Objective Procedures for Infant Auditory Assessment: *The Big Picture*

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Objective Procedures for Infant Auditory Assessment: *The Big Picture*

- Objective measures from A to Z
- Rationale for objective auditory assessment
- People who discovered or developed objective measures
- Cross-check principle revisited almost 40 years later
- Unique contributions to diagnosis of objective procedures
- Highlighting updated features for each measure
  - Aural immittance measures: An oldie but goodie
  - Otoacoustic emissions have a special role in the test battery
  - ABR permit fast and accurate estimation of auditory sensitivity
  - ASSR helps to fast track cochlear implantation
  - ECochG is very useful in the diagnosis of ANSD
  - Cortical auditory evoked responses have a place too
- Questions and answers

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- Objective measures from A to Z
  - Aural immittance measures (Z is for impedance)
    - ✓ Tympanometry
    - ✓ Wide-band reflectance or absorbance
    - ✓ Acoustic reflexes
  - Otoacoustic emissions (OAEs)
  - Auditory brainstem response (ABR)
  - Auditory steady state response (ASSR)
  - Electrocochleography (ECochG)
  - Cortical auditory evoked responses
    - ✓ Auditory middle latency response (AMLR)
    - ✓ Auditory late response (ALR)
    - ✓ P300 response

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Rationale for Objective Measurement of Auditory Function

- Site specific for auditory dysfunction
- Highly sensitive to auditory dysfunction
- Generally quick and simple to perform
- Can be automated for widespread use by non-audiologists
- Can generally be recorded in sleep and with sedation/anesthesia
- Not influenced by listener variables and behavioral factors, e.g.,
  - Attention
  - Cognition
  - Cooperation
  - Motivation
  - State of arousal
- Can be recorded in infants and young children

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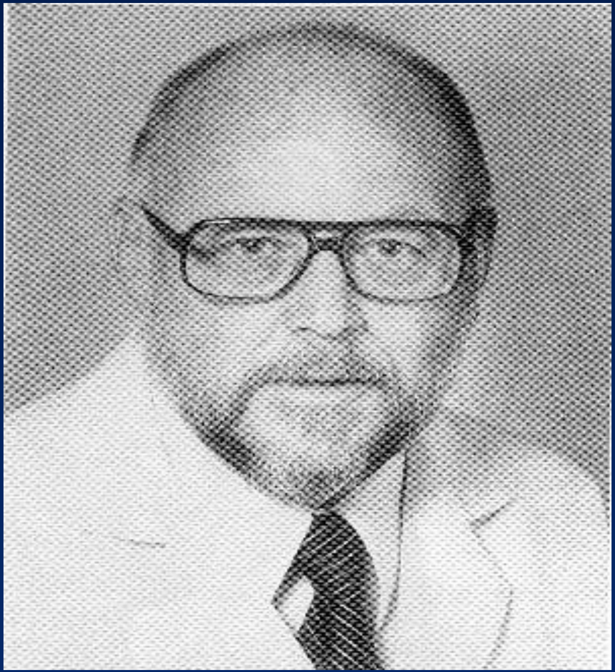
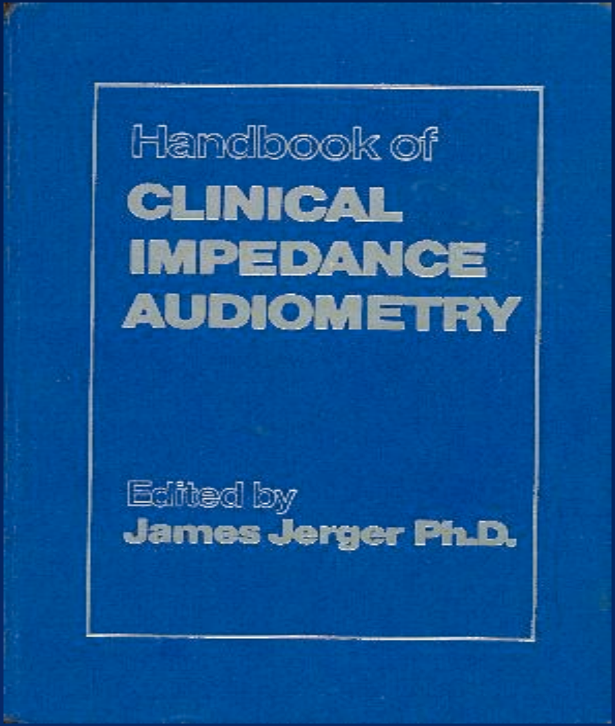
Early Identification of Hearing Loss in Infants and Young Children

Who is this woman?

Marion Downs
Mother of Pediatric Audiology

James Jerger
"Father of Diagnostic Audiology"
Impedance Measurements as Evidence-Based Clinical Procedure





Auditory Brainstem Response (ABR)

Jewett D and Williston J. Auditory evoked far fields averaged from the scalp of humans. Brain 4: 681-696, 1971.

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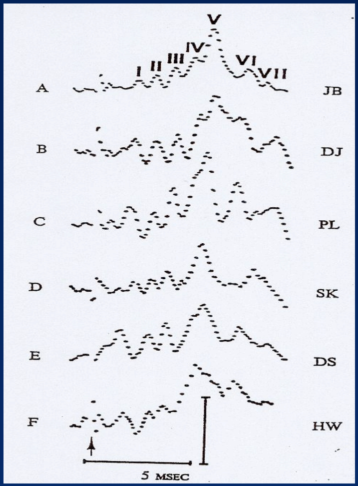
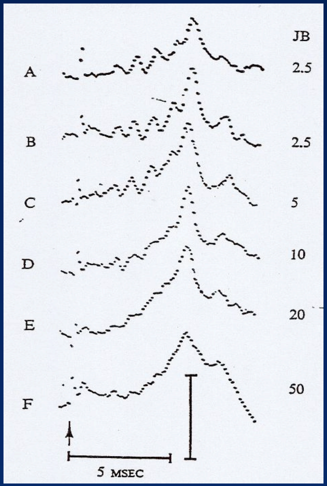
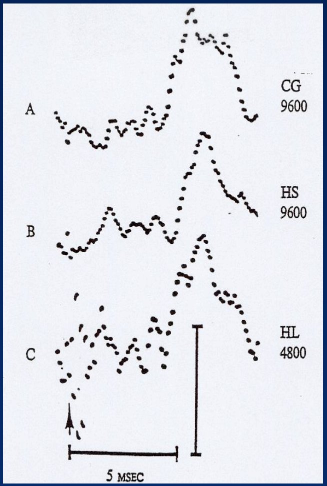
Analysis by Visual Inspection



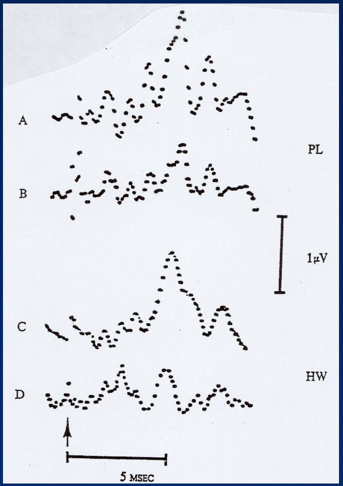
Effect of Stimulus Rate



Tone Burst Stimuli



Effect of Inverting Electrode



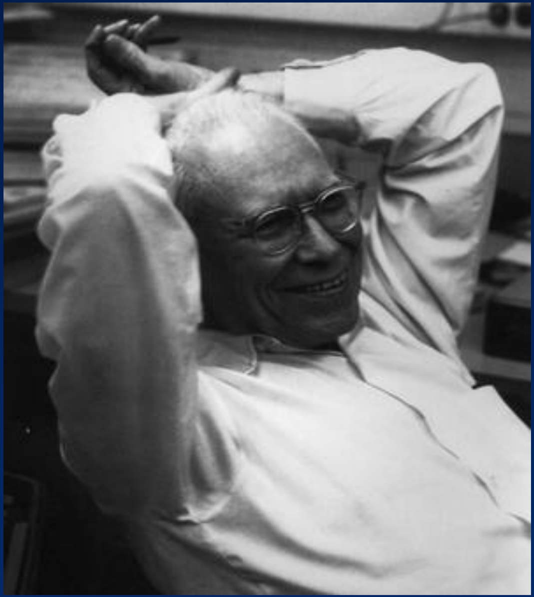
Robert Galambos

Hecox KE & Galambos R. Brain stem auditory evoked responses in human infants and adults. *Archives of Otolaryngology 99, 1974.*

Original Description of Electrocochleography (ECochG)

Wever EG and Bray CW. 1930.
Action currents in the auditory nerve in response to acoustic stimulation. Proceedings of the National Acad of Science (USA) 16: 344-350.

Wever EG and Bray CW. 1930.
Auditory nerve impulses. Science 71: 215.

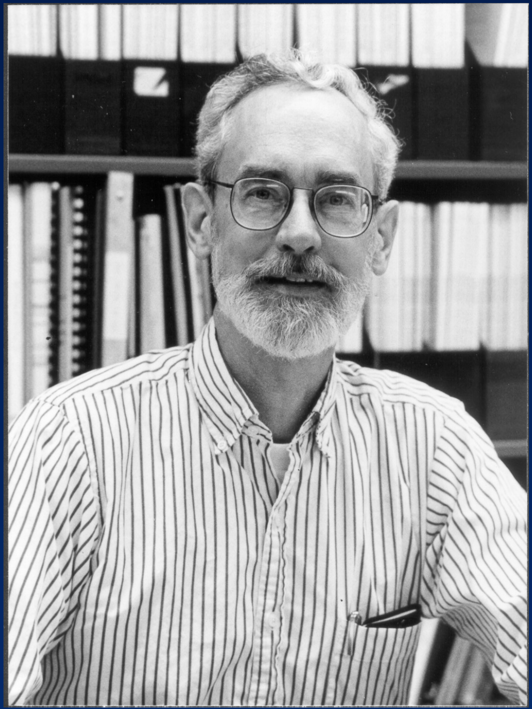


E. Glen Weaver, Ph.D.
(October 16, 1902 — September 4, 1991)

David Kemp
Discovered OAEs in mid-1970s

Terence Picton, Ph.D.
Early Research on Auditory Steady State Response (ASSR) in 1980s

Daniel Geisler, Ph.D.
Discoverer of Auditory Middle Latency Response in 1958



Father of Auditory Evoked Responses:
Hallowell Davis, Ph.D.
Co-discoverer of Auditory Late Response in 1939
and the P300 Response in 1965

Robert Galambos
"Grandfather of Newborn Hearing Screening"
(Hecox & Galambos, 1974)

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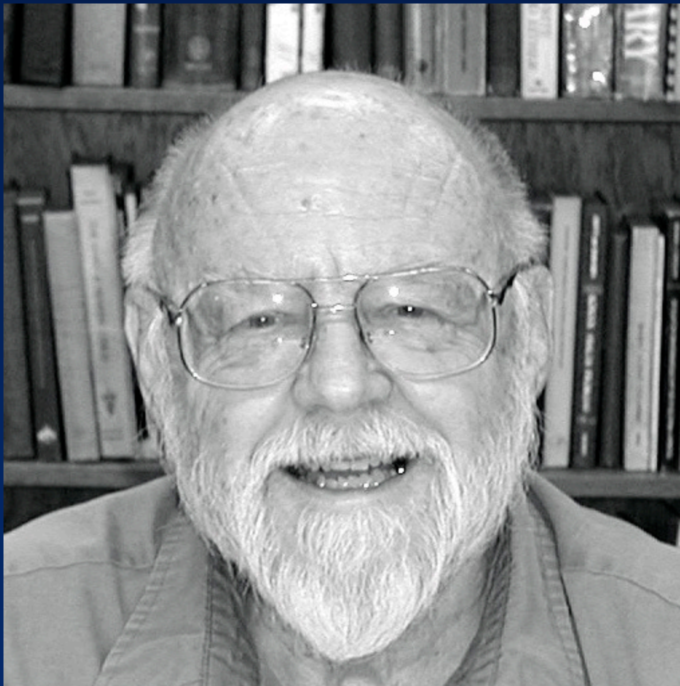
The Cross-Check Principle in Pediatric Audiology

(Jerger J & Hayes D. Arch Otolaryngol 102: 1976)



The Cross-Check Principle Pediatric Audiology
(Jerger J & Hayes D. Arch Otolaryngol 102: 1976)
What's missing from the test battery?

"We have found than simply observing the auditory behavior of children does not always yield an accurate description of hearing loss"…

"The basic operation of this principle is that no result be accepted until it is confirmed by an independent measure."

Test Battery:

- Behavioral audiometry
- Immittance (impedance) measurements
  - ✓ Tympanometry
  - ✓ Acoustic reflexes (contralateral only with SPAR)
- Auditory brainstem response (brainstem-evoked response audiometry or BSER)
  - ✓ Click stimulus air conduction
  - ✓ Click stimulus bone conduction

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Unique Contributions of Each Procedure to the Pediatric Test Battery

- Aural immittance measures
  - Sensitive measure of middle ear function
  - Confirm or rule out sensory hearing loss (acoustic reflexes
  - Diagnosis of ANSD and other disorders
  - Otoacoustic emissions (OAEs)
  - Sensitive measure of cochlear (outer hair cell) function
  - Monitoring cochlear function
  - Identification of ANSD and other disorders
- Auditory brainstem response (ABR) and ASSR
  - Electrophysiological estimation of audiogram
  - Diagnosis of ANSD
  - Cortical auditory evoked responses
  - Estimation of auditory processing
  - Documentation of outcome with intervention

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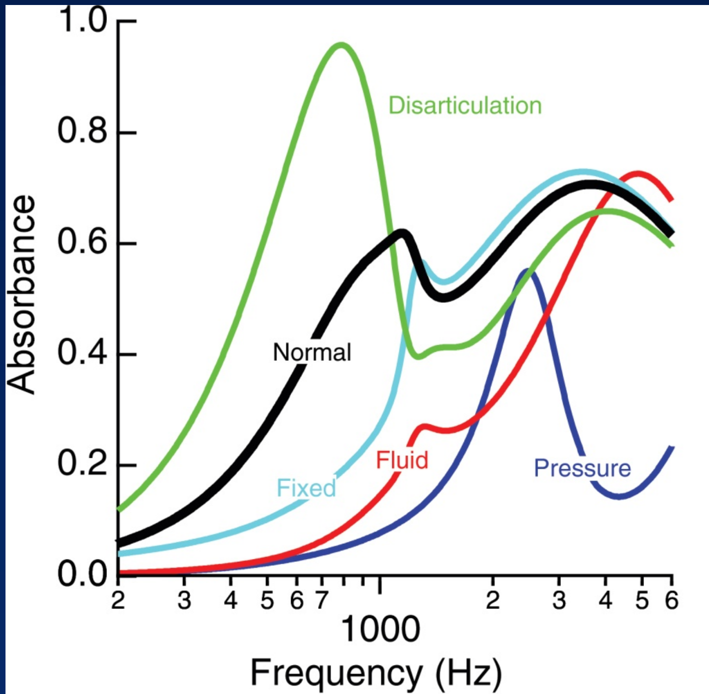
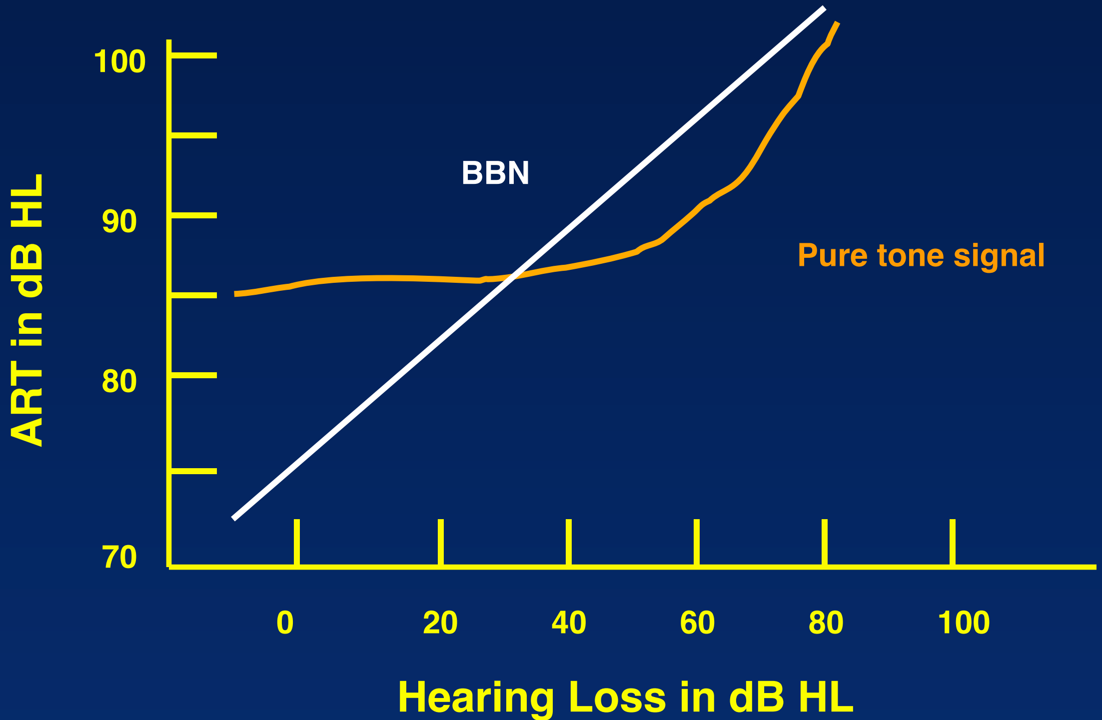
Wideband Reflectance/Absorbance
(Voss et al. Ear & Hearing, 2008)
Courtesy of Bue Kristensen, Interacoustics, 2013



Estimation of Hearing Sensitivity with Acoustic Reflex Thresholds for Pure Tones versus Broad Band Noise (BBN): Simplified SPAR (Sensitivity Prediction by the Acoustic Reflex)



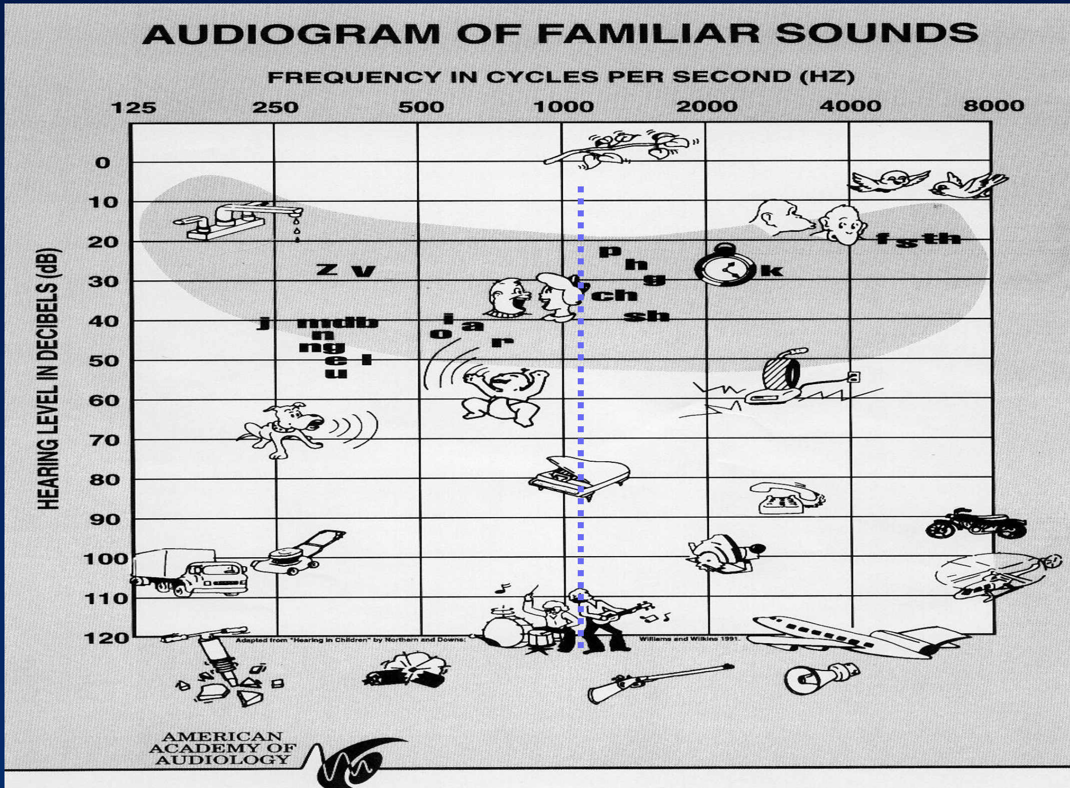
Publications on Hearing Loss Identification with Acoustic Reflexes

- Hall JW III and Bleakney ME. Hearing loss prediction by the acoustic reflex: Comparison of seven methods. Ear and Hearing 2: 156-164, 1981
- Hall JW III. Hearing loss prediction in a young population: Comparison of seven methods. International Journal of Pediatric Otorhinolaryngology 3: 225-243, 1981
- Hall JW III and Koval C. Accuracy of hearing prediction by the acoustic reflex. The Laryngoscope 92: 140-149, 1982
- Hall JW III, Berry GA and Olson K. Identification of serious hearing loss with acoustic reflex data: Clinical experience with some new guidelines. Scandinavian Audiology 11: 251-255, 1982
- Hall JW III. The effects of high-dose barbiturates on the acoustic reflex and auditory evoked responses: Two case reports. Acta Otolaryngologica (Stockholm) 100: 387-398, 1985

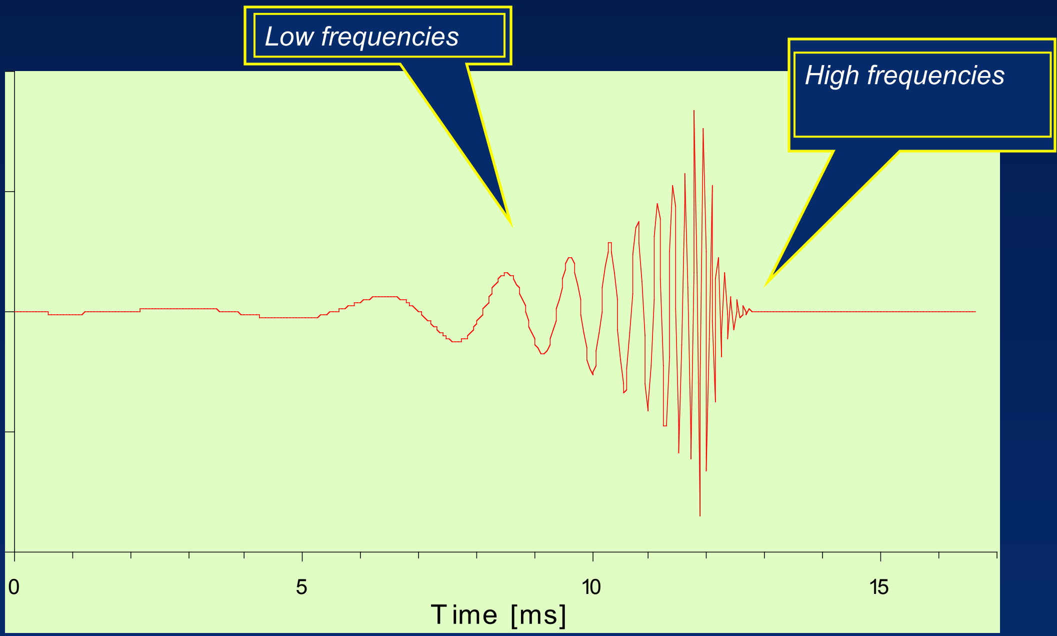
Evidence-Based Clinical Applications of OAEs in Pediatric Populations

- Infant hearing screening
- Diagnosis of auditory dysfunction in infants and young children
- Identification of auditory neuropathy spectrum disorder
- Monitoring ototoxicity
- Pre-school/school screenings
- Identification of false and exaggerated hearing loss

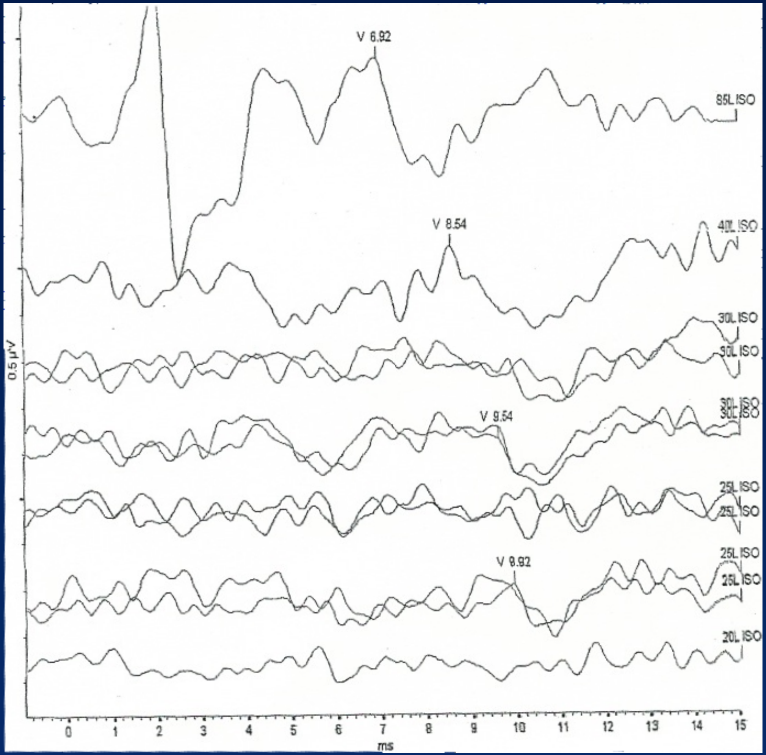
Effective and Efficient ABR Measurement with Click, Tone Burst, and Chirp Stimulation



Chirp Stimulus in ABR Measurement



4000 Hz Conventional versus Chirp Evoked ABR



Left Ear
85 dB nHL
Tone Burst

40 dB nHL
Tone Burst

30 dB nHL
Tone Burst

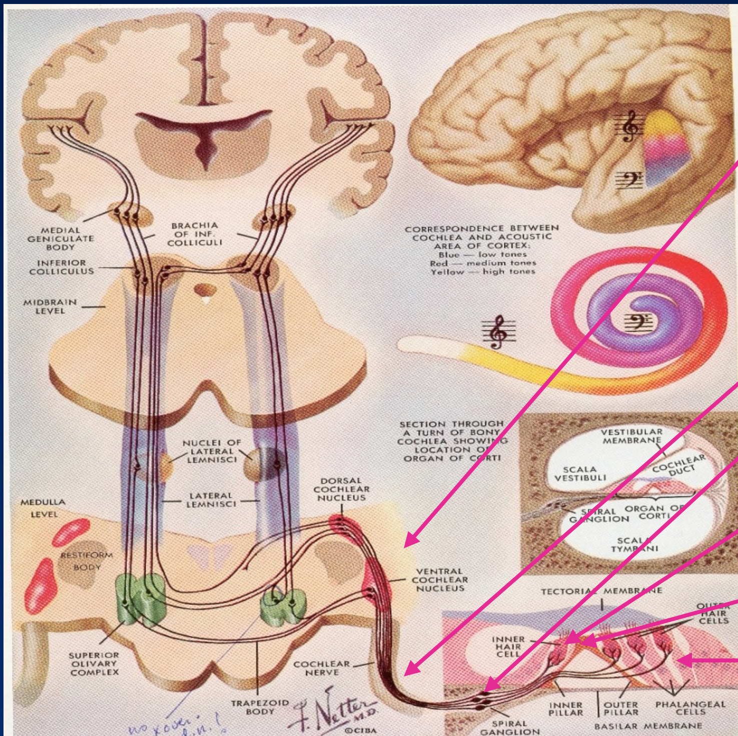
30 dB nHL, Chirp Tone Burst

25 dB nHL, Tone Burst

25 dB nHL, Chirp Tone Burst

15 dB nHL, Chirp Tone Burst

Essential Role of Electrocochleography (ECochG) in the Diagnosis and Management of Auditory Neuropathy Spectrum Disorder (ANSD)



Cerebello-pontine angle (CPA)

Internal Auditory Canal (Auditory Nerve)

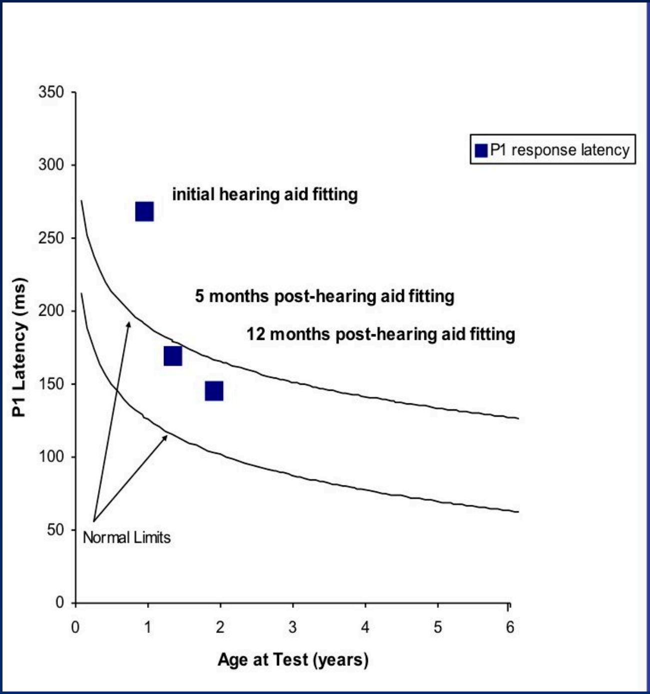
Spiral ganglion cells **(AP)**

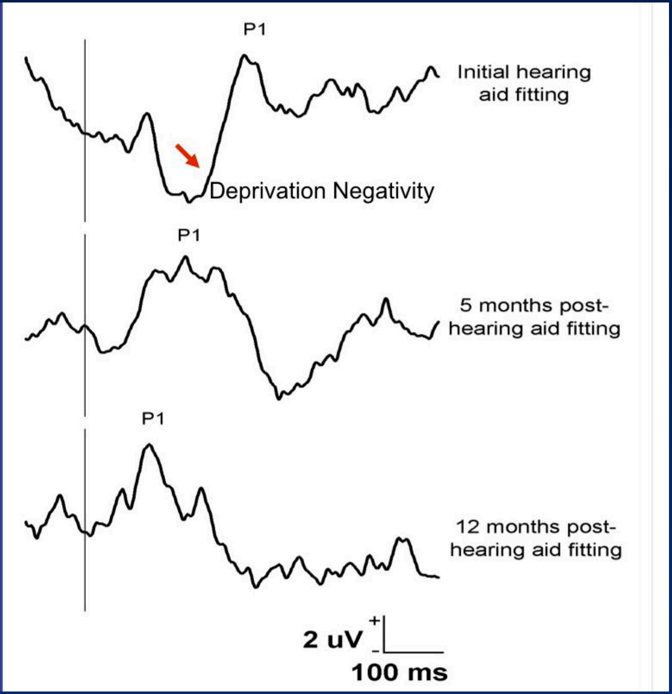
IHC - 8th CN Synapse (glutamate)

Inner hair cells **(SP)**

Outer hair cells **(CM)**

Clinical Applications of Auditory Late Response: Documenting Hearing Aid Performance
(Anu Sharma, PhD, University of Colorado)





Clinical Applications of Auditory Late Response: Hearing Aid versus Cochlear Implant Performance *(Anu Sharma, PhD, University of Colorado)*

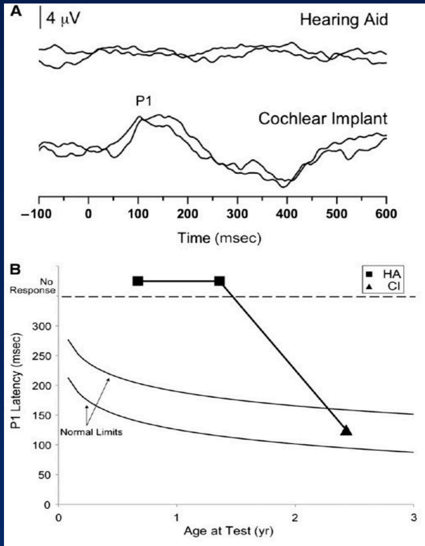
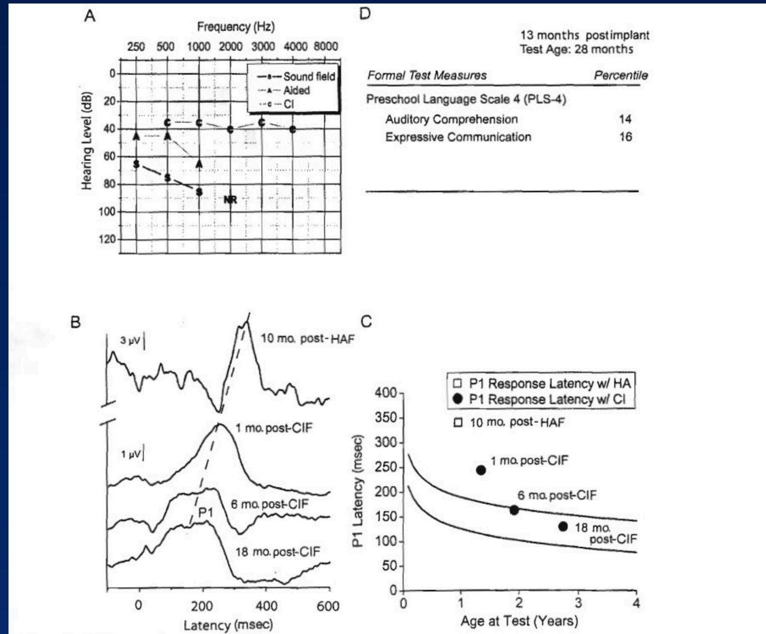


Figure 2. *A:* P1 CAEP waveforms (with replications) for both unaided *(top)* and aided *(bottom)* P1 testing sessions performed with Case 2 (JF). *B:* P1 latencies for testing done with hearing aids (closed squares) and a cochlear implant (closed triangle) plotted by age and compared with the 95% confidence intervals for normal P1 latency development (Sharma, Dorman, Spahr, 2002b). Results from hearing aid testing are plotted in the no response region at two different ages. Cochlear implant results showed P1 latencies that were within normal limits.



gure 4. Audiological, electrophysiological, and speech-language evaluation results for Case 3. *A*, audiogram; *B*, corti- auditory evoked potentials; *C*, P1 latency as a function of age plotted against the 95% confidence intervals (solid lines) normal development of P1 response latency; *D*, speech and language evaluation. CIF = cochlear implant fitting; HAF

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