

- If you are viewing this course as a recorded course after the live webinar, you can use the scroll bar at the bottom of the player window to pause and navigate the course.
- This handout is for reference only. Non-essential images have been removed for your convenience. Any links included in the handout are current at the time of the live webinar, but are subject to change and may not be current at a later date.

No part of the materials available through the continued.com site may be copied, photocopied, reproduced, translated or reduced to any electronic medium or machine-readable form, in whole or in part, without prior written consent of continued.com, LLC. Any other reproduction in any form without such written permission is prohibited. All materials contained on this site are protected by United States copyright law and may not be reproduced, distributed, transmitted, displayed, published or broadcast without the prior written permission of continued.com, LLC. Users must not access or use for any commercial purposes any part of the site or any services or materials available through the site.

Technical issues with the Recording?

- Clear browser cache using [these instructions](#)
- Switch to another browser
- Use a hardwired Internet connection
- Restart your computer/device

Still having issues?

- Call 800-753-2160 (M-F, 8 AM-8 PM ET)
- Email customerservice@AudiologyOnline.com



Grand Rounds: Auditory Processing Disorders

James W. Hall III, PhD
Professor
Salus University
Elkins Park, Pennsylvania, USA

Ghada Said A.A. Ahmed, M.S.
Student, International AuD Program
at Salus University
Audiologist, Dr. Soliman Fakeeh
Hospital
Jeddah, Saudi Arabia



Grand Rounds: Auditory Processing Disorders

Learning Outcomes

After this course, participants will be able to:

- Identify risk factors for APD in children and adults.
- List 4 tests for the assessment of APD.
- Describe 3 evidence-based options for the management of APD.

Disclosures

- **Presenter Disclosures:** Financial: James Hall is a Professor at Salus University and the University of Hawaii. He received an honorarium for this course. Non-financial: James Hall has no relevant non-financial relationships to disclose.
- **Presenter Disclosures:** Financial: Ghada Said A. A. Ahmed is employed by Dr. Soliman Fakeeh Hospital (DSFH) Jeddah Saudi Arabia. Non-financial: Ghada Said A. A. Ahmed is currently a student in the International Doctor of Audiology program at Salus University.
- **Content Disclosure:** This learning event does not focus exclusively on any specific product or service.
- **Sponsor Disclosure:** This course is presented by Salus University in partnership with AudiologyOnline.

Grand Rounds: Auditory Processing Disorders

Please note the Exam Question Number at the bottom right corner of the slide where the exam question material is covered for Questions 1 through 10.

Q1



Grand Rounds: Auditory Processing Disorders

- Introduction to Auditory Processing Disorder (APD)
- Presentation of Case 1: Child with APD
- Review of APD Assessment in Children
- Review of APD Management in Children
- Presentation of Case 2: Adult with APD
- Review of APD Assessment in Adults
- Review of APD Management in Adults
- Summary, Questions, & Answers



Grand Rounds: Auditory Processing Disorders

Time Ordered Agenda

- Hour 1
 - Introduction to Auditory Processing Disorder *[20 minutes]*
 - Presentation of Case 1: Child with APD *[20 minutes]*
 - Review of APD Assessment in Children *[10 minutes]*
 - Review of APD Management in Children *[10 minutes]*
- Hour 2
 - Presentation of Case 2: Adult with APD *[20 minutes]*
 - Review of APD Assessment in Adults *[15 minutes]*
 - Review of APD Management in Adults *[15 minutes]*
 - Summary, Questions, & Answers *[10 minutes]*

CONTINUED

SALUS
UNIVERSITY
Osborne College of Audiology

Grand Rounds: Auditory Processing Disorders

- Introduction to Auditory Processing Disorder (APD)
 - Historical perspective ... a 65-year tradition
 - Definitions of APD
 - Expanding research literature
 - Clinical practice guidelines around the world
 - Expressed questions and concerns
 - Risk factors for APD in children
 - Risk factors for APD in adults

CONTINUED

SALUS
UNIVERSITY
Osborne College of Audiology

Bocca E, Calearo C, Cassinari V. A new method for testing hearing in temporal lobe tumors. Acta Otolaryngologica 44: 1954

TESTING "CORTICAL" HEARING IN TEMPORAL LOBE TUMOURS

BY E. BOCCA, C. CALEARO, V. CASSINARI AND F. MIGLIAVACCA
MILAN, ITALY

No important contribution to the problem of topographic diagnosis of cortical deafness has been made since the publication of our preliminary report, with the exception of a recent paper by Hennebert. This author has noticed that, by fractionating a verbal message by means of a periodical commutator so as to send each of these fractions alternatively to one and the other ear, the answer of a subject with lesions of the auditory cortex is different from that of normal subjects or from that of subjects suffering from lesions of the peripheral organ of hearing. We believe that in preceding observations and researches on the behavior of hearing after cortical lesions, too much stress has been laid on tests which should be considered of little or no interest. As a matter of fact, the common sound stimuli to our cortical auditory area bear a physical structure which cannot be easily identified with the one of a plain periodic tone. Moreover, in the physiology of hearing, the cortical function should not be considered as analytical but as synthetic. Electrophysiological research has shown that there is an exact representation of the cortical projection of the cochlea, but this fact, though having an outstanding scientific value, does not help us to define the role of the cortex for the understanding of a meaningful verbal message.

We should like now to point out some observations which we think to be



CONTINUED

CONTINUED

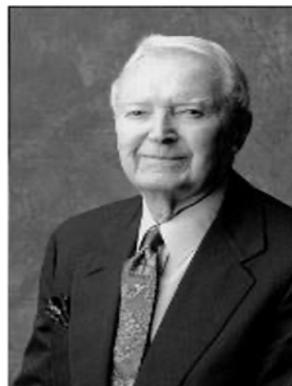
SALUS
UNIVERSITY
Osborne College of Audiology

Helmer Myklebust, Ph.D. (in psychology)
Northwestern University
Pioneer in APD Assessment & Learning Disabilities

Myklebust HR. Auditory disorders in children: A manual for differential diagnosis. New York: Grune & Stratton, 1954.

“hearing is a receptive sense ... and essential for normal language behavior” (p. 11)

“the diagnostician of auditory problems in children has traditionally emphasized peripheral damage. It is desirable that he (sic) also include central damage.” (p. 54)



CONTINUED

SALUS
UNIVERSITY
Osborne College of Audiology

Assessment of Auditory Processing:
Not a New Concept ... Dichotic Listening Tests
(1956 – 1962)

- Broadbent DE. Successive responses to simultaneous stimuli. *Quart J Exp Psychol* 8: 1956.
- Kimura D. Cerebral dominance and the perception of verbal stimuli. *Canad J Psychol* 15: 1961
- Kimura D. Some effects of temporal-lobe damage on auditory perception. *Canad J Psychol* 15: 1961
- Katz J. The use of staggered spondaic words for assessing the integrity of the central auditory nervous system. *J Aud Res* 2: 1962.



Donald
Broadbent



Jack
Katz

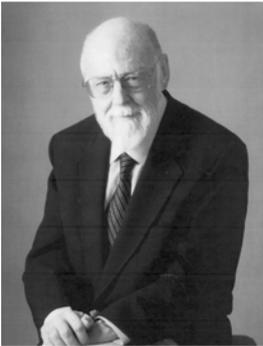


Doreen
Kimura

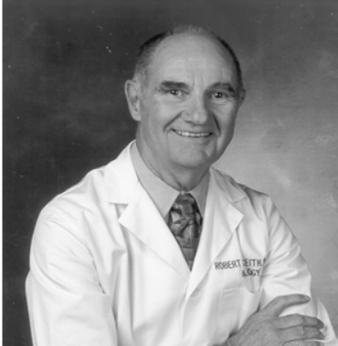
CONTINUED

CONTINUED  **SALUS**
UNIVERSITY
Osborne College of Audiology

Assessment of Auditory Processing:
*Expanded Clinical Research, New Test Procedures,
and Auditory Evoked Responses*



James Jerger
Validated Test
Battery in 1970s



Bob Keith
Developed New
APD Tests



Frank Musiek
Auditory Evoked Responses
& Developed New Tests

CONTINUED  **SALUS**
UNIVERSITY
Osborne College of Audiology

Auditory Processing Disorders:
Explosion of Relevant Research During the 1990s
(www.nlm.nih.gov)



The Decade Of The Brain
1990 - 2000

- Concept of "neural" or brain plasticity
- New imaging techniques such as functional MRI (fMRI)
- Neuroscience PhD programs with thousands of graduates
- Renewed attention to neurological diseases
- Rapid growth of auditory neuroscience
- Development of clinical practice guidelines
 - Mapping of auditory brain functions
 - Cortical auditory evoked responses
 - Computer-based treatment programs
- Ongoing research on new procedures for diagnosis and management




fMRI During Auditory Tasks (18-year old with atypical right ear deficit on dichotic listening tests)

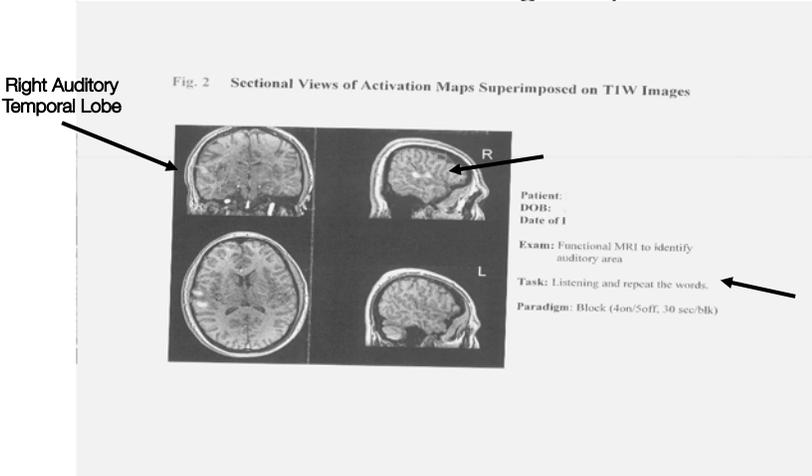


Fig. 2 Sectional Views of Activation Maps Superimposed on T1W Images
 Patient: . . .
 DOB: . . .
 Date of I . . .
 Exam: Functional MRI to identify auditory area
 Task: Listening and repeat the words.
 Paradigm: Block (4on/5off, 30 sec/bk)




Grand Rounds: Auditory Processing Disorders

- Introduction to Auditory Processing Disorder (APD)
 - Historical perspective ... a 65-year tradition
 - Definitions of APD
 - Expanding research literature
 - Clinical practice guidelines around the world
 - Expressed questions and concerns
 - Risk factors for APD in children
 - Risk factors for APD in adults

Definitions of Auditory Processing Disorders (APD)

- “APD is broadly defined as a deficit in the processing of information that is specific to the auditory modality.” (*Jerger & Musiek 2000*)
- Auditory processing is “the efficiency and effectiveness by which the CNS utilizes auditory information.” (*ASHA, 2005*)
- (C)APD is a disorder of the central auditory nervous system characterized by deficits in processing of auditory stimuli. It is seen in a wide array of populations, including children and adults. It can be the result of a number of different etiologies that involve deficits in the function of the central auditory nervous system. Neurological involvement ranging from degenerative diseases to exposure to neurotoxic substances can result in (C)APD...CAPD is often co-exists with other disorders including ADHD, learning disabilities, dementia, age-related CNS disorders, etc (*AAA, 2010*)

Definition of Auditory Processing Disorders: International Classification of Diseases (ICD-10)

Central auditory processing disorder (CAPD) is:

“A disorder characterized by impairment of auditory processing, resulting in deficiencies in the recognition and interpretation of sounds by the brain. Causes include brain maturation delays and brain traumas or tumors. Excludes mixed receptive-expressive language disorder.”

Effective October 1, 2015 (USA)

Chermak G. (2016). 20Q: CAPD - Fundamentals. AudiologyOnline, July 2016

Definitions of Auditory Processing Disorders (APD):
British Society of Audiology (BSA)

- “APD is characterised by poor perception of both speech and non-speech sounds.
- APD impacts on everyday life primarily through a reduced ability to listen, and so respond appropriately to sounds.
- APD should be assessed through standardized tests of auditory perception.
- APD does not result from failure to understand simple instructions.
- APD is a collection of symptoms that usually co-occurs with other neurodevelopmental disorders.”

Three Categories of Auditory Processing Disorders:
British Society of Audiology (BSA)

- Developmental APD: Cases presenting in childhood with normal hearing (i.e., normal audiometry) and no other known aetiology or potential risk factors. Some of these people may retain their APD into adulthood
- Acquired APD: Cases associated with a known post-natal event, (e.g., neurological trauma, infection) that could plausibly explain the APD.
- Secondary APD: Cases where APD occurs in the presence, or as a result of peripheral hearing impairment. This includes transient hearing impairment after its resolution (e.g., glue ear or surgically corrected otosclerosis).

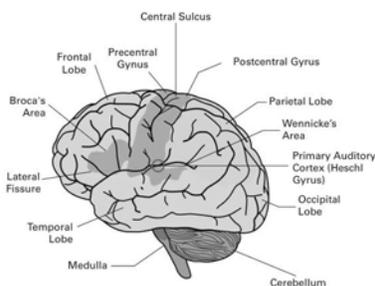
Neurobiology of APD in Children (Chermak & Musiek, 2011)

- APD in children secondary to neurological disorders and diseases
 - Seizure disorders
 - Traumatic brain injury (TBI)
 - Neoplasms (brain tumors)
 - Neurodegenerative disorders
 - Neurotoxicity (e.g., lead poisoning)
 - Cerebrovascular accidents (e.g., ischemic incidents)
 - Metabolic disorders
 - Genetic disorders

Neurobiology of APD in Children (Chermak & Musiek, 2011)

- Neurodevelopmental delay (lag)
 - Slower than normal maturation (no obvious explanation)
 - Auditory deprivation effects (e.g., conductive hearing loss)
 - Delay in myelin maturation (e.g., corpus callosum)
- Neuroanatomical abnormalities
 - Congenital or acquired
 - Documented with imaging or postmortem examination
 - Examples include
 - Ectopic areas (misplaced neurons)
 - Microgyri (underdeveloped gyri)
 - Abnormal asymmetry in planum temporale (larger on right)

Neurobiology of APD in Adults ... Role of Multiple CNS Disorders



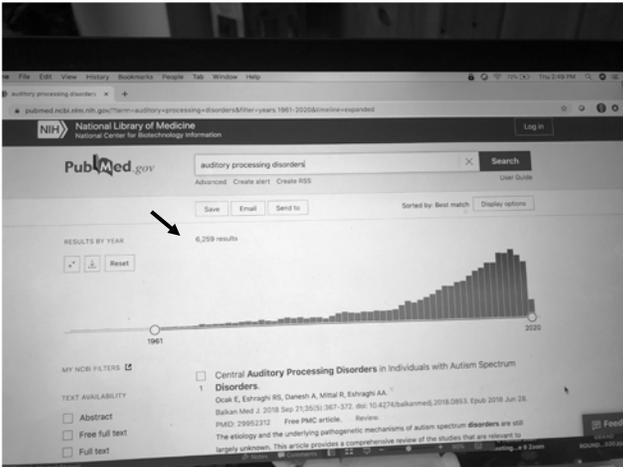
- Traumatic brain injury (TBI)
- Cerebrovascular accidents
- Arterial-venous malformations
- Aneurysms
- Neoplasms
- Cysts
- Cognitive decline and dementia
- Neuropsychiatric diseases
- Undiagnosed neurodevelopmental APD (and therefore no intervention)

Grand Rounds: Auditory Processing Disorders

- Introduction to Auditory Processing Disorder (APD)
 - Historical perspective ... a 65-year tradition
 - Definitions of APD
 - Expanding research literature
 - Clinical practice guidelines around the world
 - Expressed questions and concerns
 - Risk factors for APD in children
 - Risk factors for APD in adults




Auditory Processing Disorders:
A Large and Rapidly Growing Literature
 (www.nlm.nih.gov)



The screenshot shows a PubMed search for "auditory processing disorder" with 6,259 results. A bar chart displays the number of results per year from 1981 to 2020, showing a clear upward trend. Below the chart, a list of search results is visible, including a paper titled "Central Auditory Processing Disorders in Individuals with Autism Spectrum Disorders" by Ocak E, Eshraghi RS, Danesh A, Mittal R, Eshraghi AA, published in *Balkan Med J* in 2018.




Grand Rounds:
 Auditory Processing Disorders

- Introduction to Auditory Processing Disorder (APD)
 - Historical perspective ... a 65-year tradition
 - Definitions of APD
 - Expanding research literature
 - Clinical practice guidelines around the world
 - Expressed questions and concerns
 - Risk factors for APD in children
 - Risk factors for APD in adults



Auditory Processing Disorders... Within Our Scope of Practice (American Academy of Audiology, 2004)

Assessment and Diagnosis

Assessment of hearing includes the administration and interpretation of behavioral, physioacoustic, and electrophysiologic measures of the peripheral and central auditory systems. Assessment of the vestibular system includes administration and interpretation of behavioral and electrophysiologic tests of equilibrium. Assessment is accomplished using standardized testing procedures and appropriately calibrated instrumentation and leads to the diagnosis of hearing and/or vestibular abnormality.

Treatment

The audiologist administers audiologic identification, assessment, diagnosis, and treatment programs to children of all ages with hearing impairment from birth and preschool through school age. The audiologist is an integral part of the team within the school system that manages students with hearing impairments and students with central auditory processing disorders. The audiologist participates in the development of Individual Family Service Plans (IFSPs) and Individualized Educational Programs (IEPs), serves as a consultant in matters pertaining to classroom acoustics, assistive listening systems, hearing aids, communication, and psycho-social effects of hearing loss, and maintains both classroom assistive systems as well as students' personal hearing aids. The audiologist administers hearing screening programs in schools, and trains and supervises non audiologists performing hearing screening in the educational setting.



AAA Clinical Practice Guidelines on Auditory Processing Disorders (www.audiology.org)

American Academy of Audiology Clinical Practice Guidelines

Diagnosis, Treatment, and Management of of Children and Adults with Central Auditory Processing Disorder

(www.audiology.org, 2010)



L to R: Jane Baran, Larry Medwetsky, Katie West, Frank Musiek, Teri Bellis, James Hall, Gail Chermak

Grand Rounds: Auditory Processing Disorders *Additional Clinical Practice Guidelines*

- British Society of Audiology
 - www.thebsa.org.uk
 - Position Statement: Auditory Processing Disorder (March 2011)
 - Practice Guidelines: An Overview of Current Management of Auditory Processing Disorders (October 2011)
- New Zealand Guidelines on Auditory Processing Disorder
 - www.audiology.org.nz/assets/Uploads/APD/NZ-APD-GUIDELINES-2019.pdf

Grand Rounds: Auditory Processing Disorders

- Introduction to Auditory Processing Disorder (APD)
 - Historical perspective ... a 65-year tradition
 - Definitions of APD
 - Expanding research literature
 - Clinical practice guidelines around the world
 - Expressed questions and concerns
 - Risk factors for APD in children
 - Risk factors for APD in adults

Auditory Processing Disorders (APD): *Expressed Questions and Concerns*

- Humes L. Central auditory processing disorders in the elderly ... fact or fiction? In Katz, Stecker & Henderson. *Central auditory processing: A transdisciplinary view*, Philadelphia: Decker, 2002
- Cacace A & McFarland D. The importance of modality specificity in diagnosing central auditory processing disorders. *Amer J Audiol*, 14, 2005
- Ferguson MA, Hall RL, Riley A, Moore DR. (2011) Communication, Listening, Cognitive, and Speech Perception Skills in Children With Auditory Processing Disorder (APD) or Specific Language Impairment (SLI). *Journal of Speech, Language and Hearing Research* 54 (2):211–227.
- Dillon H, Cameron S, Glyde H, Wilson W, Tomlin D. (2012) An Opinion on the Assessment of People Who May Have an Auditory Processing Disorder. *Journal of the American Academy of Audiology* 23:97–105.
- DeBonis, DA. Is it time to rethink central auditory processing protocols for school age children? *Amer J Audiol*, 24, 2015

Auditory Processing Disorders (APD): *Additional Recent Concerns*

- Moore DR (2018). Auditory processing disorder (APD). *Ear and Hearing*, 39, 617-620
 - Highly critical essay
 - “Most if not all cases of childhood ‘APD’ are either better characterized by:
 - ✓ A more commonly recognized learning disorders, especially language disorder or
 - ✓ Specific difficulties, for example, hearing speech in noise or
 - ✓ Spatial hearing that are firmly grounded in psychoacoustics
 - “... This article is endorsed by the whole [editorial] board ... the new policy is that articles that implicitly or explicitly assume APD is a single diagnostic characteristic of the auditory system likely will not be considered for publication.”

APD in Children and Adults:
*Clinical Assessment and Management
 of Peripheral versus Central Auditory Disorders*

	Peripheral Hearing Loss	APD
Etiology always known?	No	No
Specific site of dysfunction known	Sometimes	Sometimes
Co-existing disorders in some cases	Yes	Yes
Risk factors known?	Yes	Yes
Documented sensitivity of tests?	No	No
Team approach required?	Yes	Yes
Clinical guidelines available?	Yes	Yes
Within scope of practice?	Yes	Yes
Management always successful?	No	No
Outcome usually positive?	Yes	Yes

Grand Rounds:
 Auditory Processing Disorders

- Introduction to Auditory Processing Disorder (APD)
 - Historical perspective ... a 65-year tradition
 - Definitions of APD
 - Expanding research literature
 - Clinical practice guidelines around the world
 - Expressed questions and concerns
 - Risk factors for APD in children
 - Risk factors for APD in adults

Risk Factors for APD in Children:
Team Work in Identification and Assessment

- Neurological dysfunction and disorders (*physicians*), e.g.,
 - Neonatal risk factors (e.g., asphyxia, prematurity, CMV)
 - Head injury
 - Seizure disorders
- Chronic otitis media in preschool years (*otolaryngologists*)
- Academic underachievement or failure (*teachers and educational psychologists*)
- Family history of academic underachievement (*parents*)
- Co-existing disorders (*multiple professionals*)
- *Repeated concerns about hearing loss yet normal audiograms (audiologists ... remember liability with failure to refer patients)*

Q1

Risk Factors are Important:
Evidence-Based Consequences of Late or No Identification
of APD in Children

- Reading failure
- Academic failure and poor school performance
- Psychosocial problems
 - Internalizing problems (e.g., anxiety, depression)
 - Externalizing problems (e.g., aggression, conduct problems)
 - Behavioral symptoms index (e.g., withdrawal)
 - Adaptive skills (e.g., social skills)
- School drop out
- Juvenile legal problems and crimes
- Children with late diagnosis and intervention require long-term remediation
 - Increased cost and decreased benefit versus early identification and intervention

APD in Children: *Co-Existing Disorders (Co-Morbidities)*

- Peripheral (conductive and sensory) hearing loss
- Specific language impairment (SLI)
- Learning disabilities (LDs)
- Reading disorders (dyslexia)
- Attention deficit/hyperactivity disorder (ADHD)
- Emotional and psychological disorders
- Cognitive and developmental delay
- Seizure disorders
- Traumatic brain injury (TBI)

Q3 

Grand Rounds: Auditory Processing Disorders

- Introduction to Auditory Processing Disorder (APD)
 - Historical perspective ... a 65-year tradition
 - Definitions of APD
 - Expanding research literature
 - Clinical practice guidelines around the world
 - Expressed questions and concerns
 - Risk factors for APD in children
 - Risk factors for APD in adults



Risk Factors and Comorbid (Co-existing) Disorder with APD in Adults:

*All Audiologists Must Recognize Risk Factors,
Even Audiologists Who Do Not "Specialize" in APD*

- Advancing age (over 65 years)
- Complaints of auditory problems and hearing loss (e.g. speech perception in noise) with normal audiogram or not consistent with degree of hearing loss
- Referral from select sources, e.g.,
 - Vocational rehabilitation
 - Neurology
 - Psychiatry or psychology
- Medical disorders and diseases, e.g.,
 - Neoplasms
 - Cardiovascular disease
 - Cognitive decline
 - Dementias including Alzheimer's dementia
 - Schizophrenia
- Traumatic brain injury (TBI)

Q2 Q4 ■



Grand Rounds: Auditory Processing Disorders

- Introduction to Auditory Processing Disorder (APD)
- Presentation of Case 1: Child with APD
- Review of APD Assessment in Children
- Review of APD Management in Children
- Presentation of Case 2: Adult with APD
- Review of APD Assessment in Adults
- Review of APD Management in Adults
- Summary, Questions, & Answers

A Child Case Study

By Dr. Ghada Ahmed

Under supervision of Prof. Dr. James Hall

Chief Complaint

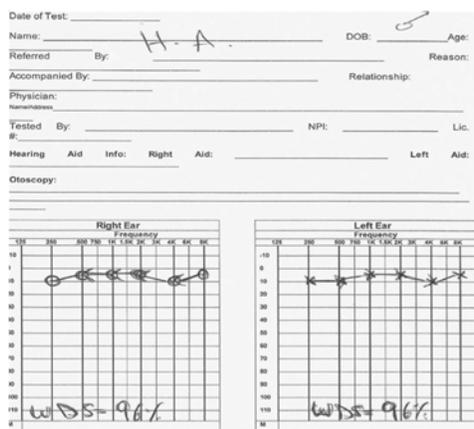
- A 7- year old boy presented to our clinic complaining of hearing difficulty in noisy environments, including
 - The classroom
 - In recess
 - While watching TV.
- He did not complain about hearing difficulties in quiet environments.
- There was no history of delayed language development.

History

- Mother reported normal prenatal, neonatal, and postnatal history.
- The patient was a full-term healthy baby who was discharged from a well baby nursery.
- The patient passed a DPOAE screening test before hospital discharge.
- There was no history of
 - NICU admission
 - Jaundice or cyanosis
 - Middle ear infection
 - Head trauma
- There is reportedly one relative with ADHD.

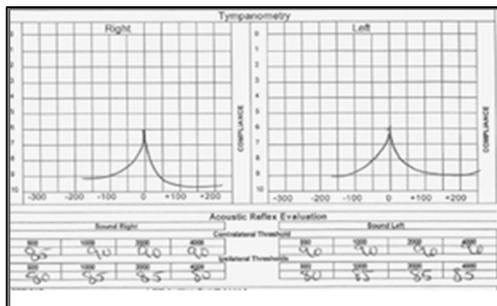
Peripheral Audiological Assessment

- Otoloscopic examination:
Normal mobile intact TM
- Pure tone audiometry:
Normal hearing sensitivity bilaterally with excellent speech recognition scores



Peripheral Audiological Assessment

- DPOAEs: Amplitudes within normal limits bilaterally
- Aural immittance measures (see figure):
 - Bilateral type A tympanograms
 - Normal ipsilateral and contralateral acoustic reflex thresholds for stimulus frequencies of 500, 1000, 2000, and 4000 Hz.



Auditory Processing Assessment Dichotic Digits Test

DICHOTIC DIGITS
DOUBLE PAIRS

Name: W.A., Age: _____, Sex: _____, Date: _____, # _____

Comments: _____

TRACK			TRACK			TRACK		
Left (Ch)	Right	Response	Left	Right	Response	Left	Right	Response
41	68	68	39	25	25	23	86	86
58	43	43	33	84	84	30	19	19
39	65	65	30	59	59	81	65	65
45	83	83	86	34	34	52	91	91
26	39	39	34	85	85	80	31	31
74	32	32	56	93	93	95	83	83
49	86	86	48	54	54	42	59	59
34	51	51	13	62	62	15	62	62
52	49	49	21	48	48	30	84	84
26	91	91	68	94	94	93	21	21
85	20	20	13	42	42	54	38	38
64	92	92	94	29	29	90	52	52
95	33	33	19	62	62	93	18	18
63	48	48	62	58	58	43	63	63
68	32	32	49	20	20	48	95	95
91	63	63	33	59	59	61	23	23
56	35	35	84	30	30			

Score RE = $\frac{29}{37} = 78\%$
Score LE = $\frac{25}{50} = 50\%$





Auditory Processing Assessment Frequency (Pitch) Patterns Test

Verbal
Response

PITCH PATTERN SEQUENCE (PPS)
SCORING FORM

Name: H.A. Age: _____ Sex: _____ Date: _____ # _____

1000 Hz or PTA Thresholds: RE: _____ LE: _____ Preferred Hand: _____ Response Mode: Verbal

PITCH DISCRIMINATION			
PITCH ORDER	CORRECT (n)	PITCH ORDER	CORRECT (n)
1. LH	---	11. HL	---
2. HH	---	12. HL	---
3. HL	---	13. HH	---
4. LL	---	14. LH	---
5. HL	---	15. LL	---
6. LH	---	16. LH	---
7. LL	---	17. HH	---
8. HL	---	18. LH	---
9. LL	---	19. HL	---
10. HL	---	20. HH	---

PITCH PATTERN SEQUENCE								
First Ear (L) (circle)			PITCH PATTERN SEQUENCE			PITCH PATTERN SEQUENCE		
PITCH PATTERN	CORRECT	REVERSEAL	PITCH PATTERN	CORRECT	REVERSEAL	PITCH PATTERN	CORRECT	REVERSEAL
1. HHL	✓	✗	21. HLH	✓	---	41. LLH	✓	---
2. HLL	✓	---	22. LLH	✗	---	42. HLL	---	---
3. LHL	✓	---	23. HHL	✗	---	43. HLL	---	---
4. LHH	✓	---	24. HLH	---	---	44. LHL	---	---
5. LHH	✓	---	25. HHL	---	---	45. HHL	---	---
6. LLH	✓	---	26. HLH	---	---	46. LHL	---	---
7. LLH	✓	---	27. HLH	---	---	47. LLH	---	---
8. HLH	---	---	28. LHL	---	---	48. HLL	---	---
9. HHL	---	---	29. LHL	---	---	49. HLL	---	---
10. LHL	---	---	30. HHL	---	---	50. LHL	---	---
11. HLL	---	---	31. LLH	---	---	51. HHL	---	---
12. LHL	---	---	32. LLH	---	---	52. HLL	---	---
13. HHL	---	---	33. HHL	---	---	53. LLH	---	---
14. HHL	---	---	34. LHL	---	---	54. LHL	---	---
15. HLH	---	---	35. LHL	---	---	55. LHL	---	---
16. LHL	---	---	36. HLH	---	---	56. HLL	---	---
17. LHL	---	---	37. HLH	---	---	57. HLL	---	---
18. LLH	---	---	38. HLL	---	---	58. LHL	---	---
19. HLH	---	---	39. HHL	---	---	59. LHL	---	---
20. LLH	---	---	40. LHL	---	---	60. LHL	---	---

RE = $\frac{15}{30} = 50\%$

LE = $\frac{13}{30} = 43\%$





Auditory Processing Assessment Frequency (Pitch) Patterns Test

Humming
Response

PITCH PATTERN SEQUENCE (PPS)
SCORING FORM

Name: H.A. Age: _____ Sex: _____ Date: _____ # _____

1000 Hz or PTA Thresholds: RE: _____ LE: _____ Preferred Hand: _____ Response Mode: Humming

PITCH DISCRIMINATION			
PITCH ORDER	CORRECT (n)	PITCH ORDER	CORRECT (n)
1. LH	---	11. HL	---
2. HH	---	12. HL	---
3. HL	---	13. HH	---
4. LL	---	14. LH	---
5. HL	---	15. LL	---
6. LH	---	16. LH	---
7. LL	---	17. HH	---
8. HL	---	18. LH	---
9. LL	---	19. HL	---
10. HL	---	20. HH	---

PITCH PATTERN SEQUENCE								
First Ear (L) (circle)			PITCH PATTERN SEQUENCE			PITCH PATTERN SEQUENCE		
PITCH PATTERN	CORRECT	REVERSEAL	PITCH PATTERN	CORRECT	REVERSEAL	PITCH PATTERN	CORRECT	REVERSEAL
1. HHL	✓	---	21. HLH	✓	---	41. LLH	---	---
2. HLL	---	---	22. LLH	---	---	42. HLL	---	---
3. LHL	---	---	23. HHL	---	---	43. HLL	---	---
4. LHH	---	---	24. HLH	---	---	44. LHL	---	---
5. LHH	---	---	25. HHL	---	---	45. HHL	---	---
6. LLH	---	---	26. HLH	---	---	46. LHL	---	---
7. LLH	---	---	27. HLH	---	---	47. LLH	---	---
8. HLH	---	---	28. LHL	---	---	48. HLL	---	---
9. HHL	---	---	29. LHL	---	---	49. HLL	---	---
10. LHL	---	---	30. HHL	---	---	50. LHL	---	---
11. HLL	---	---	31. LLH	---	---	51. HHL	---	---
12. LHL	---	---	32. LLH	---	---	52. HLL	---	---
13. HHL	---	---	33. HHL	---	---	53. LLH	---	---
14. HHL	---	---	34. LHL	---	---	54. LHL	---	---
15. HLH	---	---	35. LHL	---	---	55. LHL	---	---
16. LHL	---	---	36. HLH	---	---	56. HLL	---	---
17. LHL	---	---	37. HLH	---	---	57. HLL	---	---
18. LLH	---	---	38. HLL	---	---	58. LHL	---	---
19. HLH	---	---	39. HHL	---	---	59. LHL	---	---
20. LLH	---	---	40. LHL	---	---	60. LHL	---	---

RE = $\frac{21}{30} = 70\%$

LE = $\frac{19}{30} = 63\%$




Osborne College of Audiology

Auditory Processing Assessment Duration Patterns Sequence

**DURATION PATTERN SEQUENCE (DPS)
SCORING FORM**

Name: H.A. Age: _____ Sex: _____ Date: _____ # _____

PRACTICE ITEMS

PATTERN	CORRECT (X)	PATTERN	CORRECT (X)
1. LSS	---	6. LSL	---
2. SLS	---	7. SLS	---
3. SSL	---	8. LLS	---
4. LLS	---	9. LSS	---
5. SSL	---	10. SSL	---

TEST ITEMS

DURATION	CORRECT	REVERSEAL	DURATION	CORRECT	REVERSEAL	DURATION	CORRECT	REVERSEAL
1. SSL	✓	---	21. SLS	✓	---	41. LLS	✓	---
2. SLL	✓	---	22. LLS	✓	---	42. SLL	✓	---
3. LSL	✓	---	23. SSL	✓	---	43. SLL	✓	---
4. LSS	✓	---	24. SLS	✓	---	44. LSL	✓	---
5. LSS	✓	---	25. SSL	✓	---	45. SLS	✓	---
6. LLS	✓	---	26. SLS	✓	---	46. LSS	✓	---
7. LLS	✓	---	27. SLS	✓	---	47. LLS	✓	---
8. SLS	✓	---	28. LSL	✓	---	48. SLL	✓	---
9. SSL	✓	---	29. LSS	✓	---	49. SLL	✓	---
10. LSS	✓	---	30. SSL	✓	---	50. SLL	✓	---
11. SLL	✓	---	31. LLS	✓	---	51. SSL	✓	---
12. LSL	✓	---	32. LLS	✓	---	52. SLL	✓	---
13. SSL	✓	---	33. SSL	✓	---	53. LLS	✓	---
14. SLS	✓	---	34. LSL	✓	---	54. LSL	✓	---
15. SLS	✓	---	35. LSS	✓	---	55. LSL	✓	---
16. LSL	✓	---	36. SLS	✓	---	56. SLL	✓	---
17. LSS	✓	---	37. SLS	✓	---	57. SLL	✓	---
18. LLS	✓	---	38. SLL	✓	---	58. LSS	✓	---
19. SLS	✓	---	39. SSL	✓	---	59. LSS	✓	---
20. LLS	✓	---	40. LSS	✓	---	60. LSL	✓	---

RESULTS

	Right ear	Left ear
Percent corrects	20/30 = 66%	11/30 = 46%
Total Score		

Right Ear = 66%
Left Ear = 46%




Osborne College of Audiology

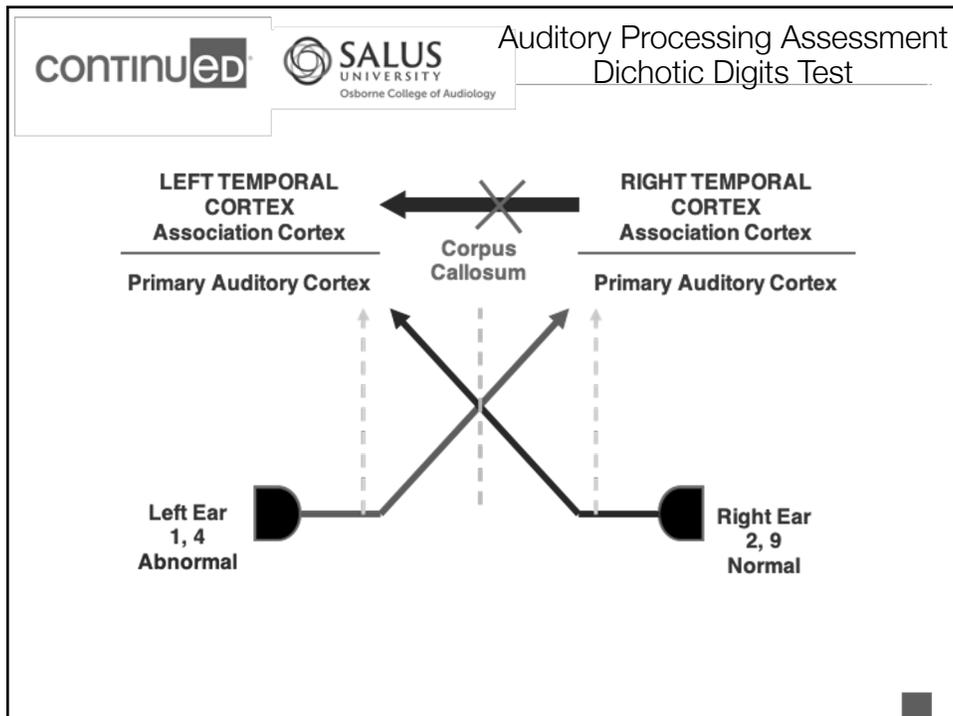
Auditory Processing Assessment Gaps in Noise (GIN) Test

GIN Score Sheet

Name: H.A.

Threshold	Duration										Total % Score
	2msec	3msec	4msec	5msec	6msec	8msec	10msec	12msec	15msec	20msec	
List 1	3/6	3/6	4/6	4/6	5/6	5/6	6/6	6/6	6/6	6/6	48/60
List 2	/6	/6	/6	/6	/6	/6	/6	/6	/6	/6	/60
List 3	/6	/6	/6	/6	/6	/6	/6	/6	/6	/6	/60
List 4	/6	/6	/6	/6	/6	/6	/6	/6	/6	/6	/60
TOTAL	24	24	24	24	24	24	24	24	24	24	240

False Positives: _____ *Total Score = Total # correct - False Positives






Case 1: Child with APD

Summary of Findings

- Test findings are consistent with diagnosis of APD, i.e., Abnormal scores for at least one ear for two different auditory processing tests
 - Dichotic digits test: Abnormally decreased scores bilaterally, more in left ear.
 - Duration patterns test: Abnormally decreased scores bilaterally, more in left ear with verbal response but normal humming response.
 - Pitch Patterns Test: Abnormally decreased scores bilaterally, more in left ear with verbal response but normal humming response..
- Findings are consistent with an auditory processing delayed maturation or disorder involving right hemisphere or interhemispheric transfer via corpus collosum to left hemisphere.

CONTINUEDSALUS
UNIVERSITY
Osborne College of Audiology

Grand Rounds: Auditory Processing Disorders

- Introduction to Auditory Processing Disorder (APD)
- Presentation of Case 1: Child with APD
- Review of APD Assessment in Children
- Review of APD Management in Children
- Presentation of Case 2: Adult with APD
- Review of APD Assessment in Adults
- Review of APD Management in Adults
- Summary, Questions, & Answers

CONTINUEDSALUS
UNIVERSITY
Osborne College of Audiology

Grand Rounds: Auditory Processing Disorders

- Review of APD Assessment in Children
 - Principles of test administration
 - Test battery for efficient and effective assessment of peripheral auditory function
 - Test battery for efficient and effective assessment of central auditory function and processing
 - Additional screening tests for attention deficit and phonological awareness
 - Test options for auditory processing assessment of young children (< 7 years)
 - Factors influencing auditory assessment of children

Auditory Processing Disorders in Children: Team Approach for Assessment and Management (AAA, 2010)

Multidisciplinary Team

Intervention planning is based on the auditory processing deficits that are documented in the diagnostic evaluation coupled with any associated functional performance deficits that may have been identified through multidisciplinary team assessment (e.g., speech-language, neuropsychology, psychoeducational, etc.). As such, intervention for individuals experiencing communicative or academic difficulty should be undertaken by a multidisciplinary team, which may include audiologists, speech-language pathologists (SLPs), educators, psychologists, parents, and others. For the small subset of children diagnosed with (C)APD who nonetheless perform at grade level due to Herculean effort and are therefore not eligible for special educational services, the audiologist may provide auditory training in the absence of a multidisciplinary effort. Similarly, adults with (C)APD who may not be able to access multidisciplinary intervention due to insurance limitations or other factors, or for whom multidisciplinary intervention is not necessary, auditory training provided by an audiologist or in some cases a speech-language pathologist should be provided. The specific composition of the team is therefore dependent on the nature of the dysfunction and the individual's complaints, as well as other external factors (e.g., insurance coverage, etc.) that may influence the composition of the team providing intervention services for the individual diagnosed with (C)APD.

APD Patient History (AAA Clinical Guidelines, 2010)

Case History Guidelines:

A carefully elicited comprehensive case history is essential to both diagnosis and intervention. (C)APD has been linked to a number of different etiological bases, including frank neurological lesions or compromise of the CNS, such as in neoplasms, degenerative processes (e.g., multiple sclerosis), seizure disorders (e.g., Landau Kleffner Syndrome), head trauma, cerebrovascular accidents, and metabolic disorders, as well as benign CNS dysfunction, such as cerebromorphological abnormalities, neuromaturational delays in the development of the CNS, often secondary to auditory deprivation, and age-related changes in CNS function (Bamiou, Musiek & Luxon, 2001; Baran & Musiek, 1999; Musiek, Baran, & Pinheiro, 1994; Musiek, Golegoly, & Baran, 1984). A substantial number of individuals seen for (C)APD evaluation are children and adults with auditory-related complaints but with no identifiable lesions of the CNS and no apparent prenatal or perinatal disease, injury, or exposure related explanation for their (C)APD. These individuals often present with difficulties in listening, language, learning, reading, and in other academic and social areas. For all of these individuals, however, information obtained from the case history can help uncover the potential etiological basis for the disorder, as well as the functional impact of the disorder on the individual's communicative, vocational, and/or academic performance. (Levels of evidence: 2, 3, 4, 5).

Specific areas that should be probed during the case history interview include the following:

- auditory and/or communication difficulties experienced by the individual
- family history of hearing loss and/or central auditory processing deficits
- medical history, including birth, otologic and neurologic history, general health history, and medications
- speech and language development and behaviors
- educational history and/or work history
- existence of any known comorbid conditions, including cognitive, intellectual, and/or medical disorders
- social development
- linguistic and cultural background

Apply the Crosscheck Principle in the Assessment of APD

(AAA Clinical Guidelines, 2010)

Selection of Behavioral Central Auditory Tests

The concept of a test battery approach and the “cross-check principle” (Jerger & Hayes, 1976) is well established in audiology, (Jerger & Musiek, 2000; Rosenberg, 1972; Musiek & Chermak, 1994). Diagnosis of (C)APD requires the use of a comprehensive test battery that assesses a variety of auditory processes and mechanisms, as well as various regions and levels within the CANS (e.g., ABR to assess brainstem and P300 to assess cortical areas). The tests in the battery should have proven validity and efficiency for identification of CANS dysfunction and for describing auditory behaviors in individuals affected by (C)APD. It should be emphasized, however, that “more” is not necessarily “better,” as the test battery’s specificity generally decreases as tests are added (Turner, Robinette, & Bauch, 1999). In general, it is advisable to select the minimum number of tests necessary to provide the best overall sensitivity and specificity while, at the same time, assessing a representative sample of the major auditory processes. Test measures should be carefully chosen so that they do not interject listener confounds as discussed above and allow for identification of patterns of auditory deficits for diagnostic and intervention purposes. Despite the overall goal of administering an efficient test battery—both in clinical diagnostic power as well as time—there are often clinical indications for utilizing two or more procedures in the evaluation of a single auditory process; perhaps to corroborate suspect findings or in those clinical situations where evidence from the case history or other test findings suggests that the auditory process of interest represents the individual’s major deficit area.

Principles of APD Test Administration & Analysis

(AAA Guidelines, 2010)

- Conduct assessment in a sound-treated room when possible
- Rely on recorded materials with established normative data
- Utilize verbal *and* nonverbal procedures
- Verify that the child understands the task, and is capable of performing it (based on other test data or practice portion of test)
- Analyze trends and tendencies in responses to detect effect of:
 - Inattention
 - Lack of motivation
 - Technical problems (e.g., bad earphone or channel)
- Abnormality in valid test performance defined as:
 - Scores for two different procedures are below normal limits for at least one ear
 - Deficits for verbal procedures confirmed by non-verbal tests

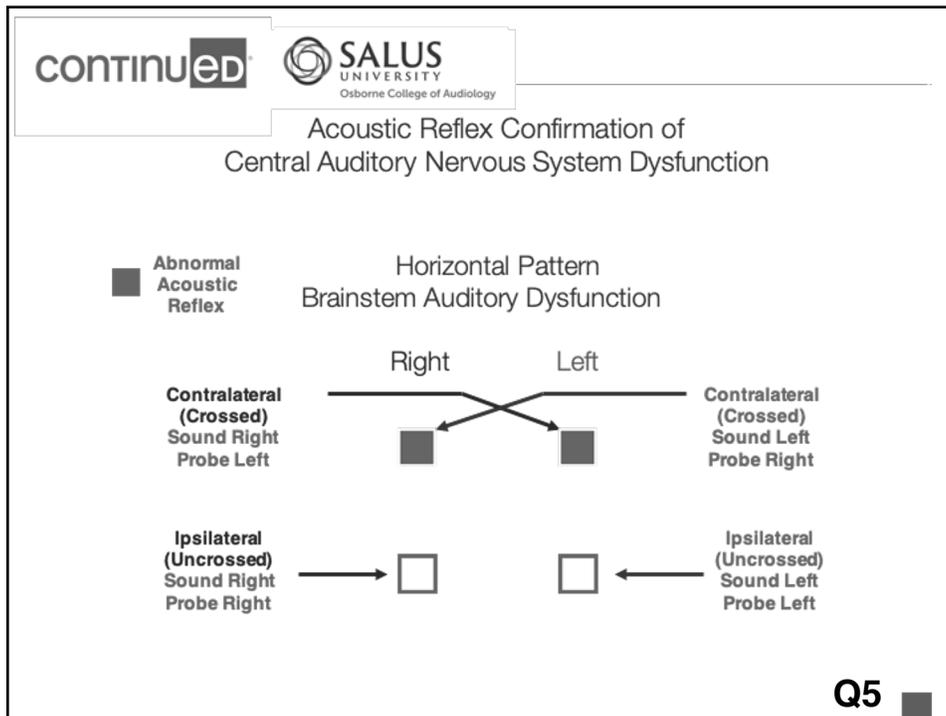
Grand Rounds: Auditory Processing Disorders

- Review of APD Assessment in Children
 - Principles of test administration
 - Test battery for efficient and effective assessment of peripheral auditory function
 - Test battery for efficient and effective assessment of central auditory function and processing
 - Additional screening tests for attention deficit and phonological awareness
 - Test options for auditory processing assessment of young children (< 7 years)
 - Factors influencing auditory assessment of children

Assessment of APD in Young Children: Begin with Thorough Yet Efficient Assessment of Peripheral Auditory Function (*Test Time = < 30 – 45 minutes*)

- Pure tone audiometry (bone conduction only as indicated)
- Speech audiometry
 - Speech reception threshold (only as indicated)
 - Word recognition in quiet (not always necessary ... use lists with 10 most difficult words first)
- Immittance measures
 - Tympanometry
 - Ipsilateral *and* contralateral acoustic reflexes
- Distortion product otoacoustic emissions (500 to 8000 Hz)
 - Sensitive measure of cochlear dysfunction (outer hair cells)
- Auditory evoked responses as indicated
 - If behavioral findings are inconclusive or incomplete
 - ABR plus cortical auditory evoked responses

Q6






Grand Rounds: Auditory Processing Disorders

- Review of APD Assessment in Children
 - Principles of test administration
 - Test battery for efficient and effective assessment of peripheral auditory function
 - Test battery for efficient and effective assessment of central auditory function and processing
 - Additional screening tests for attention deficit and phonological awareness
 - Test options for auditory processing assessment of young children (< 7 years)
 - Factors influencing auditory assessment of children



Behavioral Test Battery for Assessment of APD *(AAA Clinical Guidelines, 2010)*

Selection of Behavioral Central Auditory Tests

The concept of a test battery approach and the "cross-check principle" (Jerger & Hayes, 1976) is well established in audiology, (Jerger & Musiek, 2000; Rosenberg, 1972; Musiek & Chermak, 1994). Diagnosis of (C)APD requires the use of a comprehensive test battery that assesses a variety of auditory processes and mechanisms, as well as various regions and levels within the CANS (e.g., ABR to assess brainstem and P300 to assess cortical areas). The tests in the battery should have proven validity and efficiency for identification of CANS dysfunction and for describing auditory behaviors in individuals affected by (C)APD. It should be emphasized, however, that "more" is not necessarily "better," as the test battery's specificity generally decreases as tests are added (Turner, Robinette, & Bauch, 1999). In general, it is advisable to select the minimum number of tests necessary to provide the best overall sensitivity and specificity while, at the same time, assessing a representative sample of the major auditory processes. Test measures should be carefully chosen so that they do not interject listener confounds as discussed above and allow for identification of patterns of auditory deficits for diagnostic and intervention purposes. Despite the overall goal of administering an efficient test battery—both in clinical diagnostic power as well as time—there are often clinical indications for utilizing two or more procedures in the evaluation of a single auditory process; perhaps to corroborate suspect findings or in those clinical situations where evidence from the case history or other test findings suggests that the auditory process of interest represents the individual's major deficit area.

Behavioral Test Battery for Assessment of APD Tests of Specific Auditory Processes *(AAA Clinical Guidelines, 2010, pp. 16-21)*

- Temporal auditory processing, e.g.,
 - Gaps in Noise (GIN) test
 - Random Gap Detection Test (from SCAN)
 - Temporal sequencing tests (e.g., Pitch Pattern Sequence or Duration Pattern Sequence)
 - Newcastle Auditory Test Battery (NAB) temporal processing measures
- Dichotic listening tests
 - Non-speech tests
 - Digits (Dichotic Digits test double pairs)
 - Words (e.g., Staggered Spondaic Word test, SSW)
 - Sentences (e.g., Dichotic Sentence Identification, DSI)

Q7





Behavioral Test Battery for Assessment of APD

Tests of Specific Auditory Processes

(AAA Clinical Guidelines, 2010, pp. 16-21)

- Tests of monaural low-redundancy speech perception, e.g.,
 - Filtered word tests
 - Time compressed speech tests
 - Speech in noise tests
 - NOTE:
 - ✓ May be influenced by cognitive factors
 - ✓ Less sensitive to auditory processing deficits than other measures
- Tests of localization, lateralization & binaural interaction
 - Masking level difference (MLD)
 - Listening in Spatialized Noise-Sentences (LISN-S)
- Auditory discrimination tests
 - Speech or non-speech signals
 - Frequency or intensity
 - Syllables or words

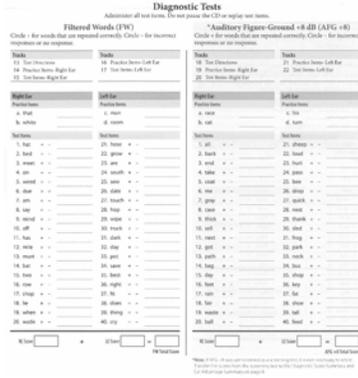




Assessment of APD

SCAN-3 (Children or Adult Version)

- Need CD or other audio player and two channel audiometer
- Under insert earphones
- Play recorded instructions at the beginning of each subtest
- Verbal patient response ... use lapel microphone location
- At 50 dB HL in each ear
- No masking noise for non-test ear
- After practice items, do not stop recording during a subtest



Q8

APD Assessment and Management: New Zealand Guidelines (2019)

- Summary (excellent review)
- Background
 - Definition
 - Causes
 - Prevalence
 - Comorbidities
- Assessment
 - Screening
 - Case history
 - Peripheral hearing assessment
 - Auditory processing tests
 - Diagnostic criteria
 - Age of assessment and diagnosis
 - Tables providing details on diagnostic tests including research articles, age range, and source

Grand Rounds: Auditory Processing Disorders

- Review of APD Assessment in Children
 - Principles of test administration
 - Test battery for efficient and effective assessment of peripheral auditory function
 - Test battery for efficient and effective assessment of central auditory function and processing
 - Additional screening tests for attention deficit and phonological awareness
 - Test options for auditory processing assessment of young children (< 7 years)
 - Factors influencing auditory assessment of children

Additional Components of the APD Test Battery (to Apply as Indicated)

- Auditory Continuous Performance Test (ACPT)
 - Developed by Robert Keith
 - For children with suspected or diagnosed ADHD
 - Rapid presentation of words
 - Task is to respond to target word “dog” only
 - Analog to visual continuous performance tests
- Screening of phonologic awareness skills
 - For children with suspected dyslexia (reading delay)
 - Test of Auditory Analysis Skills (TAAS)*
 - ✓ Say the word *smack* ... now say it again but don't say /m/

** Below normal performance requires further assessment, e.g., CTOPP (Comprehensive Test of Phonemic Processing)*

Grand Rounds: Auditory Processing Disorders

- Review of APD Assessment in Children
 - Principles of test administration
 - Test battery for efficient and effective assessment of peripheral auditory function
 - Test battery for efficient and effective assessment of central auditory function and processing
 - Additional screening tests for attention deficit and phonological awareness
 - Test options for auditory processing assessment of young children (< 7 years)
 - Factors influencing auditory assessment of children

Assembling a Test Battery for Assessment of APD in Young Children (≤ 7 years)

- Identify risk factors for APD
- Obtain complete history from parents
- Administer the most comprehensive yet feasible test battery
- Schedule annual follow-up APD assessments to
 - Monitor auditory status
 - Document parent compliance with recommendations
 - Expand diagnostic assessment with age-appropriate normative data
- Refer to *and referrals from physicians and other specialists as indicated, e.g.,*
 - Speech pathology
 - Psychology
 - Occupational therapy (OT)
 - Child development center

Q10

Test Battery for Assessment of APD in Young Children: Examples of Formal Test Options

- Behavioral tests
 - Pediatric Speech Intelligibility (PSI) test (Susan Jerger)
 - SCAN-C (revised)
 - Staggered Spondaic Word (SSW) test (5-year old norms)
 - Goldman Woodcock Johnson Test of Auditory Discrimination (quiet and noise)
 - Auditory Skills Assessment (ASA) [Gefner & Goldman, 2010, Pearson]
- Auditory electrophysiology as indicated
 - Speech evoked ABR if available
 - Cortical auditory evoked responses (e.g., AMLR or ALR) as indicated

APD Assessment in Young Children
New Zealand Clinical Practice Guidelines (2019, p. 53)

- Pediatric Speech Intelligibility (PSI) Test: 3 to 6 years
- Preschool SIFTER: 3 to 6 years
- Children's Home Inventory for Listening Difficulties (CHILD): Age 3 to 12 years
- Auditory Skills Assessment: Age 3.5 to 7 years
- Wepman's Auditory Discrimination Test: Age 4 to 12 years
- Phonemic Synthesis – Picture Test: Age 4 to 8 years
- Staggered Spondaic Word (SSW) test: Age 5 to 70 years

Grand Rounds:
 Auditory Processing Disorders

- Review of APD Assessment in Children
 - Principles of test administration
 - Test battery for efficient and effective assessment of peripheral auditory function
 - Test battery for efficient and effective assessment of central auditory function and processing
 - Additional screening tests for attention deficit and phonological awareness
 - Test options for auditory processing assessment of young children (< 7 years)
 - Factors influencing auditory assessment of children

Listener Variables in the Selection of Tests and Analysis of APD Test Findings

- Attention
 - Adapt assessment approach as indicated
 - Assessment of APD in ADHD to be discussed further
- Fatigue
 - Schedule APD assessment in the morning, not after school
 - Give patient frequent rest periods
 - Schedule two test sessions if necessary
- Hearing sensitivity and symmetry
 - Perform complete peripheral hearing assessment first
 - Pay close attention to any asymmetry in thresholds
 - Assessment of APD in patients with hearing sensitivity loss to be discussed further
 - Refer patient for management of conductive hearing loss before APD assessment

Listener Variables in the Selection of Tests and Analysis of APD Test Findings

- Medications
 - Patient takes regular medications on the APD test day
 - Take into account psychotropic drugs (e.g., sedatives)
- Motivation
 - Parent explains to child the importance of testing
 - Child is praised often during assessment
 - Most difficult tests are administered toward the end of the assessment
- Motor skills
 - Picture pointing tests for children with articulation or apraxia disorders
- Native language, language experience, language age
 - Administer non-verbal auditory tests
 - Tests with minimal linguistic loading (e.g., dichotic digits)
 - Objective auditory procedures (e.g., auditory evoked responses)

CONTINUEDSALUS
UNIVERSITY
Osborne College of Audiology

Grand Rounds: Auditory Processing Disorders

- Introduction to Auditory Processing Disorder (APD)
- Presentation of Case 1: Child with APD
- Review of APD Assessment in Children
- Review of APD Management in Children
- Presentation of Case 2: Adult with APD
- Review of APD Assessment in Adults
- Review of APD Management in Adults
- Summary, Questions, & Answers

CONTINUEDSALUS
UNIVERSITY
Osborne College of Audiology

Grand Rounds: Auditory Processing Disorders

- Review of APD Management in Children
 - Definition of terms
 - Intervention options
 - Important role of counseling
 - “Bottom up” approaches and techniques
 - Auditory training
 - Personal and classroom FM systems
 - “Top down” approaches and techniques

2010 AAA Clinical Guidelines on Auditory Processing Disorders: Terminology for Habilitation/Rehabilitation

- Intervention: "...encompassing term referring to one or more actions taken in order to produce an effect and to alter the course of a disease, disorder, or pathological condition."
- Treatment: "...any specific procedure used to prevent, remediate (i.e., cure), or ameliorate a disease, disorder, or pathological condition."
- Management: "...refers to compensatory approaches (e.g., strategies, technologies) used to reduce the impact of deficits that are resistant to remediation."

Intervention for Auditory Processing Disorders (BSA Guidelines, 2011)

- Management should be
 - Individualized
 - Cost effective
 - Time effective
- Management programs should consider
 - Primary presenting complaints
 - Case history
 - Multidisciplinary assessment results
 - Tailored to each child's needs

Grand Rounds: Auditory Processing Disorders

- Review of APD Management in Children
 - Definition of terms
 - Intervention options
 - Important role of counseling
 - “Bottom up” approaches and techniques
 - ✓ Auditory training
 - ✓ Personal and classroom FM systems
 - “Top down” approaches and techniques

Auditory Processing Disorders: *Intervention Options for Children*

- Counseling
- Advocacy
- FM technology
- Computer based auditory training
- Direct auditory remediation
- Phonological awareness programs
- Language-based options
- Appropriate multidisciplinary referrals, e.g.
 - Physicians
 - SLPs
 - Psychologists
- Documenting benefits



Q10




Grand Rounds: Auditory Processing Disorders

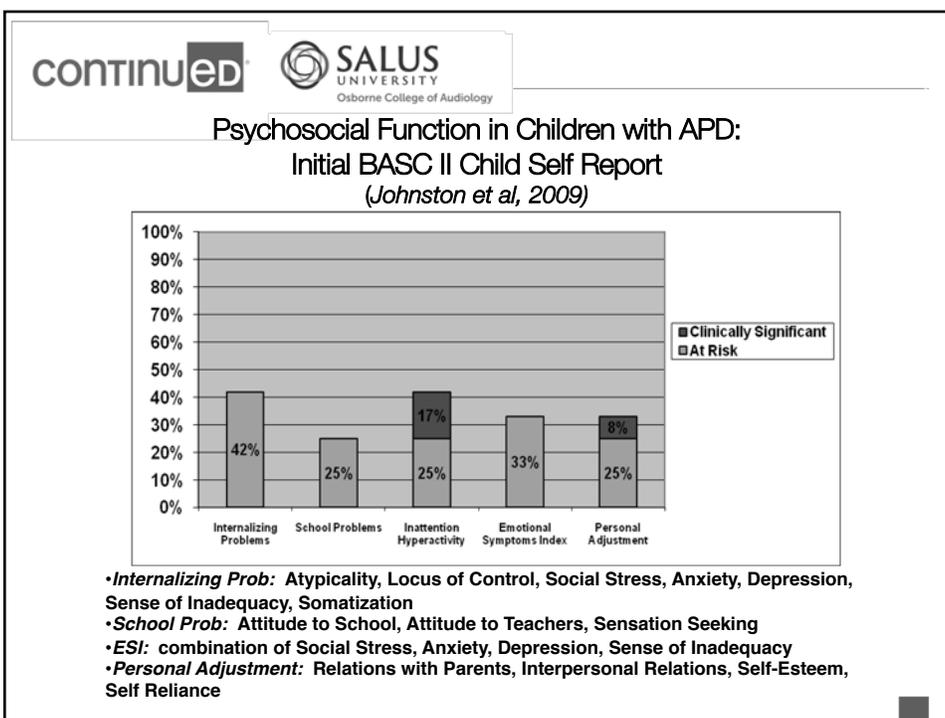
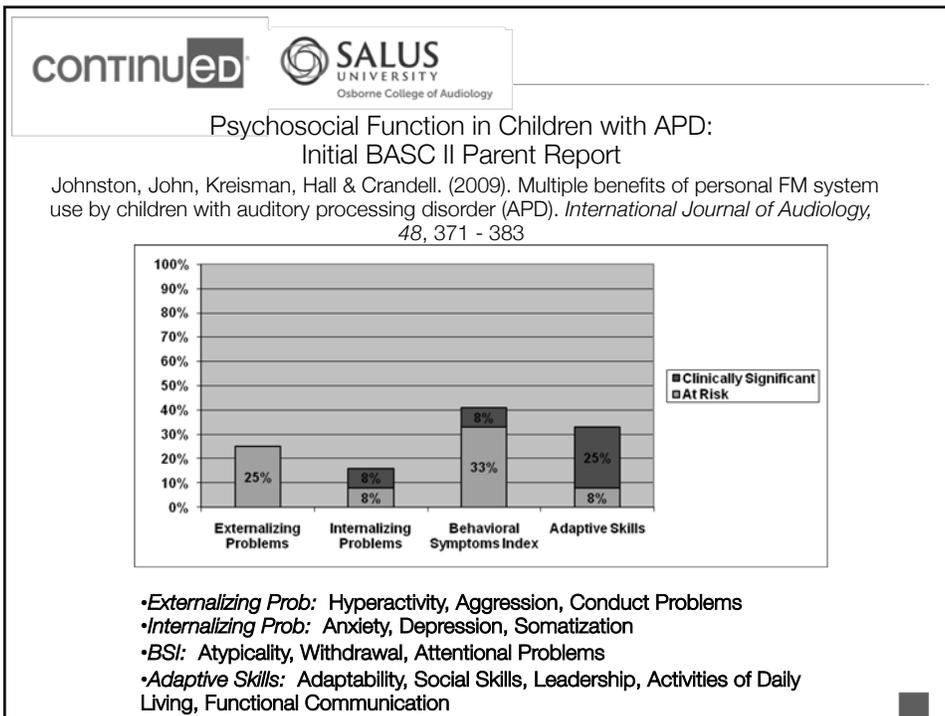
- Review of APD Management in Children
 - Definition of terms
 - Intervention options
 - Important role of counseling
 - “Bottom up” approaches and techniques
 - ✓ Auditory training
 - ✓ Personal and classroom FM systems
 - “Top down” approaches and techniques




Grand Rounds: Auditory Processing Disorders

- Family Counseling for Children with APD
 - Informational counseling
 - ✓ Clear explanation of test findings
 - ✓ Definition of APD
 - ✓ Information about evidence based intervention
 - Personal adjustment counseling of child and parents
 - Statement of advocacy for child
 - Referral to psychologist, psychiatrist, or professional counselor as indicated
 - Follow up assessment and/or counseling

Q10

Grand Rounds: Auditory Processing Disorders

- Review of APD Management in Children
 - Definition of terms
 - Intervention options
 - Important role of counseling
 - “Bottom up” approaches and techniques
 - ✓ Auditory training
 - ✓ Personal and classroom FM systems
 - “Top down” approaches and techniques

Intervention for APD with Auditory Training (AT) *(adapted from New Zealand APD Guidelines, 2019, pp. 52-67)*

- Extensive clinical research is now available, almost all generated within the past 10 to 15 years
- AT should be applied consistent with neuroscience and learning principles
 - Training should be intensive to exploit cortical reorganization
 - Multi-disciplinary effort is needed involving auditory, cognitive, meta-cognitive, and language systems
 - Active patient participation is required
- Research confirms neurophysiological basis for effectiveness of AT

2010 AAA Clinical Guidelines on APD: *Intervention ... Bottom Up Approaches*

- “Stimulus driven” approaches often implemented by audiologists
- Auditory training, e.g.,
 - Earobics
 - LACE (Listening and Communication Enhancement)
- Direct auditory skill remediation, e.g.,
 - Dichotic Interaural Intensity Difference (DIID) training
 - Aural Rehabilitation for Interaural Asymmetry (ARIA)
- Enhancement of listening environment
 - Classroom acoustical modifications
 - Classroom amplification (FM) systems
 - Personal FM systems

Q9

Phonak “EduLink” FM System Use Improves Academic Performance and Psychosocial Status in Children with APD

Johnston, John, Kreisman, Hall & Crandell. (2009). Multiple benefits of personal FM system use by children with auditory processing disorder (APD). *International Journal of Audiology*, 48, 371 - 383

EduLink
Receivers



Campus S
Transmitter



Mini-Boom
Microphone





BASC II Parent Report Results *After* EduLink Use (6 to 7 months): APD
versus Control Subjects

(Source: Johnson, John, Kreisman, Hall & Crandell, 2009)

Normal Findings per Group (%)

Domain	Control	APD
Aggression	92	100
Conduct problems	92	100
Anxiety	84	100
Depression	92	100
Internalizing problems	77	71
Withdrawal	84	71
Attention problems	92	29
Adaptive skills	92	71
Functional communication	92	57



BASC II Parent Report Results *After* EduLink Use (6 to 7 months): APD
versus Control Subjects

(Source: Johnson, John, Kreisman, Hall & Crandell, 2009)

Normal Findings per Group (%)

Domain	Control	APD
Attitude toward teachers	100	86
Attitude toward school	100	57
School problems	100	71
Conduct problems	92	100
Atypicality	100	100
Anxiety	100	100
Social stress	92	100
Depression	100	86
Internalizing problems	100	100
Sense of inadequacy	100	86
Parent relationship	92	100
Self esteem	100	100

Grand Rounds: Auditory Processing Disorders

- Review of APD Management in Children
 - Definition of terms
 - Intervention options
 - Important role of counseling
 - “Bottom up” approaches and techniques
 - ✓ Auditory training
 - ✓ Personal and classroom FM systems
 - “Top down” approaches and techniques

2010 AAA Clinical Guidelines on APD: *Intervention ... Top Down Approaches*

- “Strategy, concept, and knowledge driven” approaches often implemented by speech pathologists and other professionals
- Language strategies
- Cognitive/metacognitive strategies
- Speaker modifications
- Instructional modifications and strategies
- Accommodations in the
 - Workplace
 - Home
 - Recreational setting
 - Religious setting




Review of Bottom Up and Top Down Interventions for Children with APD

International Journal of Audiology 2012; 51: 506-518

informa
healthcare

Original Article

A randomized control trial of interventions in school-aged children with auditory processing disorders

Mridula Sharma*, Suzanne C Purdy*[†] & Andrea S Kelly[‡]

*Department of Linguistics - Audiology, Macquarie University, Sydney, Australia, and Hearing Co-operative Research Center, Australia, [†]Department of Psychology - Speech Science, The University of Auckland, New Zealand, and [‡]Department of Audiology, Auckland District Health Board, Auckland, New Zealand

Abstract

Objective: The primary purpose of the study was to compare intervention approaches for children with auditory processing disorder (APD): bottom-up training including activities focused on auditory perception, discrimination, and phonological awareness, and top-down training including a range of language activities. Another purpose was to determine the benefits of personal FM systems. *Design:* The study is a randomized control trial where participants were allocated to groups receiving one of the two interventions, with and without personal FM, or to the no intervention group. The six-week intervention included weekly one-hour sessions with a therapist in the clinic, plus 1-2 hours per week of parent-directed homework. *Study sample:* 55 children (7 to 13 years) with APD participated in the study. Intervention outcomes included reading, language, and auditory processing. *Results:* Positive outcomes were observed for both training approaches and personal FM systems on several measures. Pre-intervention nonverbal IQ, age, and severity of APD did not influence outcomes. Performance of control group participants did not change when retested after the intervention period. *Conclusions:* Both intervention approaches were beneficial and there were additional benefits with the use of personal FM. Positive results were not limited to the areas specifically targeted by the interventions.



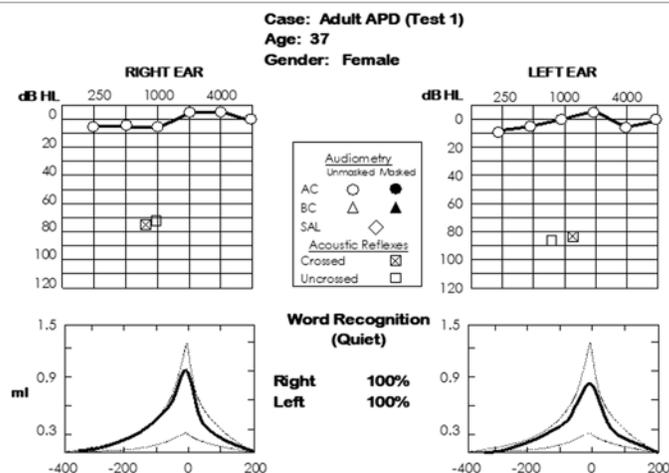

Grand Rounds: Auditory Processing Disorders

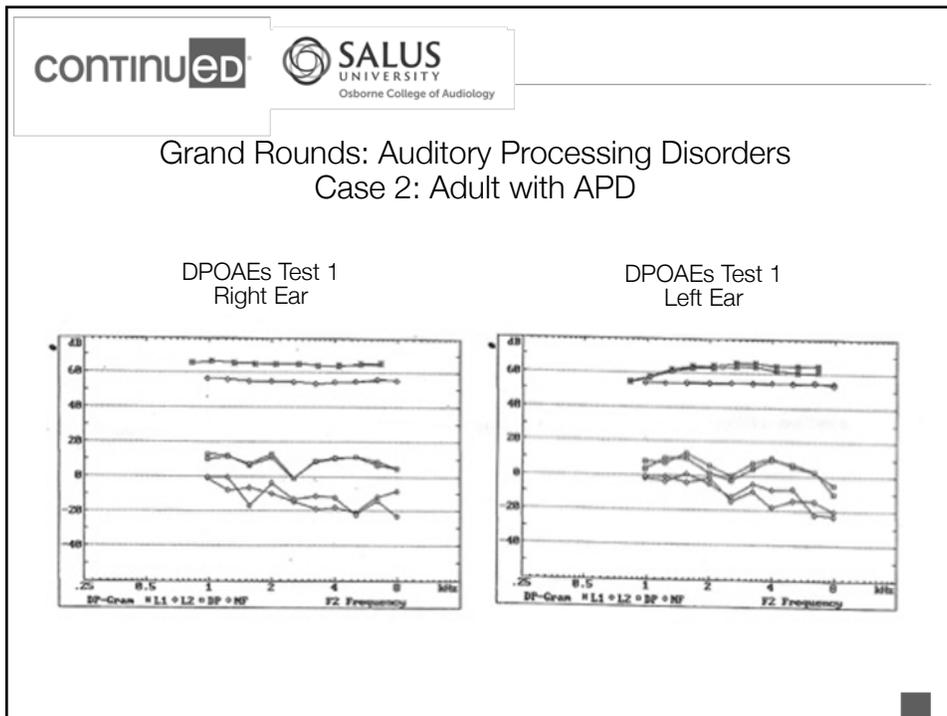
- Introduction to Auditory Processing Disorder (APD)
- Presentation of Case 1: Child with APD
- Review of APD Assessment in Children
- Review of APD Management in Children
- Presentation of Case 2: Adult with APD
- Review of APD Assessment in Adults
- Review of APD Management in Adults
- Summary, Questions, & Answers

Grand Rounds: Auditory Processing Disorders Case 2: Adult with APD

- History
 - 37 year old female
 - Speech pathologist
 - Victim of assault in a classroom setting
 - Traumatic brain injury
 - Cognitive impairment
 - Referred by attorney for audiological assessment
- Peripheral Auditory Assessment #1
 - Normal hearing sensitivity (< 15 dB HL)
 - Normal aural immittance findings
 - Normal distortion product otoacoustic emissions
 - Normal word recognition scores in quiet (100%)

Grand Rounds: Auditory Processing Disorders Case 2: Adult with APD





CONTINUED **SALUS UNIVERSITY**
Osborne College of Audiology

Grand Rounds: Auditory Processing Disorders
Case 2: Adult with APD

Central Auditory Assessment #1

Test	Right Ear	Left Ear
Staggered Spondaic Word (SSW)	Normal	Abnormal
Dichotic Digits	Normal	Abnormal
SSI-ICM + 10 MCR	Normal	Normal
0 MCR	Borderline	Borderline
Pitch Pattern Sequence	Normal	
Duration Pattern Sequence	Abnormal	

Grand Rounds: Auditory Processing Disorders Case 2: Adult with APD

- Recommendations (Test 1)
 - Counseling regarding APD
 - Accommodations to improve signal-to-noise ratio in the work setting
 - Language assessment
 - Follow up assessment with auditory evoked responses

Grand Rounds: Auditory Processing Disorders Case 2: Adult with APD

Electrophysiological Assessment (Test 1)

Test	Right Ear	Left Ear
Auditory brainstem response	Normal	Normal
Auditory middle latency response		
Right hemisphere	Normal	Normal
Left hemisphere	Abnormal	Normal
P300 Response	Normal	Normal

Grand Rounds: Auditory Processing Disorders Case 2: Adult with APD

“Dear Dr. Hall:

It was a pleasure to see you again at the _____ Convention in [state] this year. I don't even remember if I properly thanked you for your help in diagnosing me while you were working at Vanderbilt University in Nashville. Nevertheless, thank you for speaking on my behalf to the grueling lawyers I was up against in regards to my “kick in the head” and what type of damage/trauma I had suffered as a result of the incident.

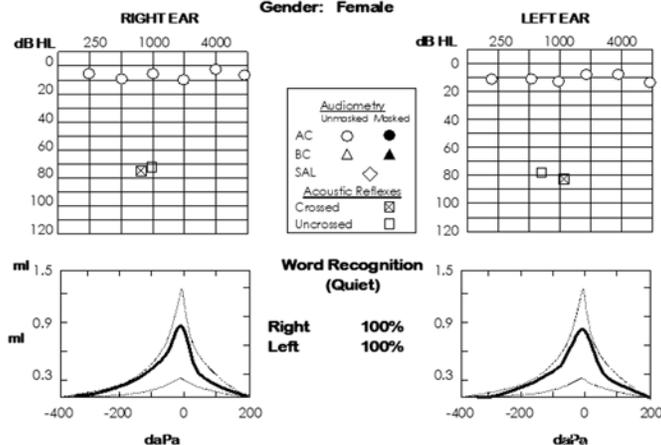
I am experiencing increased difficulty with processing information and/or hearing people correctly ...”

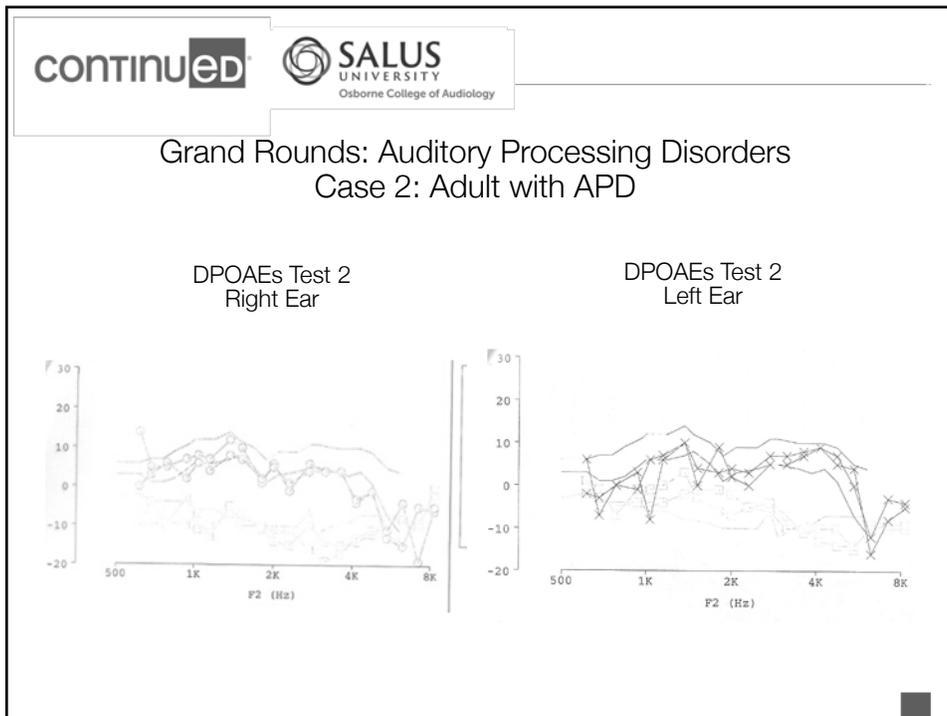
Grand Rounds: Auditory Processing Disorders Case 2: Adult (50 years) with APD

Case: Adult APD (Test 2)

Age: 50

Gender: Female





Grand Rounds: Auditory Processing Disorders
Case 2: Adult with APD
Central Auditory Assessment #2
(Black – Normal; Red – Abnormal)

Test	Right Ear	Left Ear
Staggered Spondaic Word (SSW)	96%	32%
Dichotic Digits	94%	48%
SSI-ICM All MCRs (See graph)	Abnormal	Abnormal
SCAN-A		
Filtered Words	9th percentile	
Auditory Figure Ground	Abnormal	
Competing Words	26	3 0.1st percentile



Grand Rounds: Auditory Processing Disorders Case 2: Adult with APD

- Recommendations (Test 2)
 - Use of personal FM system in work setting and any other noisy environments
 - Completion of LACE (Listening and Communication Enhancement) auditory training program
 - Completion of DIID (Dichotic Intensity Increment Difference) auditory training program
 - Follow up assessment in 1 year



Grand Rounds: Auditory Processing Disorders

- Introduction to Auditory Processing Disorder (APD)
- Presentation of Case 1: Child with APD
- Review of APD Assessment in Children
- Review of APD Management in Children
- Presentation of Case 2: Adult with APD
- Review of APD Assessment in Adults
- Review of APD Management in Adults
- Summary, Questions, & Answers

Grand Rounds: Auditory Processing Disorders Possible Patient Profiles: Adults

- Older patients with age-related auditory dysfunction
- Older patients with cognitive impairment
- Younger adults with undiagnosed APD and life change, e.g.,
 - New employment outside the home
 - New work position with greater auditory demands
 - Returning to school (e.g., training or community college)
- Adults of any age with neurological disorder, disease, or damage, e.g.,
 - TBI
 - Stroke or other cardiovascular insult
 - Dementia

Grand Rounds: Auditory Processing Disorders

- Review of APD Assessment in Adults
 - Test battery for efficient and effective assessment of peripheral auditory function ... *same as for assessment of children*
 - Test battery for efficient and effective assessment of central auditory function and processing
 - Test options for auditory processing assessment of adults with peripheral hearing loss
 - Factors influencing auditory assessment of adults

Grand Rounds: Auditory Processing Disorders

- Review of APD Assessment in Adults
 - Test battery for efficient and effective assessment of peripheral auditory function ... same as for assessment of children
 - Test battery for efficient and effective assessment of central auditory function and processing ... *more options for tests because age referenced normative data is not needed*
 - Test options for auditory processing assessment of adults with peripheral hearing loss
 - Factors influencing auditory assessment of adults

Assessment of APD in Adults *New Zealand Clinical Practice Guidelines (2019, p. 46)*

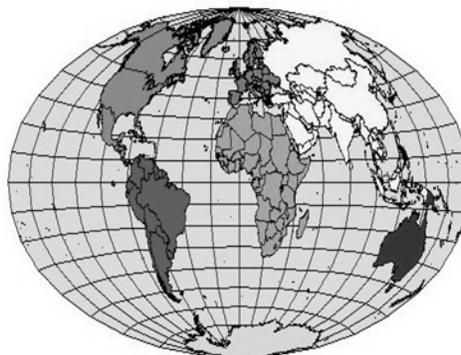
- Auditory discrimination tests (N = 2)
- Dichotic listening tests (N = 5)
- Distorted speech tests (N = 4)
- Speech understanding in noise (N = 3)
- Spatial segregation (N = 1)
- Temporal processing (N = 4)
- Pattern perception (N = 2)

Assessment of Auditory Processing Disorders:
Selected Tests from Auditec
(auditecinfo@auditec.com)

- ACAP Battery (9 common APD tests)
- Competing Sentences
- Dichotic Digits (Musiek version)
- Dichotic Digits (Standard)
- Dichotic Sentence Identification (DSI)
- Discrimination of PBK in Noise
- Duration Pattern Sequence (Musiek version)
- Duration Pattern Sequence (Standard version)
- Pitch Pattern Sequence (Musiek version)
- Pitch Pattern Sequence (Standard version)
- Gaps in Noise (GIN)
- Low Pass Filtered Speech

Assessment of Auditory Processing Disorders:
Tests in Different Languages
(auditecinfo@auditec.com)

- English
- Arabic
- Chinese
 - Cantonese
 - Mandarin
- French
- Italian
- Japanese
- Korean
- Polish
- Portuguese
- Russian
- Spanish
- Vietnamese



Assessment of Auditory Processing Disorders:
An International Approach
(auditecinfo@auditec.com)

- Acquire speech audiometry tests in different languages
- Always administer non-verbal tests of auditory processing, e.g.,
 - Gaps in Noise
 - Pitch Pattern Sequence
 - Duration Pattern Sequence
 - Frequency Discrimination
- Routinely administer multiple objective auditory measures, e.g.,
 - Acoustic reflexes (including amplitude and latency measures)
 - OAEs
 - ABR (speech ABR if feasible)
 - Cortical auditory evoked responses



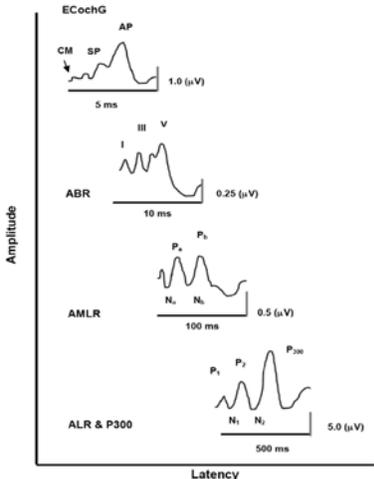
Assessment of Auditory Processing Disorders:
Speech in Noise Tests
(auditecinfo@auditec.com)

- BKB-SIN
- NU-CHIPS with 4 talker and multi-talker noise
- PBK-50 with 4 talker and multi-talker noise
- QuickSIN (Speech in Noise)
- SIN (Speech in Noise)
- SPRINT (NU-6 words in multi-talker noise)
- W-22 with multi-talker noise
- WIPI (Word Intelligibility by Picture Identification) with 4 talker noise



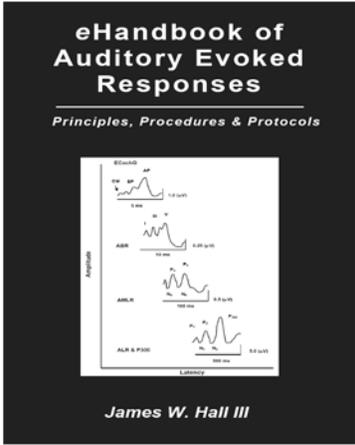

Auditory Evoked Responses in APD Assessment: Cochlea to Cortex

Auditory Evoked Responses



Amplitude

Latency



<http://www.amazon.com/dp/B0145G2FFM>




Assessment of APD in Children and Adults: Rationale for Auditory Evoked Responses (AAA Guidelines, 2010)

- Inconclusive behavioral test pattern of deficits
- Behavioral test findings incomplete or inconclusive due to listener variables
- Young age precludes administration of complete test battery
- Neurological disorder is suspected
- Information on site of dysfunction is needed
- Behavioral measures are affected by patient language and no test materials are available in the patient's native language
- Medical-legal implications or referral from an attorney (JW Hall recommendation, not AAA)

Auditory Processing Disorders: Electrophysiological Assessment

(AAA Clinical Practice Guidelines)

- “Auditory evoked responses (AER) from the auditory brainstem response (ABR) through higher level cortical auditory evoked responses have clinical value in the evaluation of (C)APD (Jerger & Musiek, 2000).
- Auditory evoked responses can be elicited with simple acoustic signals, such as clicks and tone-bursts, and also with more complex (e.g., speech) signals (see McPherson, 1996, for review).” (AAA, 2010, p. 19)
- ABR: “Recent research suggests the potential utility of the speech-evoked ABR in the diagnosis of (C)APD and in documenting the benefits of intervention for (C)APD (Banai, Nicol, Zecker, & Kraus, 2005).”

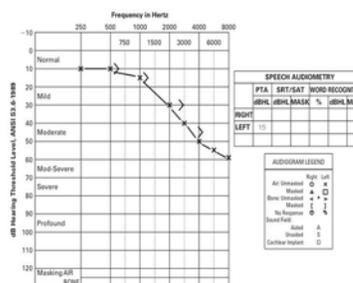
Auditory Processing Disorders: Electrophysiological Assessment

(AAA Clinical Practice Guidelines)

- AMLR: “With proper consideration of the influences of age (maturation), the AMLR offers an electrophysiologic option that appears to be underutilized at this time for evaluation of central auditory processing in children and adults.” (Levels of evidence: 2, 3).
- ALR: “There is a growing literature describing many auditory evoked responses with latencies beyond 50 ms elicited with non-speech and speech signals. Those most relevant to clinical assessment of (C)APD include the auditory late response (ALR), which is comprised of the N1 and P2 evoked potentials and the P300 response. The cortical auditory evoked responses reflect the function of sites suspected of dysfunction in the majority of children with (C)APD. “

Grand Rounds: Auditory Processing Disorders

- Review of APD Assessment in Adults
 - Test battery for efficient and effective assessment of peripheral auditory function ... same as for assessment of children
 - Test battery for efficient and effective assessment of central auditory function and processing
 - Test options for auditory processing assessment of adults with peripheral hearing loss
 - Factors influencing auditory assessment of adults



APD Assessment: Special Test Strategies in Peripheral Hearing Loss (Older Children and Adults)

- Refer for medical management, as indicated
- Increase intensity level to 30 - 40 dB SL, if feasible
- Avoid reliance on single syllable word materials (dominated by high frequency content)
- Rely on procedures with less sensitivity to effects of peripheral hearing loss, e.g.,
 - HINT
 - Synthetic sentence identification (SSI-ICM)
 - Dichotic Sentence Identification (DSI)
- Research evidence suggests that peripheral hearing loss does not preclude CAPD assessment (e.g., Cox et al, JAAA, 2008)
- Children with hearing loss or Cis may be at risk for APD

Assessment of APD in Patients with Peripheral Hearing Loss

New Zealand Clinical Practice Guidelines (2019, p. 56)

- In some cases APD assessments can be conducted in the presence of peripheral hearing loss by experienced audiologists. The information obtained may be limited but frequently some helpful information is obtained.
- If APD tests are passed despite peripheral hearing loss then APD can be ruled out.
- If APD tests are failed in the good ear in cases of unilateral hearing loss then the finding is suggestive of APD.
- Asymmetric performance on APD tests in the presence of a symmetrical hearing loss increases suspicion of APD.

Assessment of APD: *Patients with Asymmetric or Unilateral Hearing Loss*

- APD assessment is possible
- Indication is usually difficulty hearing in background noise
- Perform complete assessment of peripheral auditory dysfunction, including:
 - Performance-intensity (PI) functions for word recognition
 - Otoacoustic emissions
 - Aural immittance measures with ipsi- and contralateral acoustic reflexes
- APD assessment includes usual procedure except for dichotic listening tests
- Make appropriate referrals
 - Otolaryngology for diagnosis and to rule out neural auditory dysfunction
 - Audiology for possible amplification

Grand Rounds: Auditory Processing Disorders

- Review of APD Assessment in Adults
 - Test battery for efficient and effective assessment of peripheral auditory function
 - Test battery for efficient and effective assessment of central auditory function and processing
 - Test options for auditory processing assessment of adults with peripheral hearing loss
 - Factors influencing auditory assessment of adults

Auditory Processing Disorders *Listener Variables Influencing Test Administration and Performance in Adults*

- **Fatigue**
- **Hearing sensitivity**
- **Cognitive variables**
- **Medications**
- **Motivation**
- **Motor skills**
- **Native language**
- **Visual acuity**





Relation of Auditory Processing Deficits and Cognitive Function: Recent Research

Review Article

The Association Between Cognitive Performance and Speech-in-Noise Perception for Adult Listeners: A Systematic Literature Review and Meta-Analysis

Adam Dryden^{1,2}, Harriet A. Allen², Helen Henshaw^{3,4}, and Antje Heinrich¹

Trends in Hearing
Volume 21: 1–21
© The Author(s) 2017
Reprints and permissions:
sagepub.com/journalsPermissions.nav
DOI: 10.1177/2331214517744675
journals.sagepub.com/home/tih
SAGE

- Nottingham UK
- 25 articles met criteria for analysis
- Articles described cognitive measures
 - ✓ Attention
 - ✓ Memory
 - ✓ Executive function
 - ✓ IQ
 - ✓ Processing speed
- General association between cognitive performance and speech perception in noise





Grand Rounds: Auditory Processing Disorders

- Introduction to Auditory Processing Disorder (APD)
- Presentation of Case 1: Child with APD
- Review of APD Assessment in Children
- Review of APD Management in Children
- Presentation of Case 2: Adult with APD
- Review of APD Assessment in Adults
- Review of APD Management in Adults
- Summary, Questions, & Answers

Grand Rounds: Auditory Processing Disorders

- Review of APD Management in Adults
 - Definition of terms ... same as for children
 - Intervention options ... similar as for children
 - Counseling is also important for adults
 - “Bottom up” approaches and techniques
 - ✓ Amplification
 - ✓ FM technology (with or without amplification)
 - ✓ Auditory training ... additional options for adults
 - “Top down” approaches and techniques
 - ✓ Cognitive function and impairment is important in management of adults

Intervention in Adults with APD... Bottom Up Approaches

- “Stimulus driven” approaches often implemented by audiologists
- Auditory training, e.g.,
 - Earobics
 - LACE (Listening and Communication Enhancement)
- Direct auditory skill remediation, e.g.,
 - Dichotic Interaural Intensity Difference (DIID) training
 - Aural Rehabilitation for Interaural Asymmetry (ARIA)
- Enhancement of listening environment
 - Directional microphones with amplification
 - Workplace accommodations
 - Personal FM systems (alone or with amplification)

Auditory Processing and Cognitive Deficits Including Dementia

- Strouse A, Hall JW III & Burger M. (1995). Central auditory processing in Alzheimer's disease. *Ear & Hearing*, 16, 230-238
 - Subjects
 - ✓ 10 with mild to moderate AD
 - ✓ 10 control subjects matched for age, gender, hearing loss
 - Procedures
 - ✓ Pure tone audiogram; DPOAEs
 - ✓ Synthetic sentence identification-Ipsilateral competing message (SSI-ICM)
 - ✓ Dichotic sentence identification (DSI)
 - ✓ Dichotic digits
 - ✓ Pitch pattern sequence (PPS)
 - ✓ Duration pattern sequence (DPS)

Auditory Processing and Cognitive Deficits Including Dementia *(Strouse, Hall & Burger, 1995)*

- Conclusions
 - AD group scored significantly lower than the matched control group on four of the five measures utilized.
 - Differences for right versus left ear performance were found among AD subjects.
 - Overall patterns in findings cannot be easily explained as artifacts only of cognitive decline.
 - Results support screening for central auditory dysfunction in the AD population, since impaired processing could influence psychiatric assessment of cognitive deficit as well as audiologic management of peripheral hearing loss in this population.

Assessment of Central Auditory Dysfunction in Cognitive Deficits and Alzheimer's Dementia

Gates GA et al. (2008) Central auditory dysfunction in older persons with memory impairment or Alzheimer's dementia. *Arch Otolaryngol Head Neck Surg*, 134, 771-777

- “Central auditory function was affected by even mild memory impairment. The Dichotic Sentence Identification test in the free report mode was the most sensitive test for the presence of memory impairment.
- We recommend that central auditory testing be considered in the evaluation of older persons with hearing complaints as part of a comprehensive, individualized program to assist their needs in both the aural rehabilitative and the cognitive domains.”

APD and Cognitive Decline: Recent Research

Journal of Alzheimer's Disease 60 (2017) 1589-1600
 DOI 10.3233/JAD-170545
 IOS Press

1589

Deficit in Central Auditory Processing as a Biomarker of Pre-Clinical Alzheimer's Disease

Miranda Tuwaig^{a,b}, Mélissa Savard^a, Benoît Jutras^{c,d}, Judes Poirier^{a,b}, D. Louis Collins^{a,b}, Pedro Rosa-Neto^{a,b}, David Fontaine^a and John C.S. Breitner^{a,b,*}, for the PREVENT-AD Research Group^{a,b}

^aDouglas Mental Health University Institute, Montreal, QC, Canada

^bMcGill University, Montreal, QC, Canada

^cSainte-Justine Hospital Pediatric Research Centre, Montreal, QC, Canada

^dUniversité de Montréal, Montreal, QC, Canada




Management of APD in Adults

Considering Hearing Related Comorbid Conditions is Critical



RESEARCH ARTICLE

Dual sensory impairment: The association between glaucomatous vision loss and hearing impairment and function

Lucy I. Mudie^{*}, Varshini Varadaraj[†], Prateek Gajwani[†], Beatriz Munoz^{*}, Pradeep Ramulu^{*}, Frank R. Lin^{*}, Bonnie K. Swenor^{*}, David S. Friedman^{1,2*}, Nazlee Zebardast^{1*}

Johns Hopkins University, Baltimore, MD, United States of America

^{*} These authors contributed equally to this work.
[†] These authors are co-senior authors on this work.
^{*} david.friedman@jhu.edu

- Dual impairment was associated with significantly more severe driving limitation
- More difficulty with communication compared to those without sensory impairment when adjusted for age, race, gender and number of comorbidities
- Older individuals with glaucoma and hearing loss seem to have generally poorer functioning than those with single sensory loss.
- Relation between dual sensory deficits and depression




Selected Key References

- Hall JW III & Bellis TJ. Assessment and Management of Auditory Processing Disorders: It's Real, It's Here, and It's Mainstream Audiology. **Audiology Today** **20 (2)**: 42-44, 2008
- Johnston, KN, John AB, Kreisman, NV, Hall JW III & Crandell CC. Multiple benefits of personal FM system use by children with auditory processing disorder (APD). **International Journal of Audiology**, **48**, 371-383, 2009
- Bellis TJ. Assessment and Management of Central Auditory Processing in the Educational Setting. Clifton Park NY: Thomson Delmar Learning (2003)
- Musiek F & Chermak G (eds). (2014). Handbook of Central Auditory Processing Disorder. Volume 1: Auditory Neuroscience and Diagnosis (2nd ed.). San Diego: Plural Publishing
- Musiek F & Chermak G (eds). (2014). Handbook of Central Auditory Processing Disorder. Volume 2: Comprehensive Intervention (2nd ed.). San Diego: Plural Publishing
- Chermak G & Musiek F (2011). Neurological substrates of central auditory processing deficits in children. *Current Pediatric Reviews*, 7, 241-251

