Auditory Processing Disorder

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Midwest Ear Institute
SAINT LUKE'S HOSPITAL OF KANSAS CITY

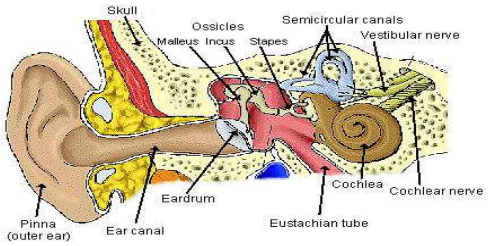
Hearing involves more than pure tone thresholds

Hearing loss
Speech in Noise problems
Auditory Processing Disorder
Cognitive load
Dementia

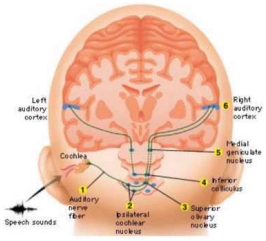
Auditory processing is not only what we hear, it is *how we process and use* the information that we hear.

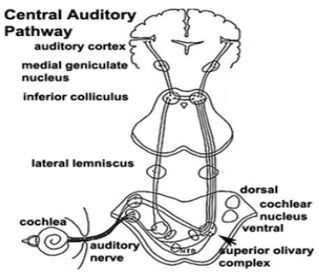
Auditory Processing Disorder (APD) occurs when a listener does not effectively process auditory information.

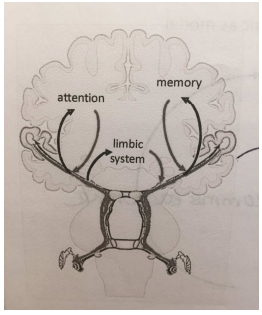
Hearing



Central Auditory System







Principles of auditory processing(Calearo & Antonelli, 1973)

- Channel Separation
- Binaural Fusion
- Contralateral Pathways
- Hemispheric Dominance for Language

Auditory Processing

- Central Auditory Processing includes the auditory mechanisms that underlie the following abilities:
  - Sound localization and lateralization
  - Auditory discrimination
  - Auditory pattern recognition
  - Temporal aspects of auditory – including temporal integration, temporal discrimination (ie: gap detection), temporal ordering and temporal masking
  - Auditory performance with competing or degraded acoustic signals

Auditory Processing Disorder

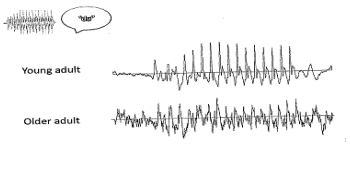
- ASHA 2005
  - An observed deficiency in one or more of the previously listed behaviors
- AAA 2010
  - Difficulties in the perceptual processing of auditory information in the CNS and the neuro-biologic activity that underlies that processing and gives rise to electro-physiologic auditory potentials

Evidence of APD

- Audiological evidence from children and adults with known lesions of the auditory system
- Studies of children and adults whose only complaint is the inability to hear well in difficult listening situations, yet they have normal hearing and no concomitant speech and language deficits
- Listening problems of the elderly that can be associated with age related changes in the central auditory system

Evidence of APD

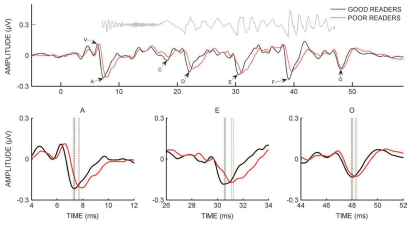
- Biological Effects of Aging
  - Smaller harmonics
  - Delayed neural timing
  - Less consistency
  - Poorer timing
  - Weaker synchrony (jitter)



Anderson et al., 2013

Evidence of APD

- Poor Readers
  - Poor timing – delayed latencies
  - Poor representation of pitch – reduced amplitude
  - More variation of response – less consistency



Banai et al., 2009

Characteristics of APD

- Misunderstanding messages
- Responding inconsistently or inappropriately
- Frequently asking that information be repeated
- Taking longer to respond in oral communication situations
- Poor articulation
- Difficulty understanding speech in background noise
- Difficulty attending and avoiding distraction
- Difficulty with phone conversation

Characteristics of APD

- Difficulty following complex auditory directions
- Difficulty following long conversations
- Reduced tolerance or sensitivity to loud noise
- Poor hearing test takers
- Weak auditory memory
- Difficulty with sound localization
- Reading, spelling and learning problems
- Reduced musical and singing skills

Early Childhood Characteristics of APD

- Poor rhyming
- Poor singing and melody skills
- Sensitivity to sound or noise
- Difficulty telling where sound is coming from
- Difficulty following multi step directions
- Not responding to speaker
- Poor articulation or language skills
- History of ear infections / allergies

APD Diagnosis

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How APD is diagnosed

- Referrals
  - Primary Care Physicians
  - Otolaryngologists
  - Neurologists
  - Teachers
  - Speech Language Pathologists
  - Psychologists
  - Occupational Therapists
  - Self Referral

Case History of APD

- Referral History
- Birth History
- Developmental Milestone History
- Hearing History
- Medical History
- Educational History
- Social and Behavioral functioning
- Previous Evaluations
- Previous Therapies

Medical History of APD

- Degenerative processes such as multiple sclerosis
- Seizure disorders
- Head trauma – concussion, traumatic brain injury, blast injury
- Cerebrovascular accidents
- Metabolic disorders
- Cerebromorphological abnormalities
- Neuro-maturational Delays, often secondary to auditory deprivation
- Age related changes in CANS function
- Schizophrenia

Pogoda, et al, 2012

Other Evaluations

- Medical Evaluation
- Speech / Language Evaluation
- Psycho-Educational Evaluation
  - Cognitive and IQ testing
- PT/ OT testing
- Visual Processing testing

Social and behavioral functioning

Social and Emotional Information

Trait	Yes	No	Trait	Yes	No
Anxiety, Tension			Lacks motivation		
Appears confused in noisy places			Lacks self-confidence		
Awkward, clumsy			Maintaining proper sequence/order		
Dislikes school			Mixes up speech sounds		
Disobedient			Needs quiet to study		
Disruptive			Often says 'huh' or 'what' a lot		
Does not complete assignments			Over-reacts emotionally		
Does not express emotion			Preference play with younger kids		
Does opposite of what is requested			Preference for solitary activities		
Easily distracted			Problems with the law		
Easily flustered or confused			Restless, problems sitting still		
Easily frustrated			Sensitivity to loud sounds		
Easily upset by new situations			Short attention span		
Excessive talking			Short-term memory problem		
Fakes illness			Shy		
Forgetful			Temper tantrums		
Generally appears sad			Tires easily		
Had psychological counseling			Trouble following directions		
Hyperactive			Trouble telling where sounds are		
Impulsive			Trouble understanding television		
Inappropriate social behavior			Uncooperative		

Hearing Evaluation

- Diagnostic Audiological Evaluation
  - Immittance
    - Tympanograms
    - Acoustic Reflexes / Decay
  - Air, Bone, Speech in quiet
  - Otoacoustic Emissions

How to choose a battery

- ASHA 2005 Test Principles
  - Training of audiologist
  - Tests should be driven by complaint
  - Tests with good reliability and validity
  - Tests should examine different central processes
  - Tests should be verbal and non-verbal
  - Consider patient variables
  - Consider patient / mental age
  - Test procedures must follow test manual
  - Appropriate test duration
  - Multidisciplinary evaluations
  - Referral for other evaluations
  - Consider tests, observations, and self assessments

APD Evaluation at Midwest Ear Institute

- APD Screening Evaluation
  - Ages 3 years, 6 months through 6 years, 11 months
- APD Diagnostic Evaluation
  - Ages 7 years to 60 years

APD Screening Evaluation

- Auditory Skills Assessment
  - Ages 3.6 to 6.11 years
  - 3 Domains:
    - Speech Discrimination – speech in noise, mimicry
    - Phonological Awareness – blending, rhyming
    - Nonspeech Processing – patterning, ordering
  - Scored by cut score and percentile rank

APD Screening Evaluation

- Auditory Skills Assessment Demo

APD Screening Evaluation

- SCAN 3 C – screening
  - Auditory Figure Ground (+ 8 dB SNR)
  - Competing Words – Free Recall
  - Random Gap Detection Screening
- Phonemic Synthesis
  - Ages 6 and up

APD Diagnostic Evaluation

- Staggered Spondaic Word (SSW) Test
- Phonemic Synthesis Test (up to age 18)
- SCAN 3
  - Child version, ages 5:0 to 12:11
  - Adolescent and adult version, ages 13:0 to 50:11

Staggered Spondaic Word (SSW) Test

- Binaural test with different words going to each ear
- Administration:
  - 40 items
  - Approximately 7.5 minutes to complete
  - Norms for ages 6 to 60
  - Counterbalanced
- Normative data is available for total errors, response bias and qualifiers

SCAN - 3

- SCAN-3 (Child and Adult versions)
  - Filtered Words
    - Low pass filtered at 750Hz
    - 20 monosyllabic words to each ear, monaural
  - Auditory Figure Ground
    - +0, +8 or +12 dB SNR
  - Competing Words
    - Directed Ear
    - Free recall

SCAN-3

- SCAN-3 (Child and Adult versions)
  - Competing Sentences
  - Time Compressed Sentences
    - 60% time compressed
  - Random Gap Detection
  - Ear Advantage Scoring

Phonemic Synthesis Test

- Sound Blending Test
- Administration:
  - 25 test items
- Norms for quantitative and qualitative scores for each age group

Scoring Tests

- Raw Score
  - 2010 Academy of Audiology Recommendations: Two or more tests that are two or more standard deviations away from the mean
- Behavioral Score
- Ear Advantage findings
- Patterns of test findings

Differential Diagnosis

- APD can coexist with or mimic other disorders
- Clinicians must consider the following:
  - ADHD
    - Low scores globally
    - Lack of consistent pattern
    - Poorer performance on easier tests
  - Dyslexia
    - Left ear advantages
    - Integration findings
  - Hearing loss
    - Cannot test persons with more than a moderate hearing loss

Differential Diagnosis

- Autism Spectrum Disorder
  - Global disorder causing significant social, communication and behavioral challenges
  - Integration findings
  - Left ear advantages
- Sensory Processing Disorder
  - Sensitivity to loud sounds
  - Integration findings
  - Left ear advantages

Differential Diagnosis

- Communication Disorder
  - Expressive language, receptive language, phonological processing, articulation
  - Input versus output
- Visual processing
  - More difficulty with visually presented information versus auditoraly presented information

Differential Diagnosis

- Cognitive deficits
  - Higher order, supramodal disorder that affects function across sensory modalities
  - Compare mental age versus chronologic age
- Mental disorders
  - Must consider effects of medication on central system
  - Schizophrenia is known to cause temporal processing deficits

Differential Diagnosis

- Traumatic Brain Injury
  - Caused by a bump, blow or jolt to the head or a penetrating head injury that disrupts the normal function of the brain
  - Severity – mild to severe
  - Functional deficits
    - Thinking – memory and reasoning
    - Sensation – touch, taste and smell
    - Language – communication, expression and understanding
    - Emotion – depression, anxiety, personality changes, aggression, acting out, social inappropriateness

Special Populations

- Diagnostic tests and therapy can be completed with patients with hearing loss
- ADD, Autism and Low IQ are not contra-indications to therapy
- Age and general cognitive decline can play a big part in auditory processing

Traumatic Brain Injury Case – 48 year old female

- History:
- Test Findings:
  - SSW
  - SCAN

	RNC	RC	LC	LNC	Total
Total Errors	1	7	6	1	15
Age Norms	1	2	4	1	6
Interpretation	Normal	Abnormal	Abnormal	Normal	Abnormal

	Reversals	Ear Effect	Order Effect	Type A	Qualifier
Score	3	-1	-3	2	4
Age Norms	1	-3	-2	3	0
Interpretation	Abnormal	Normal	Abnormal	Normal	Abnormal

Sub-Test	Raw Score	Standard Score	%tile rank	Interpretation
Filtered Words	19	5	5th	Borderline
Auditory Figure Ground +0	18	4	2nd	Borderline
Competing Words-DE	22	1	0.1	Abnormal
Competing Sentences	57	5	5th	Borderline
Composite Score		15	0.3	Abnormal

Traumatic Brain Injury Case – 48 year old female

- Post Therapy Re-evaluation

Sub-Test	Raw Score	Standard Score	% rank	Interpretation
Filtered Words	29	8	25th	Normal
Auditory Figure Ground +0	29	10	50th	Normal
Competing Words-DE	39	7	16th	Normal
Competing Sentences	70	12	75th	Normal
Composite Score		37	32nd	Normal

	RNC	RC	LC	LNC	Total
Total Errors	0	0	1	0	1
Age Norms	1	2	4	1	6
Interpretation	Normal	Normal	Normal	Normal	Normal

APD Intervention

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Intervention

- Intervention should begin as soon as possible after diagnosis is made
  - To exploit plasticity of CNS
  - To maximize successful therapy outcomes
  - To minimize residual functional deficits
- Training can include bottom up and top down approaches
  - Must be intensive to exploit plasticity and cortical reorganization
  - Extensive to maximize generalization and reduce functional deficits
  - Should provide salient reinforcement to promote learning

Intervention

- Training should be based on:
  - diagnostic test findings
  - case history
  - related speech/language and psycho-educational assessment data
  - remediation of deficits skills
  - management of the disorder's impact on the individual

Approaches to treat APD

- Direct Auditory Training
  - Purpose: to maximize neuroplasticity and improve auditory performance by changing the way the brain processes auditory information
- Environmental Modifications
  - Purpose: to improve access to information that is presented orally
- Compensation Strategies
  - Purpose: to strengthen central resources (language, attention, etc) and teach responsibility for active listening participation

Direct Auditory Training

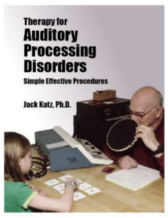
- Uses brain plasticity to improve performance
  - Plasticity is the ability of the connection, or synapse, between two neurons to change in strength in response to either use or disuse of transmission over synaptic pathways
  - The younger brain is generally more plastic
  - Plasticity is based on stimulation

Direct Auditory Training

- How to maximize auditory training
  - Auditory only presentation
  - Vary the stimuli and tasks
  - Present stimuli at comfortable listening levels
  - Present tasks systematically and graduated in difficulty
  - Target a moderate degree of accuracy with generous feedback and reinforcement
  - Require a moderate degree of performance before moving onto next level
  - Provide intensive practice
    - Length of training session
    - Number of training sessions
    - Time interval between sessions
    - Period of time over which training is conducted

Therapy Book

Available from the Educational Audiology Association webstore



Therapy for Auditory Processing Disorders

$84.95

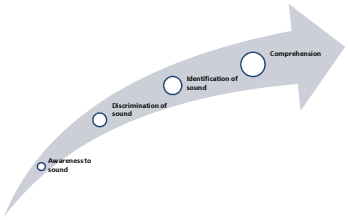
In stock

1 Add to cart

THERAPY FOR DECODING DEFICITS

Phonemic Training Program (PTP)

- Decoding (DEC) is the most important auditory processing category



PTP

- Purpose: to teach the sounds of English and make sure the auditory system has the correct engram of each sound
- Equipment
  - An acoustically transparent screen or hoop
  - A deck of cards with the letters symbolizing the sounds to be trained

PTP Sounds

Ă	Ā	B	Ch	D
Ĕ	Ē	F	G	H
Ĭ	Ī	J	K	L
M	N	Ŏ	Ō	P
R	S	Sh	T	Th
Th	Ŭ	Ū	V	W
Y	Z	AW	OO	OW
OI	ER	NG		

Appendix 5-B
Phonemic Error Analysis (PEA) Group Data

64

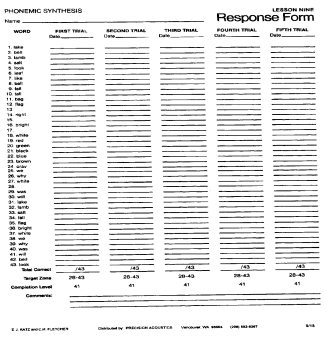
Phonemic Synthesis Therapy

- Synthesis: the ability to blend sounds together to form words
- Phonemes are the basis of speech
  - One must be able to discriminate individual sounds with minimal differences, remember them and blend them together in order to respond with the correct answer
  - Phonemes in isolation require the listener to focus on the sound only

Phonemic Synthesis Program

- Diagnostic Test
- Recorded therapy program
  - Improves phonemic discrimination, memory and analysis-synthesis
- Available from:
  - Precision Acoustics (360.892.9367)

Phonemic Synthesis


PHONEMIC SYNTHESIS

Response Form

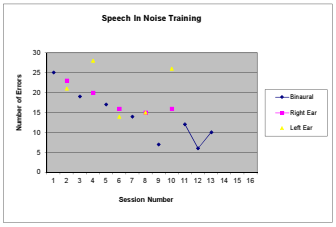
TOLERANCE FADING MEMORY THERAPY

Speech in Noise Training

- Goals:
  - To improve ability to hear in noise
- To reduce stress and improve confidence in noise
- Choose speech material
  - Sentences
  - Paragraphs
  - Single words
- Choose noise type
  - Speech shaped noise, white noise
  - Babble – 12 talker vs. 8 talker vs. 4 talker

Speech in Noise Training

- Procedures:
  - Start with speech comfortably louder than noise (or in some cases, no noise)
  - Slowly increase difficulty by increasing noise level
  - Work on each ear individually if ear advantages are present
  - Making repairs
- Formal Programs:
  - Words in Noise Therapy (WINT)
    - **Upstate Advanced Technologies, 12 Shadow Vale Drive, Penfield, NY 14526 585-381-3459 gsbusat@frontiernet.net**



STAM – Short Term Auditory Memory Training

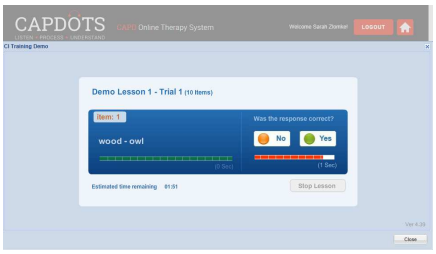
- Purpose: to increase auditory memory
- STAM stimuli
  - Digits
  - Words
  - Working Memory
  - Auditory Directives
- Materials
  - Score forms
  - Acoustically transparent hoop

INTEGRATION THERAPY

CAPDOTS

- Online therapy program that provides intervention for dichotic listening deficits using a staggered dichotic listening paradigm
- The goal is to improve the performance of the poorer ear allowing for improved interaural symmetry
- Procedure
  - 15-30 minutes per day, 5 days per week, 8-12 weeks
  - Student and assistant
  - Can be carried out at home and school

CAPDOTS demonstration

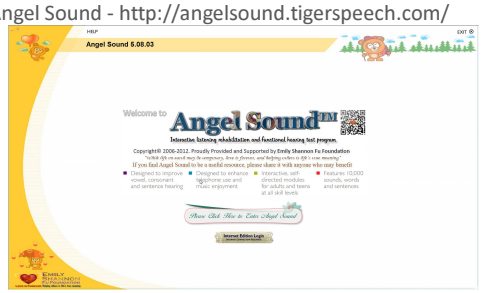


Other Therapies

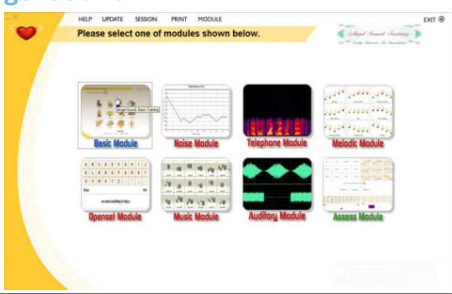
- Computer activities
  - Benefits of computer training
    - Multi-sensory stimulation
    - Adaptive training
    - Can be completed at home for persons living far away from clinic

Other Therapies

- Angel Sound - http://angelsound.tigerspeech.com/

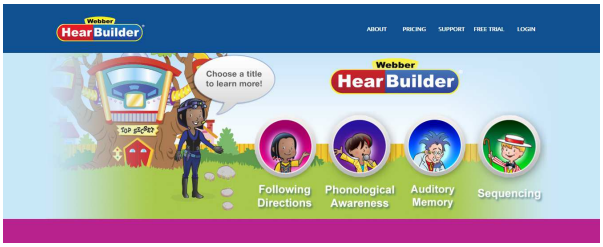


Angel Sound



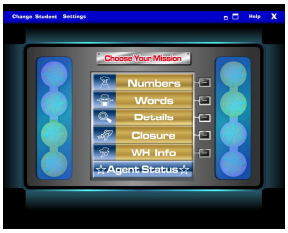
Other Therapies

- Hear Builders – www.hearbuilder.com



Hear Builder

- Phonological Awareness
- Sequencing
- Following Directions
- Auditory Memory



Hear Coach by Starkey

- Website demonstration

Sound Success by Advanced Bionics

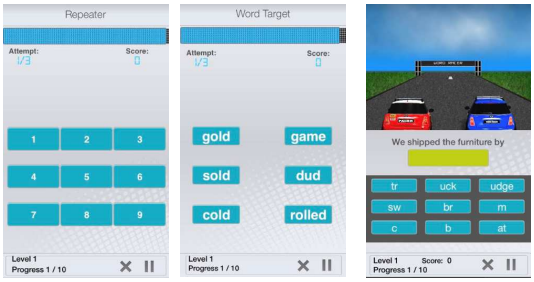
- www.ABrehABportal.com
- Demonstration

Other Therapies - apps

- Sound Match
- Voices
- ABC Pocket Phonics
- Magic Penny Reading
- Simon HD
- ABC magic
- i-Angel
- Hear Coach
- Hear Builder
- ABLE

i - angel

Hear coach



More Therapies!

- Brain Fitness Programs
  - Posit Science (aka Brain HQ)
  - Lumosity
- Games
  - Marco Polo
  - Simon Says
  - Twister
  - Bopit
  - Simon
  - Pictionary
  - Video games

Environmental Modifications

- Modify environment to reduce noise and reverberation
- Preferential seating
- Get attention before speaking
- Use slow and clear speech
- Use gestures
- Look and Listen
- Pre-teach new concepts and vocabulary
- Written notes given before lecture
- Written instructions
- Ask for verification
- Show an example of the 'finished product' if there is a new task to do
- Animated teacher

Environmental Modifications: FM Systems

- Device to amplify speech where distance, noise and reverberation may be decreasing signal to noise ratio
- Pros: Can improve attention and focus and access to sounds for reduced listening effort
- Cons: Who pays for it? Who manages it? What about when they are home? What about neural plasticity?

Environmental Modifications: Hearing aids

- Mild gain hearing aids can function similarly to an FM system. Can receive a small signal to noise ratio benefit. The use of directional microphones helps reduce noise as well
- Pros: Don't need speaker to use a microphone, discrete
- Cons: Cost, Stigma, How much gain to provide to avoid future or further hearing loss

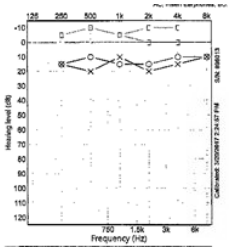
Significant Air Bone Gap – 9 year old male

- History
  - 3 sets of tubes
- Test Findings

	RNC	RC	LC	LNC	Total
Total Errors	0	0	4	1	5
Age Norms	2	6	8	2	14
Interpretation	Normal	Normal	Normal	Normal	Normal

	Raw Score	Age Norm	Interpretation
Quantitative Score	20	18	Normal

Sub-Test	Raw Score	Standard Score	% rank	Interpretation
Filtered Words	15	5	5th	Borderline
Auditory Figure Ground +8	33	5	5th	Borderline
Competing Words-DE	39	10	50th	Normal
Competing Sentences	67	12	75th	Normal
Composite Score		32	18th	Normal

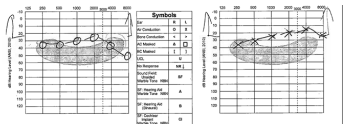


Significant Air Bone Gap – 9 year old male

- Interpretation:
  - Better performance on more difficult, more sensitive tests.
  - Poorest performance on FW and AFG+8
- Recommendations:
  - ENT referral
  - Medical management of allergies

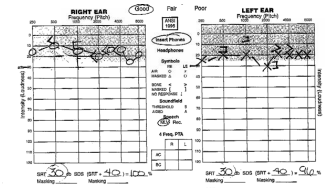
59 year old female

- APD eval revealed significant APD
  - 34 errors on SSW (norm 6), 1.5 dB SNR loss BKB SIN, sf/nf
- Fit with bilateral Linx 3D 962's, recommended hear coach and i-angel
- APD re-evaluation after 6 month HA use
  - 25 errors SSW, -0.5 dB
  - SNR Loss (18% improvement



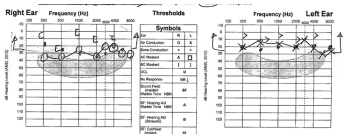
36 year old male

- OCI dx: essentially normal hearing, refer to MEI for APD
- APD eval: normal except for Filtered Words and Speech in Noise.
- Fit with bilateral Linx 3D 961 hearing aids



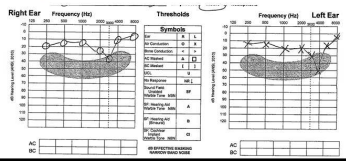
22 year old female

- Referred by ENT, history of ET dysfunction and fluctuating conductive hearing loss
- APD eval normal overall, Filtered Words was only abnormal test
- Fit with Resound Linx 3D 561, and app, recommended aural rehab apps



23 year old female

- Originally referred at age 15, APD eval was normal. Tried hearing aids but pt was not motivated
- Seen at age 22, struggling in college, worried about hearing
- Hearing test: No change to hearing loss
- APD eval: Significant decline in skills (see next slide)



- Fit with bilateral Linx3D rechargeable 961 hearing aids
- Will re-evaluate this fall Working on aural rehab apps at home but may complete formal therapy over summer

Staggered Spondaic Word (SSW) Test

This test requires the patient to repeat 2 overlapping spondee words. They are presented as right non-competing, right an competing, and then left non-competing. It is very complex auditory task to tax the central auditory system. All scores are compared to 2 standard deviations.

	Right Non-Competing	Right Competing	Left Competing	Left Non-Competing	Total Score
Total Errors	1	5	4	11	21
Age Norms	1	2	3	4	5
Interpretation	Abnormal	Abnormal	Abnormal	Abnormal	Abnormal
Comparison	Worse	Worse	Worse	Worse	Worse
Category	DEC, TFM	DEC	TFM INT	DEC	ALL
	Reversals	Ear Effect	Order Effect	Type A	Qualifier Errors
Score	4	6	3	2	10+
Age Norms	1	2	3	5	0
Interpretation	Abnormal	Abnormal	Abnormal	Normal	Abnormal
Comparison	Worse	Worse	Worse	Same	Worse
Category	ORD, IT	DEC, TFM	DEC TFM	INT	DEC, TFM, INT

SCAN-3 Adolescent / Adult

A battery of tests used to evaluate auditory processing abilities in the areas of temporal processing, listening in noise, dich listening (different signals to both ears simultaneously), and listening to degraded speech. All scores are compared to age norms.

Sub-Test	Raw Score	Standard Score	Percentile Rank	Interpretation	Comparison	Category
Filtered Words	27	8	25th	Normal	Worse	DEC
Auditory Figure Ground	23	6	9th	Borderline APD	Same	TFM
Competing Words-Directed Ea	36	5	5th	Borderline APD	Worse	TFM, ORD, INT
Competing Sentences	41	1	0.1	APD	Worse	ORD, INT
Composite Score		20	1st	APD	Worse	

Recommendations

- All patients were happy with hearing aids due to decreased effort
  - App control was important to them
- Any hearing loss can affect central processing and overall cognitive load (negative plasticity, sensory deprivation)
- When in doubt, refer for APD. APD tests will show if hearing loss is the only problem or if higher up processing is already affected

Billing / Reimbursement

- Diagnostics:
  - 92620: Evaluation of central auditory function, 1 hour
  - 92621: each additional 15 minutes
- Therapy:
  - 92507: Treatment of speech, language, voice, communication and/or auditory processing disorder; individual
  - Experiences with coverage
- Diagnosis code:
  - H93.25 – Central auditory processing disorder

Key Points:

- APD can be reliably tested for
- Stable middle ear status and hearing status is essential to making progress with therapy
- When hearing loss is present, the lack of treatment leads to negative plasticity changes in the brain
- APD therapy is very effective
- Insurance coverage for evaluations and therapy is attainable

When to refer:

- Poor understanding persists with normal hearing
- Fluctuating, conductive hearing loss in children
- Traumatic brain injury / concussion
- If there is a possibility, send for an evaluation

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