

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. It may not include content identical to the powerpoint. 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.

Auditory Processing Disorders: An Overview of Current Research Evidence for Audiologists (Course #23529)

James W. Hall III, Ph.D.

*Adjunct Professor
Nova Southeastern University*

*Adjunct Professor
Salus University*

*Extraordinary Professor
University of Pretoria
South Africa*

*jwhall3phd@gmail.com
www.audiologyworld.net*

3

Auditory Processing Disorders (APD): An Overview of Current Research Evidence for Audiologists

- ☐ Introduction
- ☐ Survey of definitions of APD
- ☐ Risk factors for APD in children and adults
- ☐ Disorders co-existing with APD
- ☐ Summary (Q & A)

4

Auditory Processing Disorders (APD): An Overview of Current Research Evidence for Audiologists *Introduction*

- ❑ **Dichotic Listening Deficits: Diagnosis and Management (Course #23531)**
 - Jeff Weihing, PhD (U. of Louisville)
 - February 12, 2014
- ❑ **(Central) Auditory Processing Disorder: Lessons from the Past and Evidence for the Future (Course #23535)**
 - Wayne Wilson, PhD (U. of Queensland)
 - February 19, 2014
- ❑ **Auditory Processing Disorders: Evidence-Based Assessment and Intervention (Course #23530)**
 - James W. Hall III, PhD
 - February 26, 2014



5

Handbook of Central Auditory Processing Disorder. Volume 1*: Auditory Neuroscience and Diagnosis (2nd ed) Frank E. Musiek & Gail D. Chermak. Plural Publishing (2014)

- ❑ Auditory neuroscience and central auditory processing disorder (F Musiek & G Chermak)
- ❑ Development of the central auditory nervous system (Jos Eggermont)
- ❑ Neurological substrate of central auditory processing disorder (G Chermak & F Musiek)
- ❑ An introduction to central auditory neuroscience (D Phillips)
- ❑ Auditory processing disorders: An intersection of cognitive, sensory, and reward circuits (K Banai & N Kraus)
- ❑ Clinical and research issues in central auditory processing disorder (*J Weihing*, TJ Bellis, G Chermak, F Musiek)
- ❑ Screening for central auditory processing disorder (*W Wilson*)
- ❑ Dichotic listening tests (*J Weihing* & S Atcherson)

* A total of 23 chapters in Volume 1

6

Handbook of Central Auditory Processing Disorder. Volume 2*: Comprehensive Intervention (2nd ed)

Frank E. Musiek & Gail D. Chermak. Plural Publishing (2014)

- ❑ Neurobiology, cognitive science, and intervention (G Chermak & F Musiek)
- ❑ Evidence-based practice and treatment efficacy (J Pimental & E Inglebrot)
- ❑ The efficacy of auditory training in children and adults with central auditory processing deficits (*J Weihsing*, G Chermak, F Musiek & TJ Bellis)
- ❑ Historical foundations of central auditory processing disorder (*JW Hall III* & A Bantwal)
- ❑ Auditory training (F Musiek, G Chermak & *J Weihsing*)
- ❑ Remediation of spatial processing issues in central auditory processing disorder (S Cameron & H Dillon)
- ❑ Dichotic interaural intensity difference (DIID) training (*J Weihsing* & F Musiek)
- ❑ Clinical and research issues in central auditory processing disorder (*J Weihsing*, TJ Bellis, G Chermak & F Musiek)

*** Also a total of 23 chapters in Volume 2**

7

Auditory Processing Disorders (APD): An Overview of Current Research Evidence for Audiologists

The screenshot shows the AudiologyNOW! website for the Central Auditory Processing Disorder (CAPD) Global Conference. The header includes the AudiologyNOW! logo, a search bar, and navigation links for Academy Research Conference, CAPD Conference, and SAA Conference. The main content area features a banner for the Orlando conference (March 25-29, 2014) and a 'Register Now' button. Below the banner, there is a 'QUICK LINKS' section with links to Home, Program, CAPD Conference, Schedule, Special Events, Educational Sessions, Handbooks, CEUs, Tier 1 & State Approval, Open House & Related Organizations, Academy Research Conference (ARC), CAPD Conference, Display/Exhibitor Zone, and Useful Tools & Apps. The main text describes the CAPD Global Conference, its focus on clinical populations with CAPD, and the importance of the conference for audiologists. It also mentions the CAPD Program Committee, including Gail Chermak, PhD, as the Program Chair. A 'Place Your Ad Here!' button is visible on the left. On the right, there is a box for the 'audiology solutions network' with the text 'Visit the industry's most dynamic resource directory!'. At the bottom, there is a table for 'CAPD Registration Rates'.

CAPD Registration Rates	
Member	\$120
Student Member	\$40
Nonmember	\$150
AudiologyNOW! and CAPD (Members Only)	\$95

8

**Helmer Myklebust, Ph.D. (in psychology)
Northwestern University
“Pioneer in APD Assessment”**

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

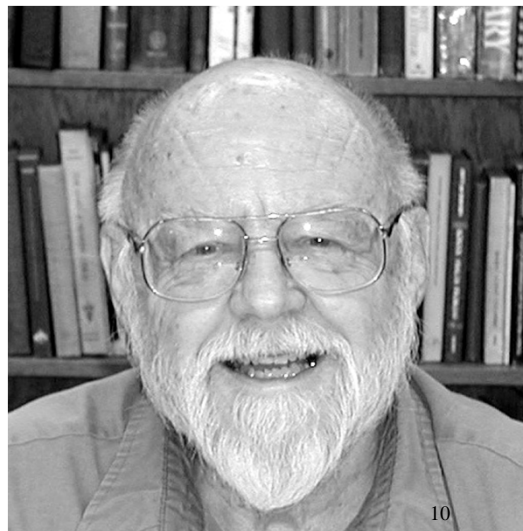
“hearing is a receptive sense ... and essential for normal language behavior” (p. 11)

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

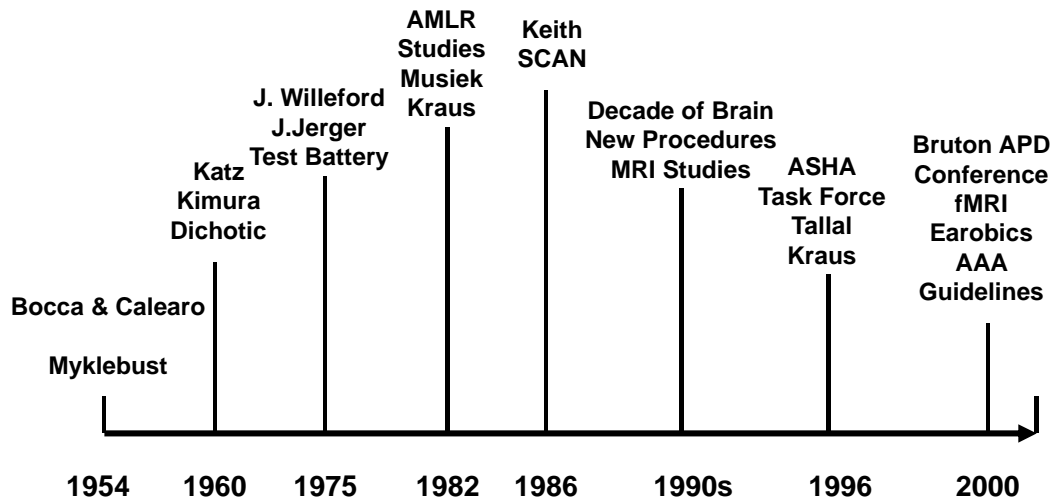


**James Jerger, PhD
Student of Myklebust at Northwestern University in the 1950s
(Comments from Foreword of Musiek & Chaemak. Handbook of Central Auditory Processing Disorders. Volume I, 2014)**

“Myklebust began to realize that some of the children with apparent hearing problems had normal audiograms ... They heard faint sounds normally in the sound booth, but in the real acoustic world ... these children seemed unable to successfully suppress background competition in order to focus on a particular source.”



Auditory Processing Disorders (APD): An Overview of Current Research Evidence for Audiologists



11

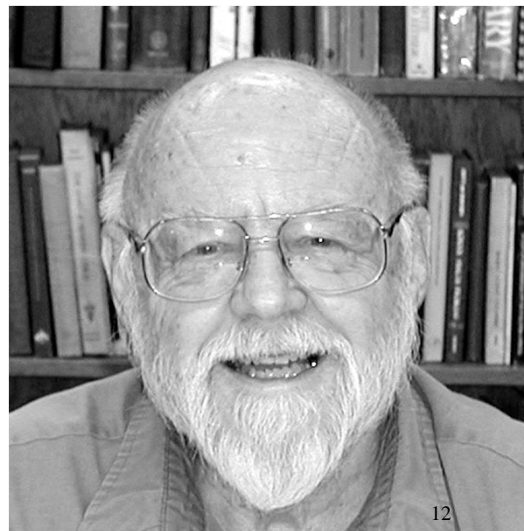
James Jerger, PhD

Student of Myklebust at Northwestern University in the 1950s

(Comments from Foreword of Musiek & Charmak. Handbook of Central Auditory Processing Disorders. Volume I, 2014)

“Within the past decade ... two important advances can be cited. The first is a growing understanding of the influence of extra-auditory cognitive processes ... on the fundamental nature of the disorder and on our diagnostic tests and instruments.

The second is the emergence of innovative treatment options, many of which actually seem to work.”



12

Auditory Processing Disorders (APD): An Overview of Current Research Evidence for Audiologists

- ☐ **Best Practice = Evidence Based Practice**
- ☐ **Categories of Research Evidence (ASHA, 2004)**
 - **1a: Well-designed meta-analysis of randomized controlled trials**
 - **1b: Well-designed randomized controlled trials**
 - **2a: Well-designed controlled studies without randomization**
 - **2b: Well-designed quasi-experimental studies**
 - **3: Well-designed non-experimental studies, i.e., correlational and case studies**
 - **4: Expert committee reports, consensus conferences and clinical experience**

13

Auditory Processing Disorders (APD): An Overview of Current Research Evidence for Audiologists

- ☐ **Introduction**
- ☐ **Survey of definitions of APD**
- ☐ **Risk factors for APD in children and adults**
- ☐ **Disorders co-existing with APD**
- ☐ **Summary (Q & A)**

14

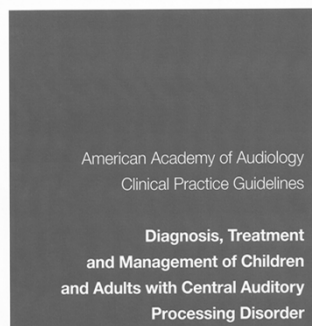
Definitions of Auditory Processing Disorders (APD)

“APD means different things to different people.” (Jerger, 2009)

- ❑ **“APD is broadly defined as a deficit in the processing of information that is specific to the auditory modality.”**
(Bruton Conference in Dallas, Jerger & Musiek 2000)
- ❑ **Auditory processing is “the efficiency and effectiveness by which the CNS utilizes auditory information.” (ASHA, 2005)**
- ❑ **“(C) APD is seen in a wide array of populations, including children and adults. It can be the result of a number of 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.” (AAA, 2010)**
- ❑ **APD is not a deficit in:**
 - **Linguistic processing as defined by speech-language pathologists**
 - **Cognitive processing as defined by psychologists**
 - **Attention deficit hyperactivity disorder (ADHD)**

15

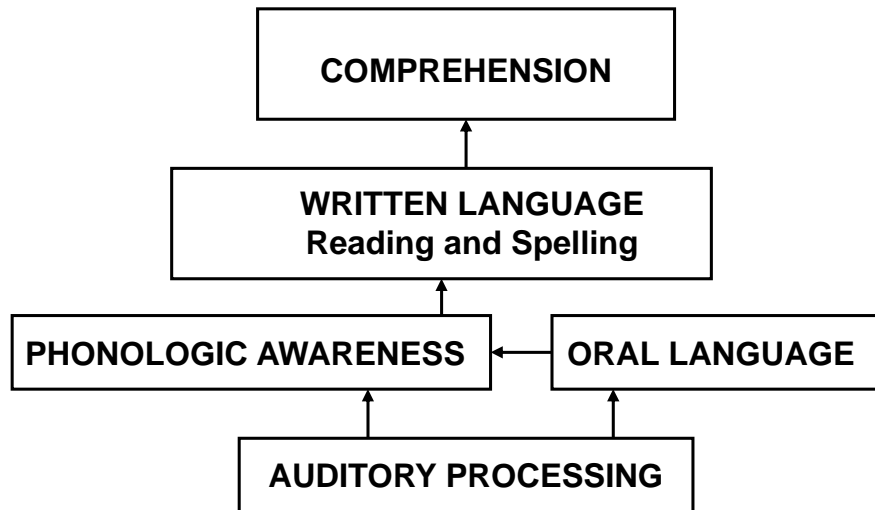
AAA Clinical Guidelines on Auditory Processing Disorders: A Manual for Evidence Based Assessment and Management (www.audiology.org)



AMERICAN ACADEMY OF AUDIOLOGY
www.audiology.org



**AUDITORY PROCESSING:
Cornerstone of Language and Literacy (Reading)**



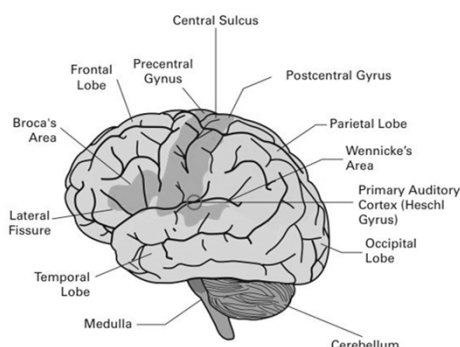
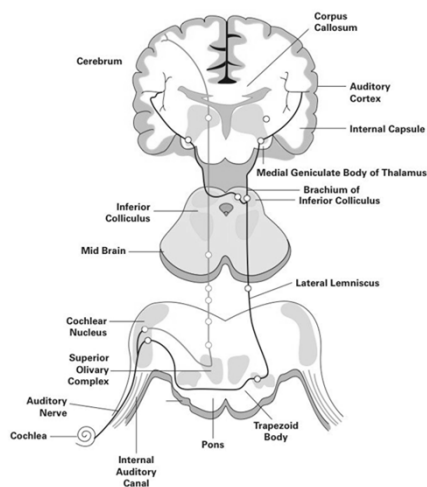
17

Consequences of Late Identification of APD in Children

- ☐ Ineffective and inefficient communication
- ☐ Risk for reading delay or failure
- ☐ Academic underachievement or failure
- ☐ Risk for special education and school drop out
- ☐ Risk for language impairment
- ☐ Clinically important psychosocial problems
- ☐ Remediation that is
 - Longer in duration
 - More expensive
 - Less effective

18

Central Auditory Nervous System: “We Hear with Our Brain”

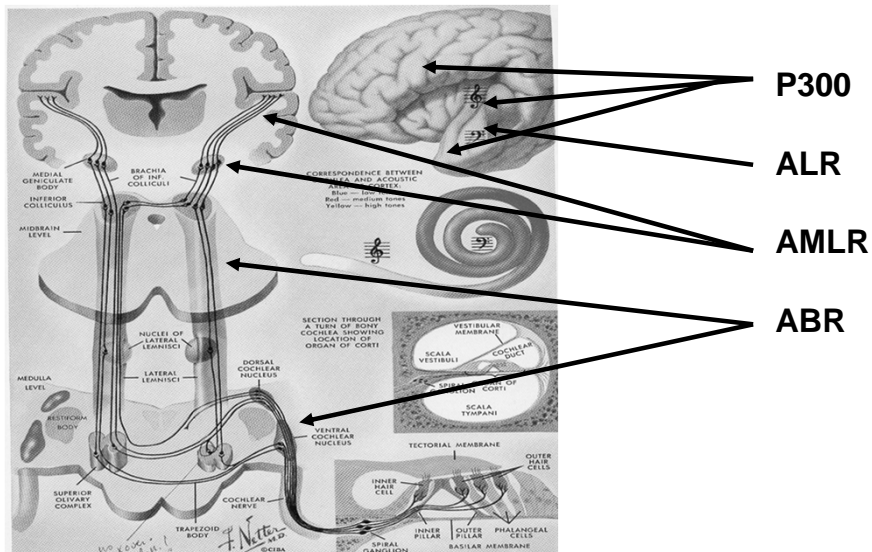


Hall JW III. *Introduction to Audiology Today*. Copyright © Pearson 2014 19

Basic Neuroscience Advances in the Decade of the Brain (1990s) Impacted Understanding of APD

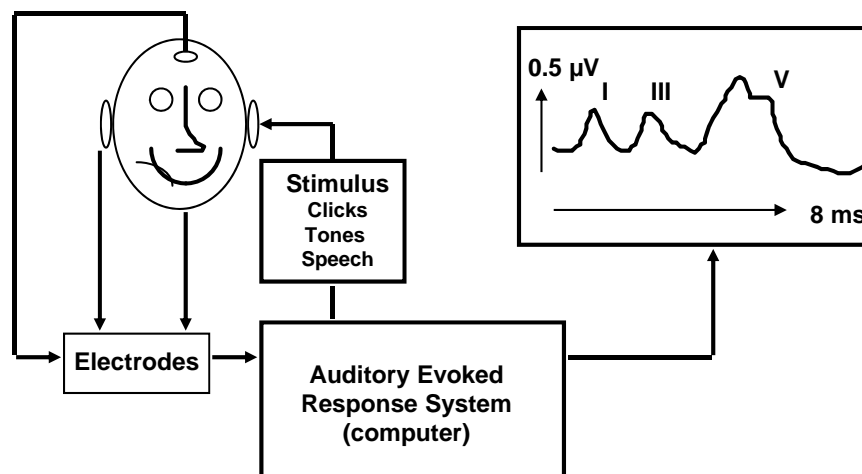
- ❑ Different regions mature at different rates
 - Maturation occurs along caudal to rostral gradient
- ❑ Development of auditory pathways and centers involves
 - Cell differentiation and migration
 - Myelination
 - Arborization
 - Synaptogenesis
- ❑ Consistent and typical auditory stimulation (experience) within the first years after birth shapes nervous system development (plasticity)
- ❑ Perinatal and childhood factors influence development of auditory processing, e.g.,
 - Neurological risk factors (e.g., asphyxia, hyperbilirubinemia)
 - Conductive hearing loss
 - Environmental deprivation
- ❑ Genetic factors play a role in etiology of auditory processing disorders

Auditory Evoked Responses: Objective Site-Specific Indices of Auditory Processing Disorders



21

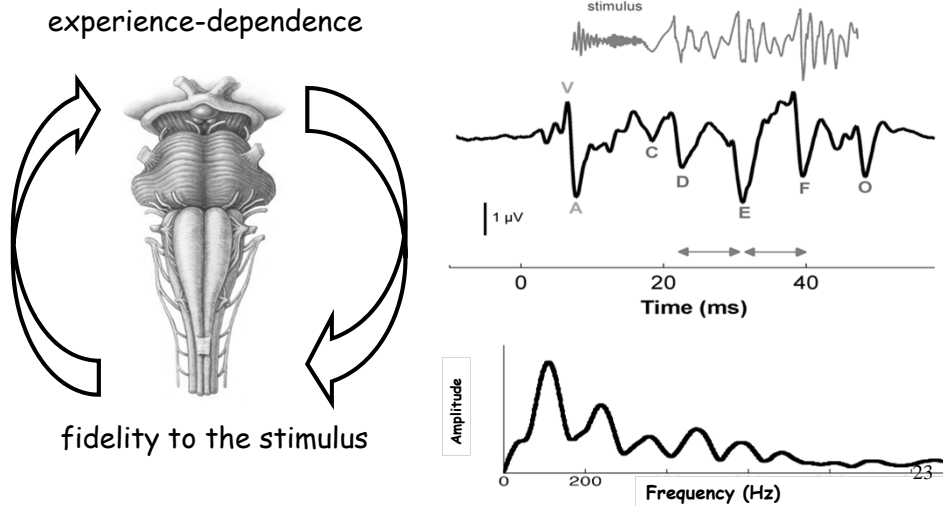
Confirmation of Brainstem-Level Auditory Processing Deficits with Speech-Evoked Auditory Brainstem Response



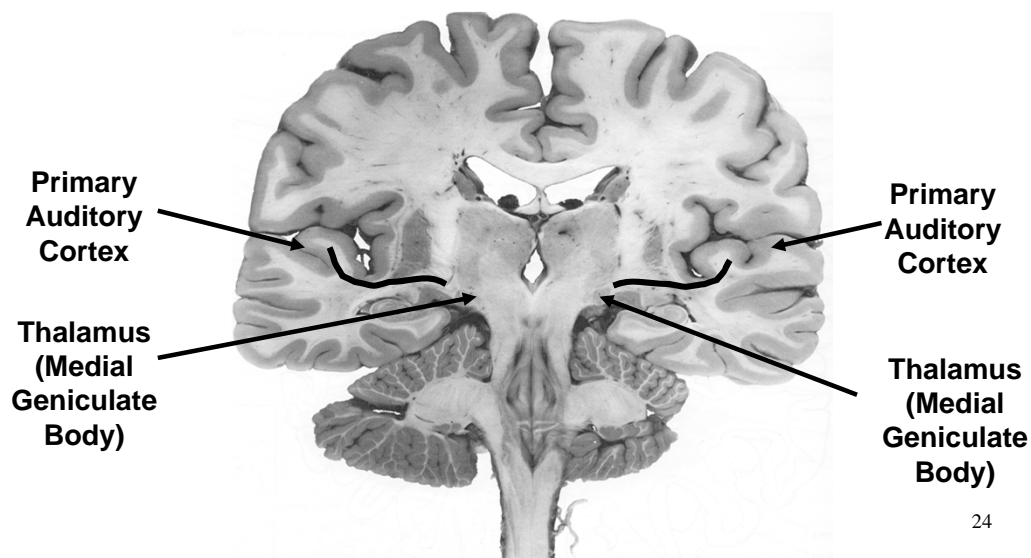
22

Speech-Elicited ABR: Nina Kraus at Northwestern University Auditory Neuroscience Laboratory

(<http://www.soc.northwestern.edu/brainvolts/projects/neuroeducation/index.php>)

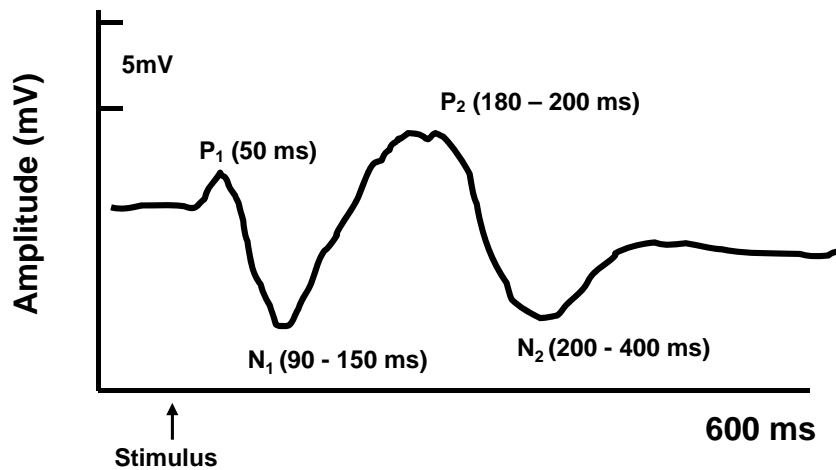


Origins of the Auditory Middle Latency Response (AMLR) (Photograph adapted from F.E. Musiek)



24

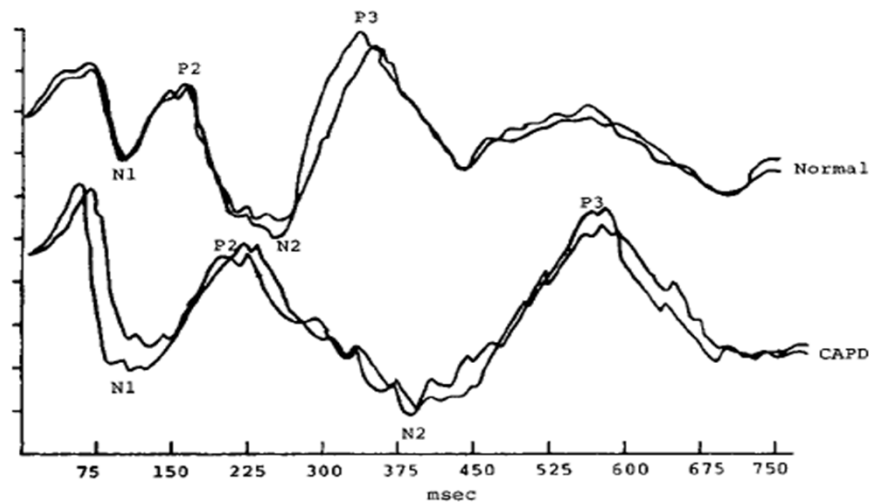
Auditory Late Response (Cortical): Published Research on Diagnosis of APD and Documentation of the Benefits of Intervention



25

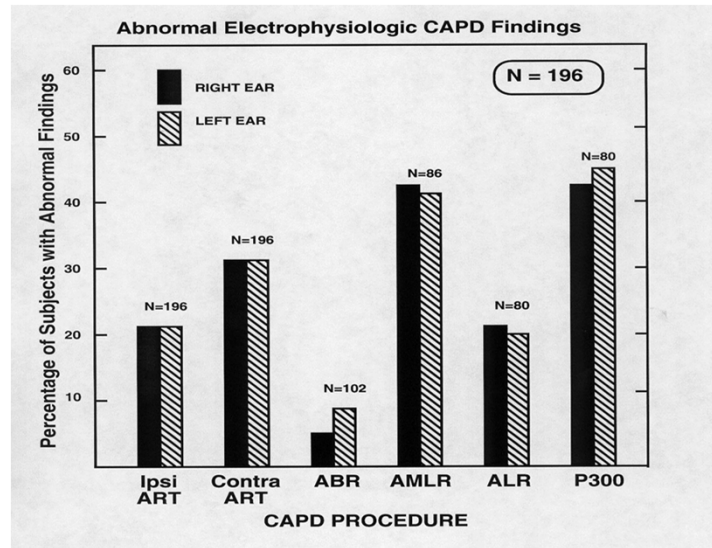
P300 Response in Auditory Processing Disorders (APD)

Jirsa RE (1992). The Clinical Utility of the P3 ERP in Children with Auditory Processing Disorders. *Journal of Speech and Hearing Research*, 35, 903-912



26

Auditory Evoked Responses in Auditory Processing Disorders (APD): Clinical Experience (Hall, 1995)

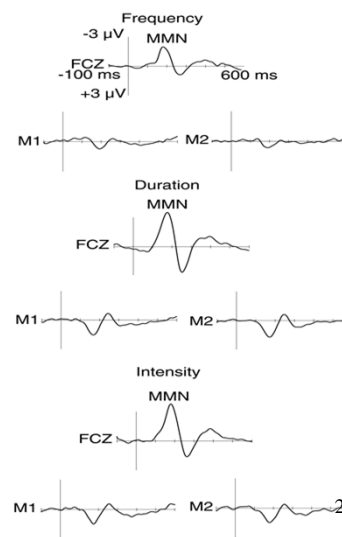


27

Mismatch Negativity (MMN) Response: “Unconscious Brain Response Elicited by Different Properties of Sound (Courtesy of Catharine Pettigrew, Ph.D.)



Naatanen et al (2012). The mismatch negativity response (MMN) ... A unique window to disturbed auditory processing in ageing and different clinical conditions. *Clinical Neurophysiology*, 123, 424-458



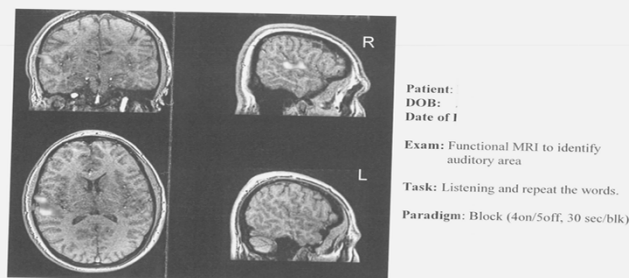
MISMATCH NEGATIVITY (MMN) RESPONSE: Investigations in clinical populations

- ❑ Assessment of infant speech perception, including children at risk for disorders, e.g., language (e.g., *Leppanen & Lyytinen, 1997*)
- ❑ Hearing aid fitting of infants and young children with speech signals (e.g., *Kraus, et al*)
- ❑ Cochlear implant fitting infants and young children with speech signals (e.g., *Kraus, et al*)
- ❑ Documentation of auditory training and language treatment (e.g., *Kujala et al, 2001*)
- ❑ Description of Alzheimer' s disease (e.g., *Pekkonen et al, 1994*)
- ❑ Electrophysiologic documentation of attention deficit hyperactivity disorder (e.g., *Barry, Johnstone, Clarke, 2003*)
- ❑ Prognosis of recovery from coma (e.g., *Kane et al, 1993*)
- ❑ Diagnosis of frontal and auditory temporal lobe dysfunction in schizophrenia (e.g., *Michie et al, 2000*)
- ❑ Neurophysiologic documentation of auditory processing disorder (APD) and dyslexia in children

29

Neuroscience Evidence for APD from fMRI Research (18 year old male APD Patient with Right Ear Dichotic Deficit)

Fig. 2 Sectional Views of Activation Maps Superimposed on T1W Images



30

“fMRI” and “Auditory” Medline Citations: > 700 Peer Reviewed Articles (1)

- ❑ Bernal B, Altman NR, Medina LS. Dissecting nonverbal auditory cortex asymmetry: an fMRI study. *Int J Neurosci*. 2004 May;114(5):661-80
- ❑ Rowan A, Liegeois F, Vargha-Khadem F, Gadian D, Connelly A, Baldeweg T. Cortical lateralization during verb generation: a combined ERP and fMRI study. *Neuroimage*. 2004 Jun;22(2):665-75.
- ❑ Okada T, Honda M, Okamoto J, Sadato N. Activation of the primary and association auditory cortex by the transition of sound intensity: a new method for functional examination of the auditory cortex in humans. *Neurosci Lett*. 2004 Apr 8;359(1-2):119-23.
- ❑ Blau V, van Atteveldt N, Ekkebus M, Goebel R, Blomert L. Reduced Neural Integration of Letters and Speech Sounds Links Phonological and Reading Deficits in Adult Dyslexia. *Curr Biol*. 2009 Mar 11.
- ❑ Leff AP, Iverson P, Schofield TM, Kilner JM, Crinion JT, Friston KJ, Price CJ. Vowel-specific mismatch responses in the anterior superior temporal gyrus: An fMRI study. *Cortex*. 2009 Apr;45(4):517-26. Epub 2008 Feb 7.
- ❑ Warrier C, Wong P, Penhune V, Zatorre R, Parrish T, Abrams D, Kraus N. Relating structure to function: Heschl's gyrus and acoustic processing. *J Neurosci*. 2009 Jan 7;29(1):61-9.

31

“fMRI” and “Auditory” Medline Citations: Hundreds of Peer Reviewed Articles (2)

- ❑ Talavage et al. (2013). Auditory neuroimaging with fMRI and PET. *Hearing Research, (September)*
- ❑ Scott SK. (2013). **The neurobiology of speech perception and production--can functional imaging tell us anything we did not already know?** *J Communication Disorders, 45, 419-425*
- ❑ Talavage TM & Hall DA (2012). How challenges in auditory fMRI led to general advancements for the field. *Neuroimage, 62, 641-64*
- ❑ Lazard et al. (2012). Speech processing: from peripheral to hemispheric asymmetry of the auditory system. *Laryngoscope, 122, 167-173*
- ❑ Miller CA (2011). Auditory processing theories of language disorders: past, present, and future. *Language, Speech, Hearing in the Schools 42, 309-319*

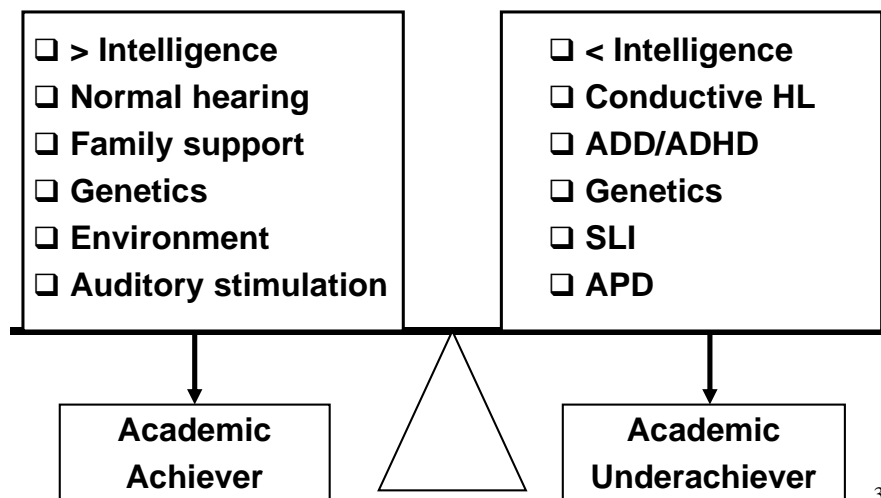
32

Auditory Processing Disorders (APD): An Overview of Current Research Evidence for Audiologists

- ☐ Introduction
- ☐ Survey of definitions of APD
- ☐ Risk factors for APD in children and adults
- ☐ Disorders co-existing with APD
- ☐ Summary (Q & A)

33

AUDITORY PROCESSING DISORDERS (APDs): Incremental Deficits Model



34

Auditory Processing Disorders (APD): The Multi-Risk Model for Developmental Learning/Language Disorders

- ☐ Evidence for “incremental deficits model”
 - APD is usually not a separate entity or “core deficit”
 - Part of multi-component developmental learning/language disorders
 - There are multiple risks for auditory function, spoken language, and written language
 - Multiple underlying weaknesses reach a “clinical threshold”
- ☐ Ferguson et al. (2011). Communication, listening, cognitive, and speech perception skills in children with APD. *J Speech Language Hearing Research*, 54, 211-222
- ☐ Pennington & Bishop (2009). Relations among speech, language, and reading disorders. *Annual Review of Psychology*, 60, 283-306
- ☐ Banai & Kraus (2014). Auditory processing disorder: An intersection of cognitive, sensory, and reward circuits. In Musiek FE and Chermak GD (eds). *Handbook of Central Auditory Processing Disorder: Volume I. Auditory Neuroscience and Diagnosis (2nd ed)*. pp. 191-210

35

Relation Between Auditory Processing Disorders (APD) and Specific Language Disorder

- ☐ Fey et al. (2011). Auditory processing disorder and auditory/language interventions: An evidence-based systematic review. *Language, Speech and Hearing Services in Schools*, 42, 246–264.
- ☐ Bellis Chermak, Weihing, & Musiek (2012). Efficacy of auditory interventions for central auditory processing disorder: A response to Fey et al (2011). *Language, Speech and Hearing Services in Schools*, 43, 381-386.
- ☐ Kamhi AG. (2011). What speech-language pathologists need to know about auditory processing disorder. *Language Speech Hearing Services in the Schools*, 42, 265-272
- ☐ Murphy CF & Schochat E (2013). Effects of different types of auditory temporal training on language skills: A systematic review. *Clinics (Sao Paulo)*, 68, 1364-1370
- ☐ Specht K. (2013). Neuronal basis of speech comprehension. *Hearing Research*, pre-print

36

Auditory Processing Disorders: Indicators in Early School Age Population (e.g., Kindergarten)

- ☐ **Neurological dysfunction and disorders**
 - Neonatal risk factors (e.g., asphyxia, CMV)
 - Head injury
 - Seizure disorders
- ☐ **Chronic otitis media in preschool years**
- ☐ **Academic underachievement or failure**
- ☐ **Family history of academic underachievement**
- ☐ **Behavior typical of peripheral hearing loss, but normal audiogram**
- ☐ **Scatter in results on psychological and language tests, with weakness in auditory domains**
- ☐ **Verbal IQ score lower than performance IQ score**
- ☐ **May have poor musical skills**
- ☐ **Problems with fine and/or gross motors skills**
- ☐ **Teacher and/or parent concern about hearing and listening abilities (and the audiogram is normal)**

37

Auditory Processing Disorders in Adults: Risk Factors and Clinical Indications

- ☐ **Medical history revealing one or more etiologies in previous slide**
- ☐ **Audiological history**
 - Communication complaints greater than expected by audiogram
 - Deterioration in communication abilities with stable audiogram
 - Unusually poor benefit from amplification
- ☐ **Audiological findings**
 - Abnormality for crossed versus uncrossed acoustic reflexes
 - Speech audiometry
 - ✓ Very poor speech perception
 - ✓ Rollover on PI PB functions
 - ✓ Problems with speech in noise
 - Slow response time and processing speed
 - Poor benefit from amplification

38

Auditory Processing Disorders (APD): An Overview of Current Research Evidence for Audiologists

- ☐ Introduction
- ☐ Survey of definitions of APD
- ☐ Risk factors for APD in children and adults
- ☐ Disorders co-existing with APD
- ☐ Summary (Q & A)

39

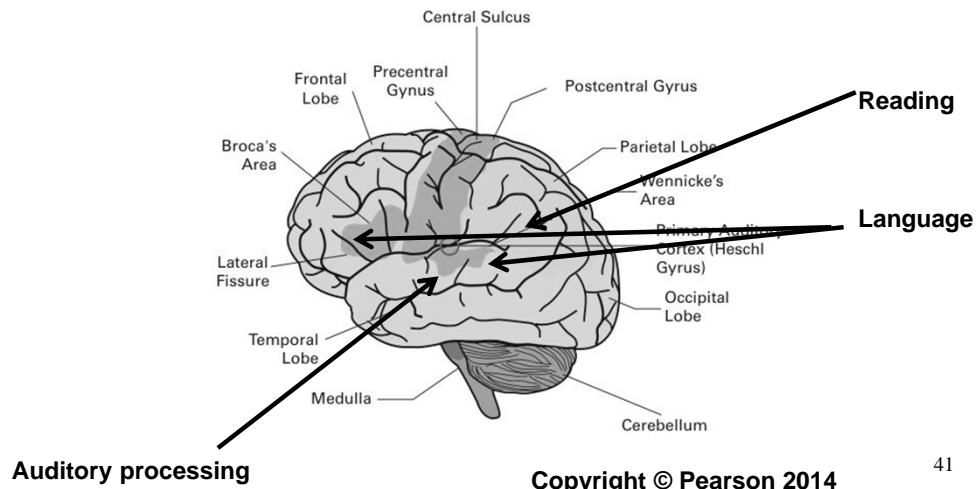
Auditory Processing Disorders: Differential Diagnosis

“Differential Diagnosis:

**Diagnosis based on comparison of symptoms (signs) of
two or more similar diseases (disorders) to determine
which the patient is suffering from.”**

40

Co-Existing Disorders: One Brain with Shared and Related Anatomy



41

AUDITORY PROCESSING DISORDERS: Co-existing Disorders (Co-morbidity)

- ☐ 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
- ☐ Developmental delay
- ☐ Seizure disorders
- ☐ PDD, autism, and autism spectrum disorders

42

Auditory Processing Disorders in Adults: Some of the Co-Existing Etiologies

- ☐ Aging of the central auditory nervous system
 - Longstanding evidence
 - Recent findings
- ☐ Combined peripheral and central auditory disorders
 - Central auditory dysfunction with progressive peripheral hearing loss
 - Peripheral hearing loss with progressive central auditory dysfunction
- ☐ Dementia and psychiatric/Neurological disorders, e.g.,
 - Neoplasms
 - Cardiovascular disease
 - Dementias (Alzheimer's dementia)
 - Schizophrenia?
 - Parkinson's Disease
- ☐ Traumatic head injury
 - Motor vehicle accidents
 - Gunshot wounds
 - Military blasts and explosions

43

Auditory Processing Disorders (APD): An Overview of Current Research Evidence for Audiologists

- ☐ Introduction
- ☐ Survey of definitions of APD
- ☐ Risk factors for APD in children and adults
- ☐ Disorders co-existing with APD
- ☐ Summary (Q & A)
 - www.nlm.nih.gov
 - January 28, 2014 (3 pm eastern time)
 - “auditory process disorder” = 3106 publications

44