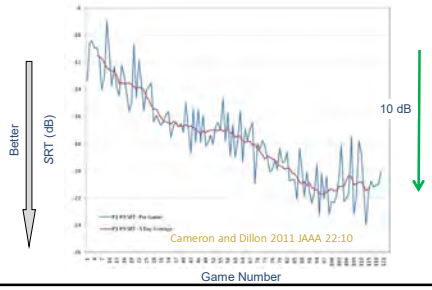
Sound Storm: Spatial stream segregation



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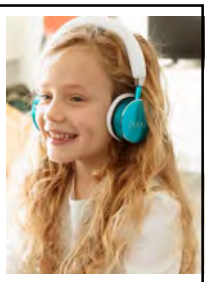
Auditory enrichment with mildly amplified whole language: Audiobooks

- evidence inferred from RMHA system research and evidence with other groups
- listen at upper part of comfortable range, earphones or headphones, no visual or other distractions, sufficiently interesting to engage and maintain attention



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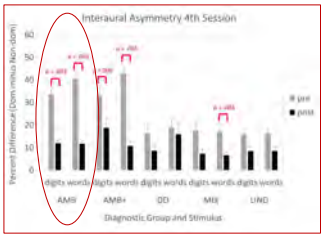
Correction of amblyaudia

- suppression of input from non-dominant ear
- observed as abnormal degree of interaural asymmetry on dichotic testing
- auditory training in clinic – ARIA (Auditory Rehabilitation for Interaural Asymmetry)
- research –
  - gain variation of remote mic hearing aids
  - gain variation during audiobook listening



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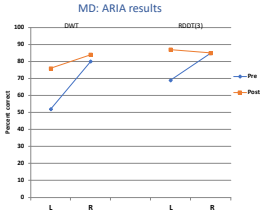
Pre and Post ARIA treatment

MD
12yo m

PASS:
Comp/rev words
Freq pattern
Random gap
Digit span
LiSN-S

Borderline:
Dichotic Digits Test

Mother (SLT) requested intervention



ARIA: Aural Rehabilitation for Interaural Asymmetry

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Post ARIA treatment

MD
12yo m

Mum reports much better, loves school now; going very well, sitting towards the front at school … Max doesn't say "What??" anymore, such as when he's playing X box. She noted this as a great improvement. Max now says he enjoys going to class - and it has been noted that he "raises his hand all the time in English now." Mom said that Max is "shining" more. Reading comprehension is improving along with maths. Has extra tuition with reading. Referred to SLT for phonological awareness.

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Amplification with remote microphone hearing aid (RMHA) systems: Audio demonstration



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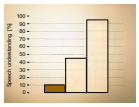
Speech recognition score



- No RMHA system
- Traditional RMHA system
- Dynamic RMHA system

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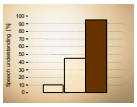
Speech recognition score



- No RMHA system
- Traditional RMHA system
- Dynamic RMHA system

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Amplification with remote microphone hearing aid (RMHA) systems

- RMHA systems benefit most if not all children with APD (and many with ASD, dyslexia, other learning disorders)
- must be fitted by audiologists
- there is no predictive test of who will benefit, a trial is necessary
- an education specialist is critical
  - for school liaison, teacher/parent/child guidance, classroom observation, trial management, IEPs, funding applications, fitting decision
- wear in multiple situations including therapy
- RMHA systems are both assistive and therapeutic
  - possibly the single most powerful treatment for APD in children
  - average duration of use is 2yrs 9mo

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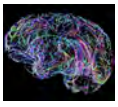
RMHA system benefits: assistive, therapeutic

Assistive

- academic performance
- attention and participation
- phonological awareness, reading
- psychosocial development, confidence, self-esteem
- reduced classroom stress (children with ASD)
- less tired

Neuroplastic, permanent

- cortical evoked responses to tone stimuli
- auditory brainstem responses to speech stimuli
- frequency discrimination
- binaural temporal resolution
- frequency pattern recognition
- auditory working memory
- language
- phonological awareness
- speech perception in quiet and in spatially separated noise



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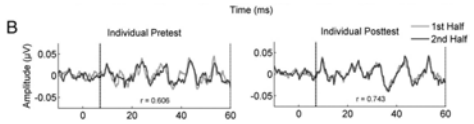
Hornickel et al 2012: Neuroplasticity in Auditory Processing Engendered by RMHA System Use in the Classroom



After 1 year RMHA system use, children with dyslexia improved on phonological awareness and reading and showed increased consistency in auditory brainstem responses to speech. More inconsistent brainstem responses at pre-test predicted greater gain in phonological awareness.
Inconsistent neural processing of sound underlies and reflects variability contributing to poor phonological awareness, … RMHA system use addresses this deficit …

Hornickel J, Zecker SG, Bradlow AR, Kraus N. Assistive listening devices drive neuroplasticity in children with dyslexia. Proc Natl Acad Sci USA 2012;109(41):16731–16736

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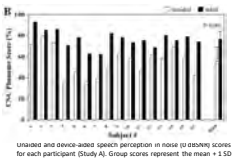
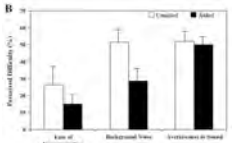
RMHA system benefits in ASD

- aided speech perception in noise
- less communication difficulty
- amplification did not increase aversiveness to noise
- reduced stress (salivary cortisol) in aided condition during listening tasks
  - both personal RMHA and classroom loudspeaker systems

Rance, G., Chisari, D., Saunders, K., & Rault, J. L. (2017). Reducing listening-related stress in school-aged children with autism spectrum disorder. Journal of autism and developmental disorders, 47(7), 2010-2022.



Unaided and device-aided speech perception in noise (a dB SNR) scores for each participant (Study A). Group scores represent the mean +1 SD



Abbreviated Profile of Hearing Aid Benefit questionnaire results for unaided and aided listening conditions. Shown are the group means for the Ease of Communication, Listening in Background Noise and Aversiveness to Sound subscales in each listening condition. *Error bars* represent 1 SD

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Language therapy: APD, language and reading

- phoneme perception is at the crux between hearing, language, reading, dyslexia
- "there is considerable evidence that auditory processing skills….. underlie language acquisition and reading mastery
  - …. a significant proportion of language and later reading problems appear to stem from auditory processing problems
  - ….. auditory processing interventions in language and reading impaired children have shown improvements in several cognitive domains, most dramatically reading"

  Geffner D, Ross-Swain, D. (2013) Auditory Processing Disorders: Assessment, Management, and Treatment. 2nd edn Plural Publishing 301-317 Chapter 13. Auditory Processing Disorders and Literacy. Martha S Burns
- language therapy including phonological perception will be helpful for many children with APD
- SLTs, SPELD, learning support personnel can provide training in phonological awareness, phonics

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Frequently used treatments (SoundSkills)

- dichotic training, mostly ARIA
- amplification, mostly with RMHA systems
- Sound Storm (hearing in noise)
- LACE software for home-based auditory training for adults
- audiobooks
- phonological and language therapy

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Non-evidence-based treatments to avoid:

- DORE motor exercises
- cerebral dominance training
- passive listening to processed music
  - Auditory Integration Therapy (AIT)
  - Integrated Listening Systems (ILS)
  - Tomatis training
  - Berard, Johansen, Sound Therapy, Learning Development Centres

Evidence-based music treatments:

- *professional music therapy is excellent for children with severe disabilities, and*
- *active music training is excellent for auditory skills!*

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APD Services in New Zealand

- "Sapere" Report - Auditory Processing Disorder: New Zealand Review *Min of Health* 2014
  https://www.health.govt.nz/publication/auditory-processing-disorder-new-zealand-review
- some public hospital services
  - Auckland – restarting, 8 yrs and over
- private sector clinics, APD services additional to mainly adult hearing aid services
  - lower cost
  - some use unvalidated app
- specialist APD services
  - Angela Alexander, Taupo, Auditory Processing Institute, "Buffalo" Model afficionado
  - SoundSkills, Auckland, multi-disciplinary, mainstream, evidence-based
- SoundSkills mentored services in Wellington and Christchurch
  - Courtenay Hearing Centre, Wellington
  - University of Canterbury Speech and Hearing Clinic
- Compliance with NZ Guidelines on APD is key criterion

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When professional APD services are not an option

- referral checklist plus TEAP give a good indication of "at risk" children
- if there is peripheral hearing loss, even mild, free conventional (not RM) hearing aids may be available through hospital audiology clinics on the basis of the peripheral hearing loss (Note: the Health system excludes APD as a criterion, there has to be peripheral hearing loss)
- online assistive hearing devices eg Nuheara IQ buds might be better than nothing but drawbacks of size, form, lack of remote microphone
- when assessment is not possible treat any apparent difficulties, eg language, phonological awareness, phonics
  - Reading Doctor http://www.readingdoctor.com.au/
- parent advice in Guidelines Summary/General
- teacher advice, and "Strategies to assist at school" in Guidelines Summary/Education (sit close to teacher etc)
- audiobooks (auditory only, upper level of comfortable range)
- there's no validated home or school treatment for amblyaudia, yet
- apps/online can't diagnose, and won't fix, APD (possible exception CAPDOTS)

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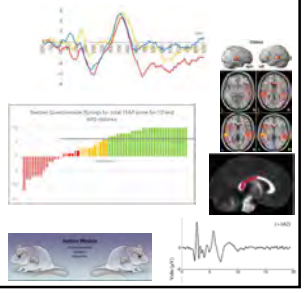
Local APD research

- Use of RMHA systems, prosody training in children with ASD
- Quantifying disability in APD
- Treatments for amblyaudia
- Duration of use of RMHA systems by children with APD
- Phonological perception training
- Brain imaging studies in children with APD
- Central auditory deficits in mice with autism traits



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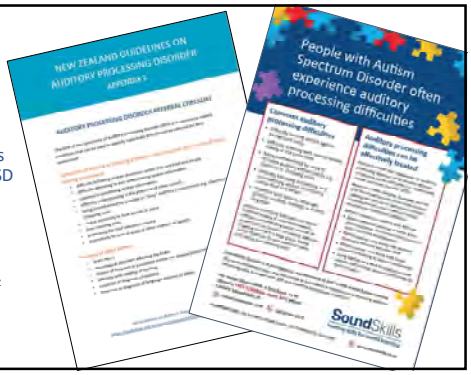
APD handouts

- referral criteria
- auditory treatments for children with ASD

- bill.keith@soundskills.co.nz



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APD handouts

- school poster

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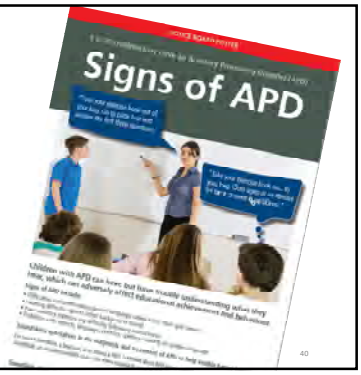

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APD Guidelines Summary for Professionals in Education, Speech-Language and Psychology

- NZ Audiological Society website
  www.audiology.org.nz
  Menu/For the Public/Other Hearing Conditions/Auditory Processing Disorder
- https://audiology.org.nz/assets/Uploads/APD/NZ-APD-GUIDELINES-SUMMARY-EDUCATION.pdf
- bill.keith@soundskills.co.nz

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Client handouts
APD Guidelines: General Summary
SoundSkills brochure

- NZ Audiological Society website
  www.audiology.org.nz
  Menu/For the Public/Other Hearing Conditions/Auditory Processing Disorder
- https://audiology.org.nz/assets/Uploads/APD/NZ-APD-GUIDELINES-SUMMARY-GENERAL.pdf

- bill.keith@soundskills.co.nz

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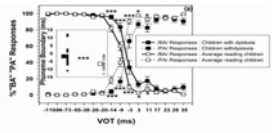
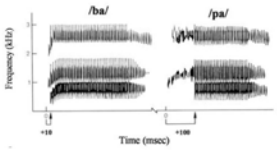
Veuillet et al 2007

- Abnormal phoneme discrimination in children with dyslexia
- Responds to training





Veuillet, E., Magnan, A., Ecalle, J., Thai-Van, H., & Collet, L. (2007). Auditory processing disorder in children with reading disabilities: effect of audiovisual training. *Brain : a journal of neurology, 130*(Pt 11), 2915-28.

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Current research: Does phonological perception training benefit children with APD?

- 12 weeks training in phonological awareness
- are there benefits in phonological awareness?
- are there benefits in reading?
- are there benefits in hearing ability (speech perception in noise)?
- does training proceed faster with amplification?

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Music education

- Benefits of music education for children with disorders
  - noticeable changes in brain structures and electrophysiological responses to sound, which generalise to…
  - communication and literacy skills such as speech and language improvement
  - dyslexic children showed gains in spelling and phonological awareness from music training
  - music training targets the very areas in which children with APD are deficient, - temporal processing, backward masking and speech in noise
    - music training can't treat all aspects of APD, and may not be as efficient and cost-effective as other therapy methods, but is an excellent complement for families interested in music education

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