

Audiological Diagnosis after Newborn Screening



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**Ifos World Course on Hearing Rehabilitation
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Universal Newborn Hearing Screening (UNHS): What's next?



0 -1 month

3 months

6 months

UNHS

Diagnosis

Intervention

Behavioral Audiometry: when and how

Objective measures: what is children-specific?

Diagnostic strategy

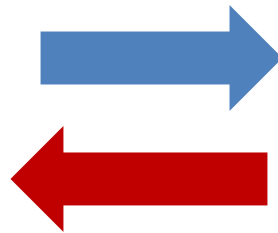


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Principles of Behavioral Audiometry

- Building a circular path between the clinician and the child

Deliver stimuli
Take reactions



Take stimuli
Deliver reactions

- Adapt your testing to the child age (neurodevelopmental, not chronological)
- Always use the parents as partners when testing

Before 6 months: Behavioral Observation Audiometry (BOA)

- **Take your time and look for the infant reflexive behaviors to auditory stimuli:** i.e., eye blink/widening, modification of cardiac rhythm, startle responses (Moro reflex)...
- **Bias 1:** can be elicited by a wide range of intensity levels
- **Bias 2:** babies can get bored very quickly
- **Bias 3:** observer experience-dependent

Behavioral Audiometry: when and how

Objective measures: what is child specific?

Diagnostic strategy

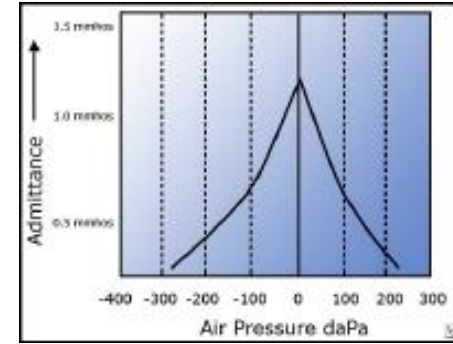


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TARGETTING...

- **Middle Ear**
- Inner Ear
- Afferent pathway & beyond

Otitis with middle ear effusion



$P_1 = 0 \text{ atm}$

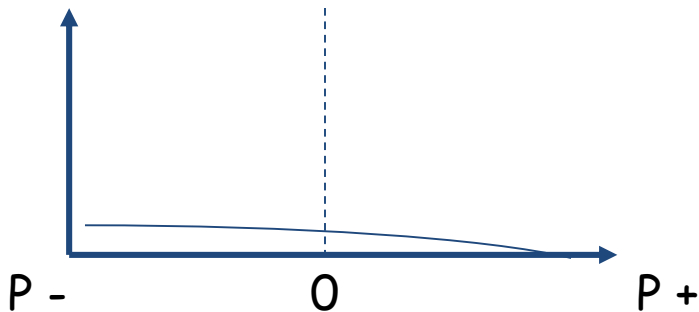
glu

0 atm

Tympanometry

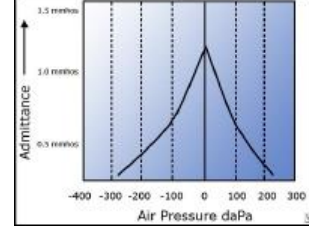
(Otto Metz, 1946; Jerger, 1970)

Impedance : type B



Adapted from Van Den Abbeele et al.

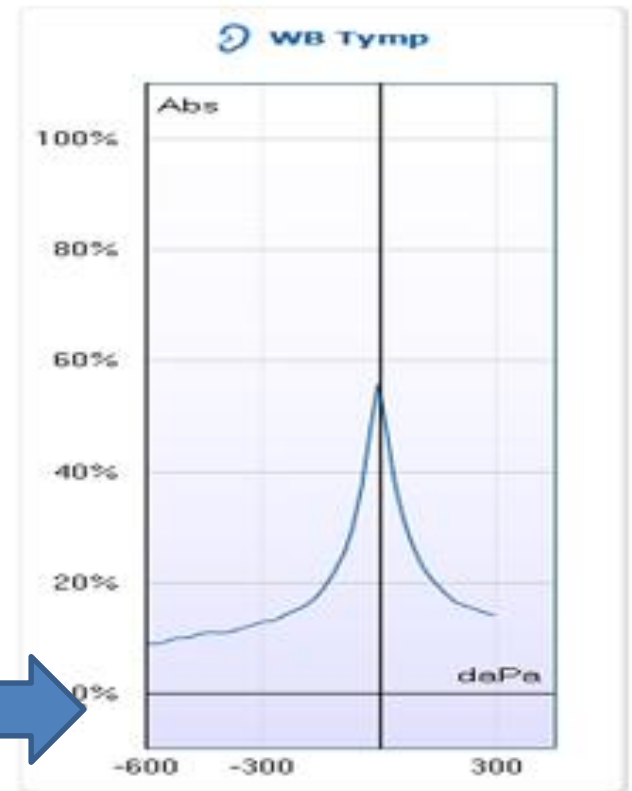
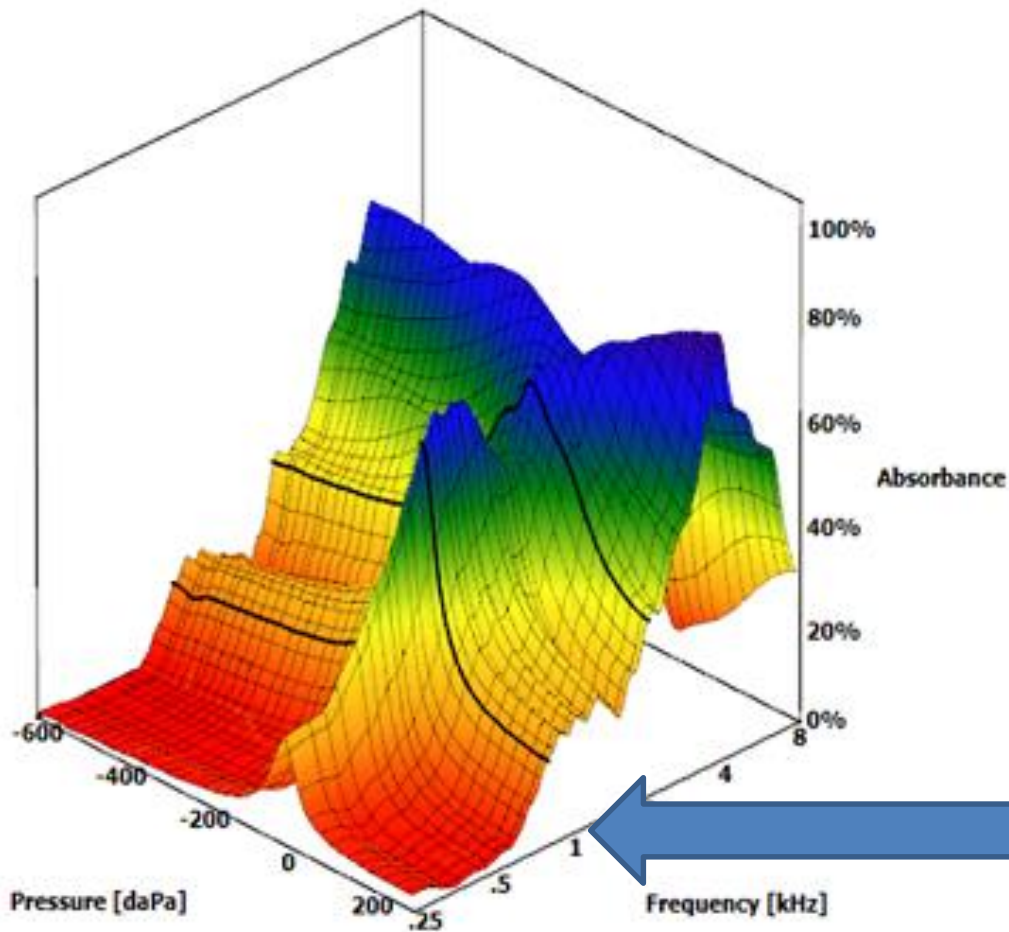
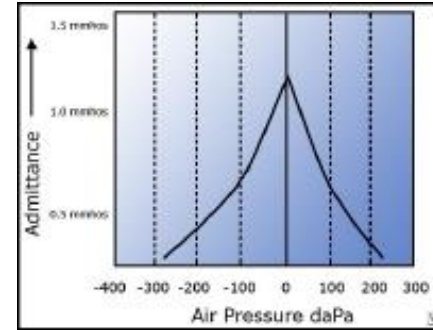
Effect of ear canal volume



Age Group	Equivalent ear canal volume (V_{ec})	Static compensated admittance (Y_{tm})	Tympanometric width (TW)	Tympanometric peak pressure (TPP)
Newborns and Infants <6 months (1000 Hz probe)	0.2 - 0.8 cc	≥ 0.6 mmho for negative compensation ≥ 4 mmho for positive compensation	<150 daPa	NA
6-18 months - (226 Hz probe)	0.5 - 1.0 cc	≥ 0.2 mmho	<250 daPa	+25 to -75 daPa
>18 months to 10 years (226 Hz probe)	0.6 - 1.2 cc	≥ 0.3 mmho	<200 daPa	+25 to -75 daPa
>10 years and Adults (226 Hz probe)	1.0 - 2.2 cc (males) 0.8-1.9 cc (females)	≥ 0.3 mmho	<125 daPa	+5 to -105 daPa

[Consensus statement: Eriksholm workshop on wideband absorbance measures of the middle ear.](#) Feeney MP et al., Ear Hear. 2013

3D wideband tympanometry

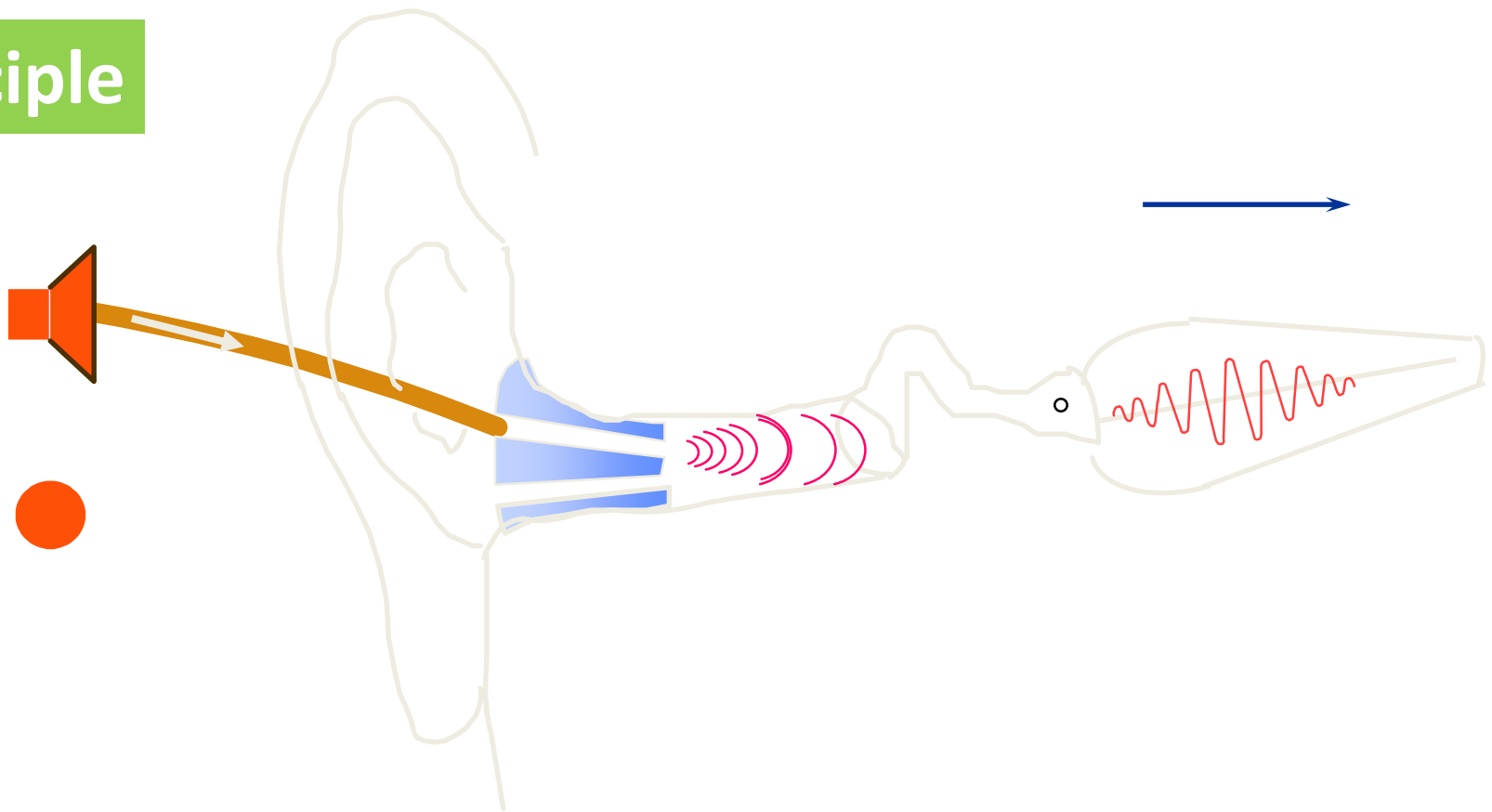


TARGETTING...

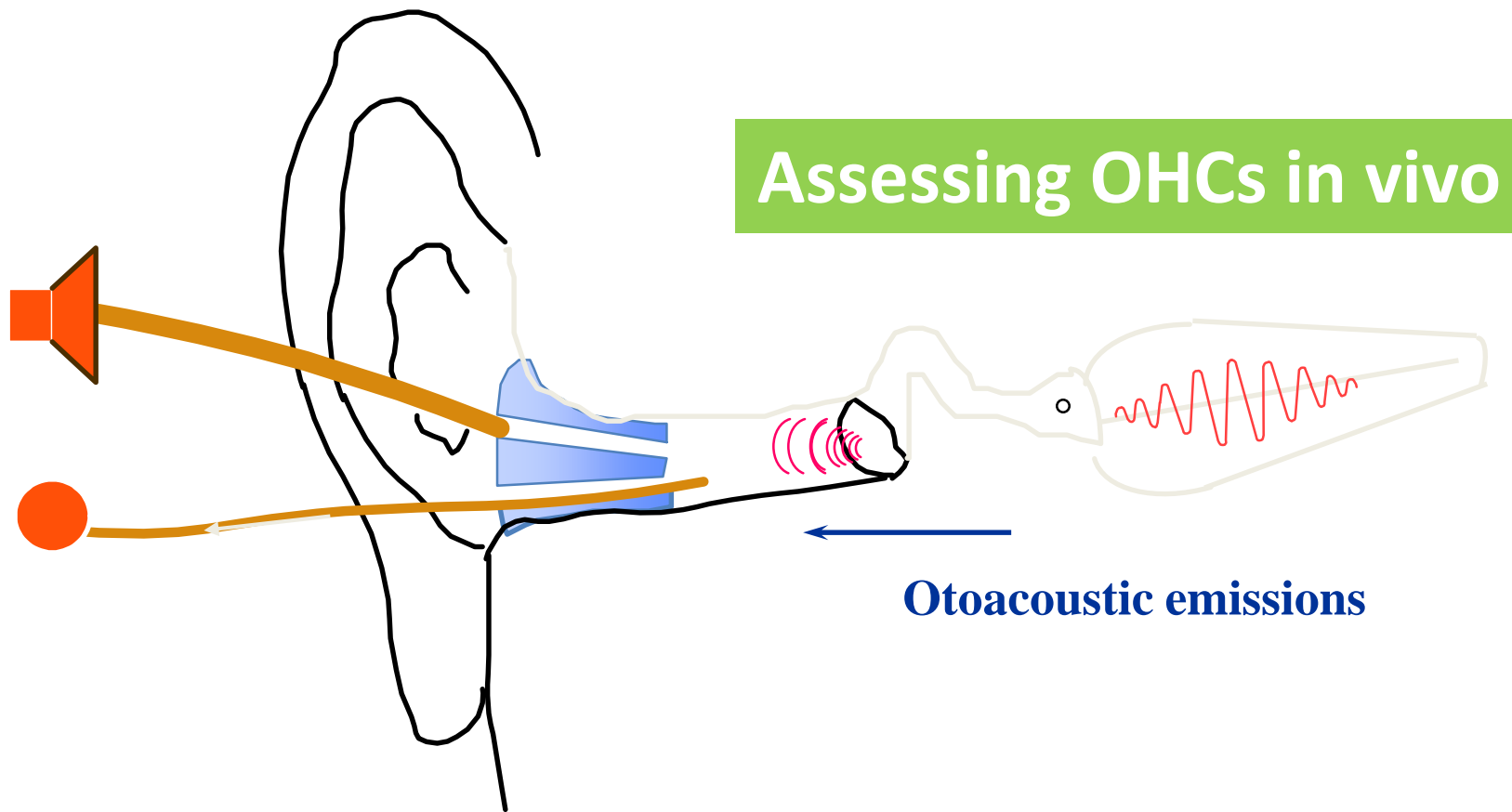
- Middle Ear
- **Inner Ear**
- Afferent pathway & beyond

Transient evoked otoacoustic emissions

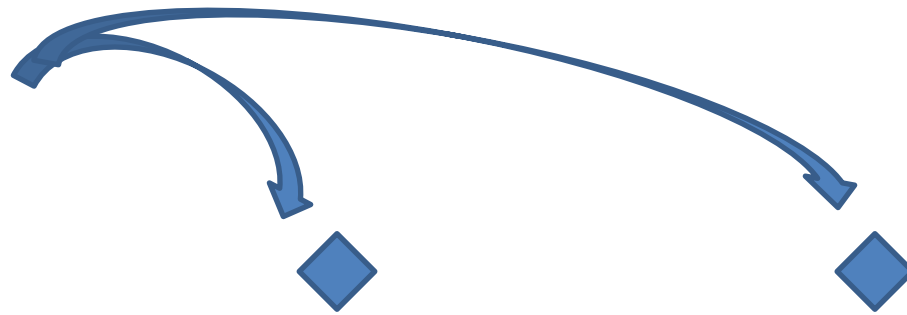
Principle



Transient evoked otoacoustic emissions



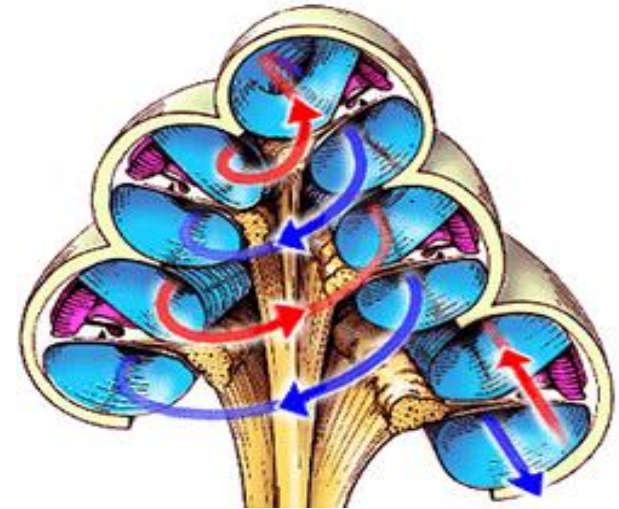
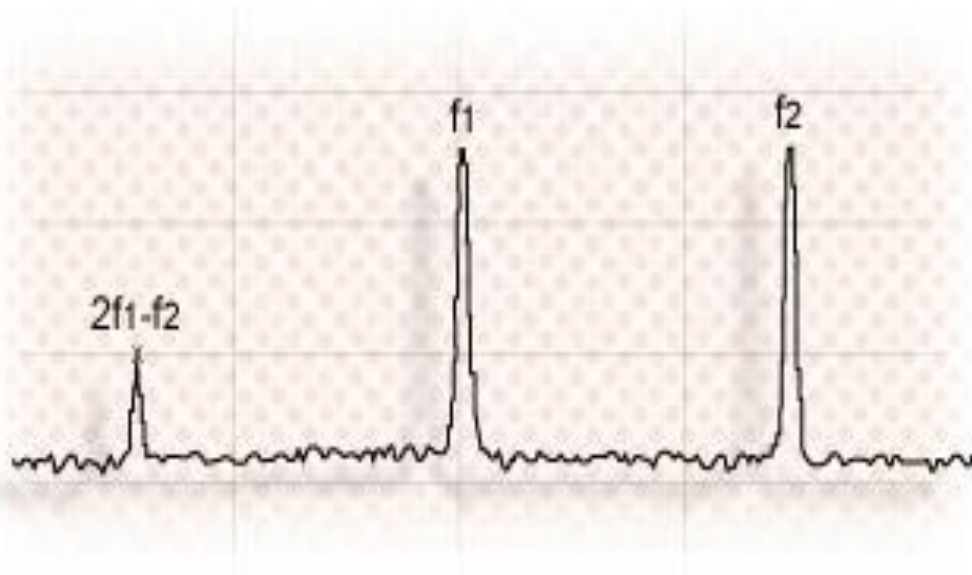
Distortion Product Otoacoustic emissions



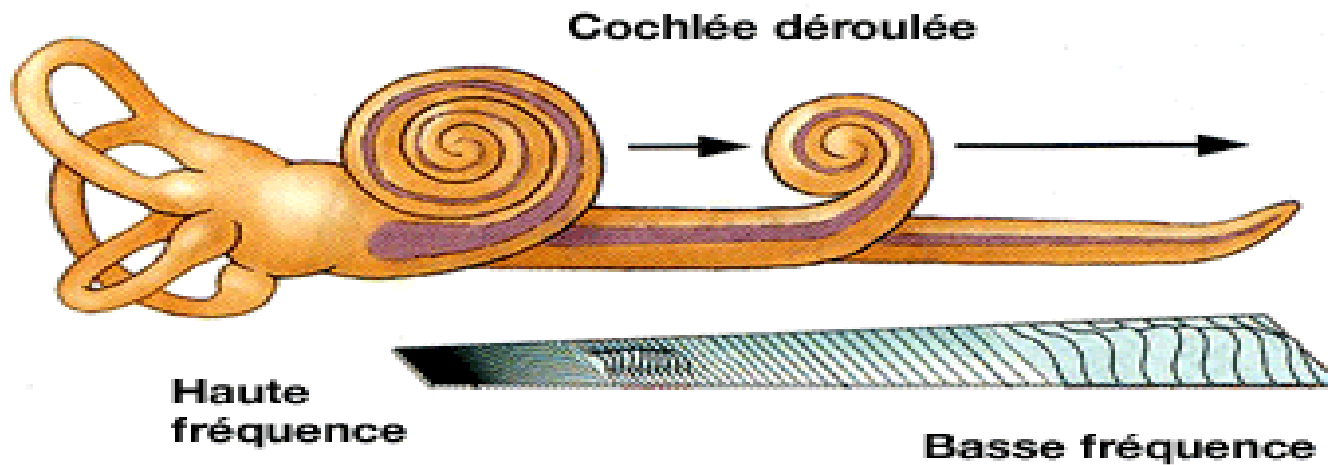
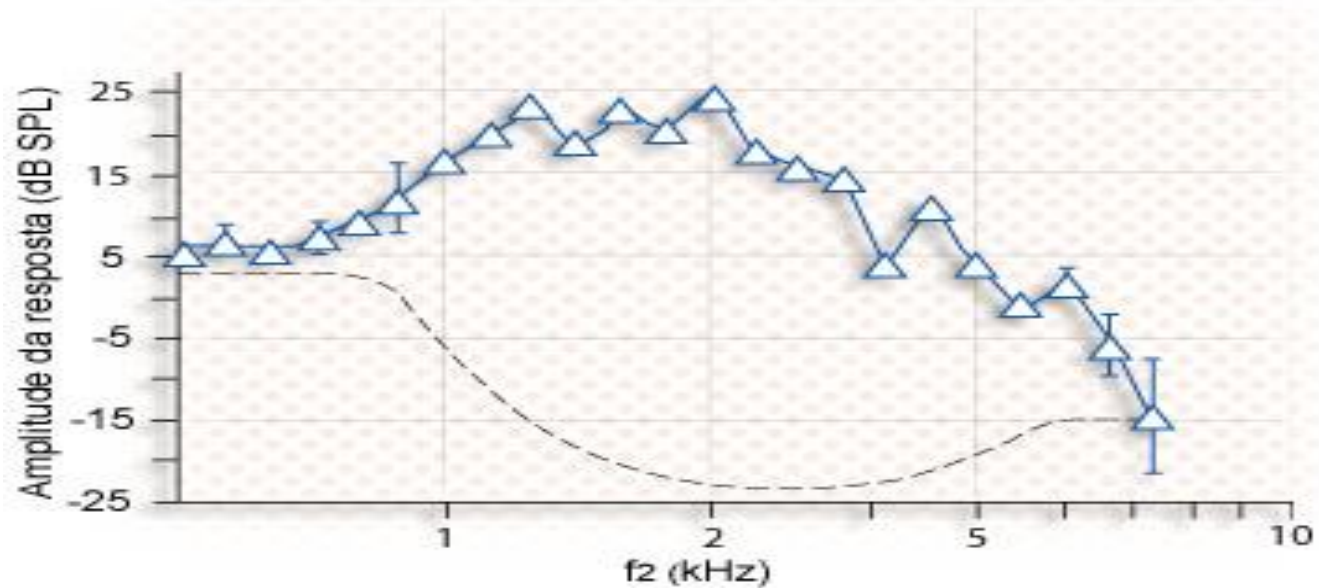
**Objective
Audiometry:
DPOAEs are back!**



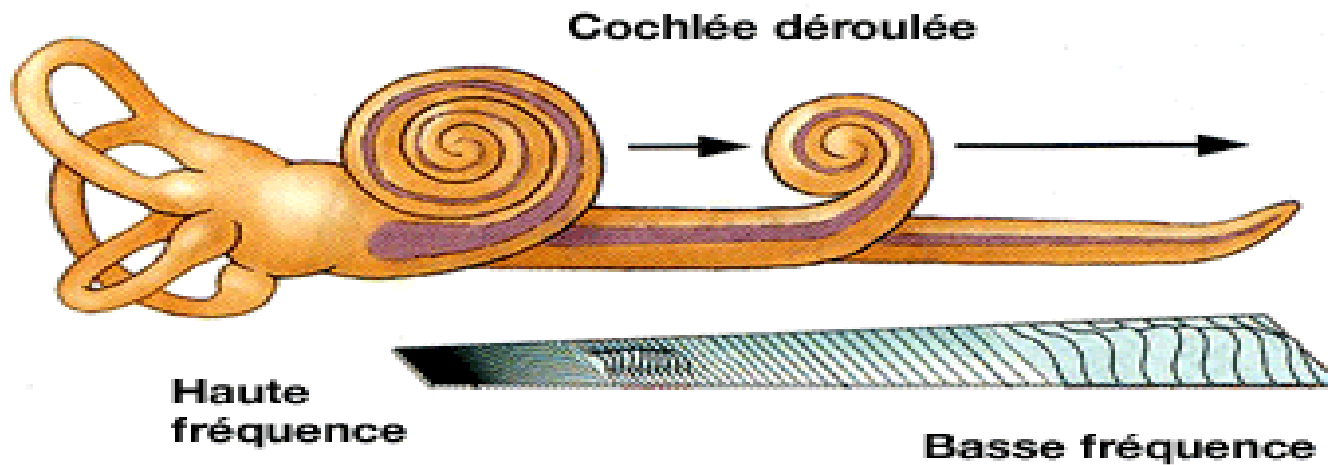
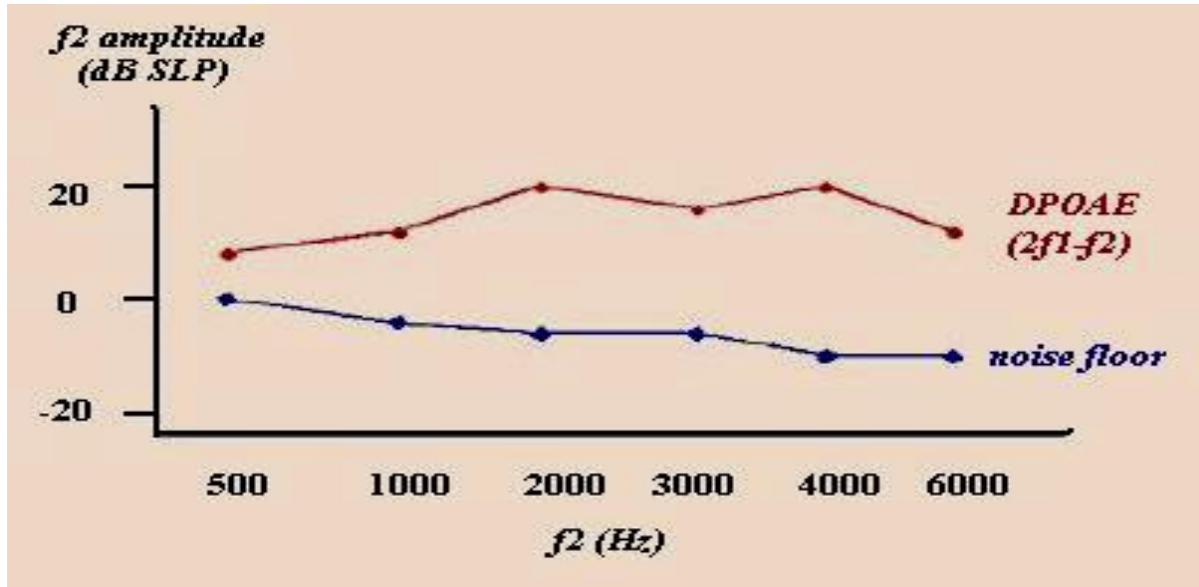
Distorsion Products



Distorsion Products



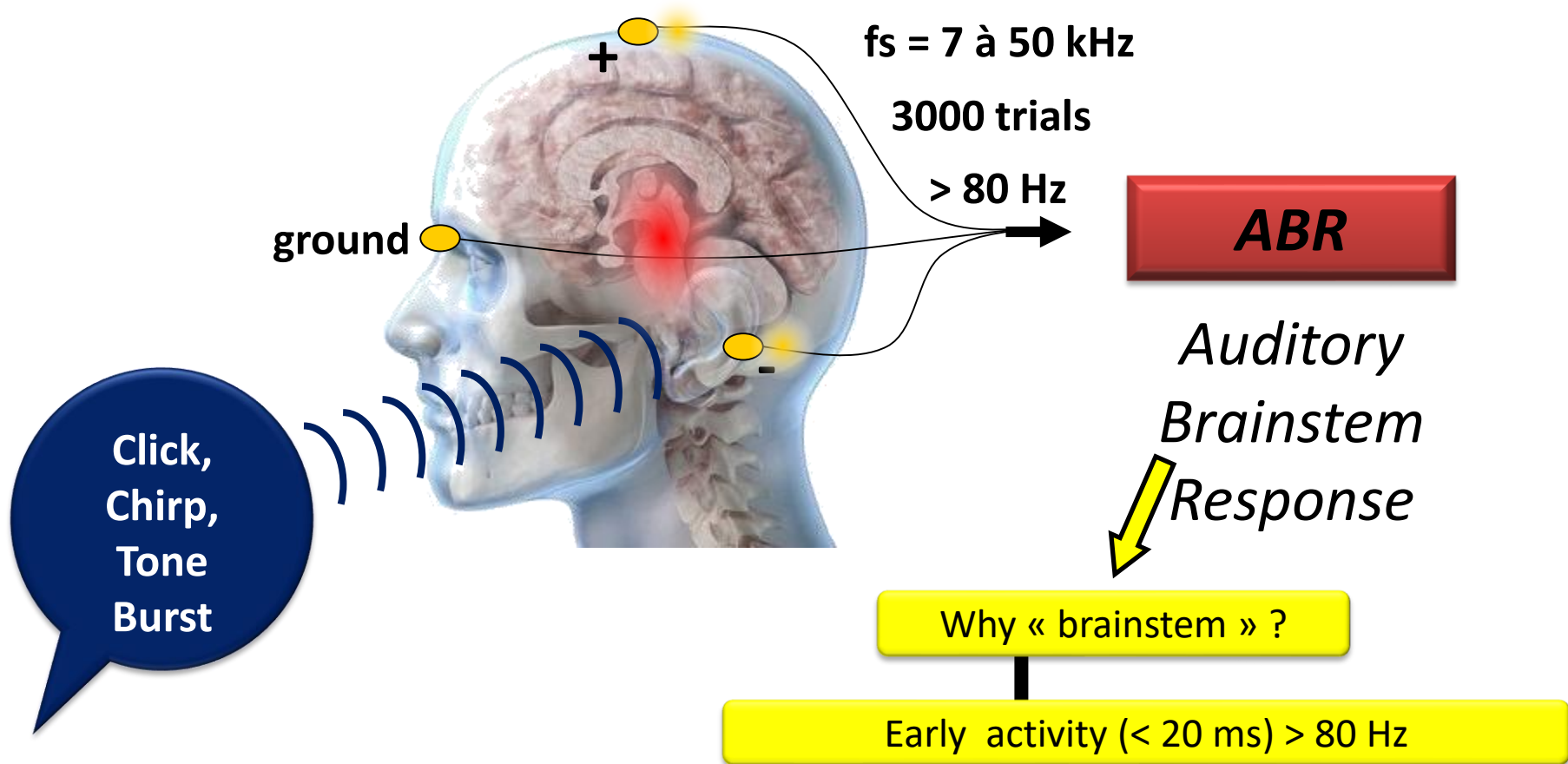
Distorsion Products



TARGETTING...

- Middle Ear
- Inner Ear
- **Afferent pathway & beyond**

AUDITORY BRAINSTEM RESPONSES



Auditory Evoked Potentials (AEP)

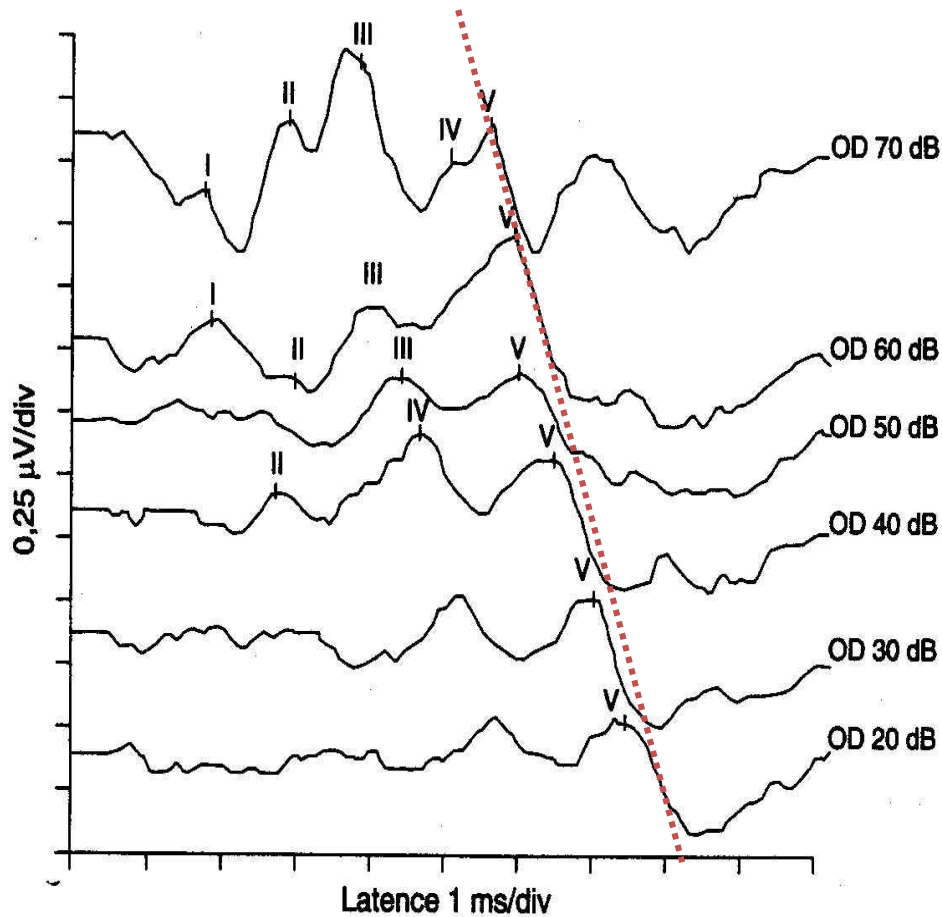
I) CLICK ABRs

II) FREQUENCY-SPECIFIC DIAGNOSIS

III) HOW TO GET RID OF CONDUCTIVE HL

ABR RECIPE IN YOUNG CHILDREN

Looking for objective hearing threshold

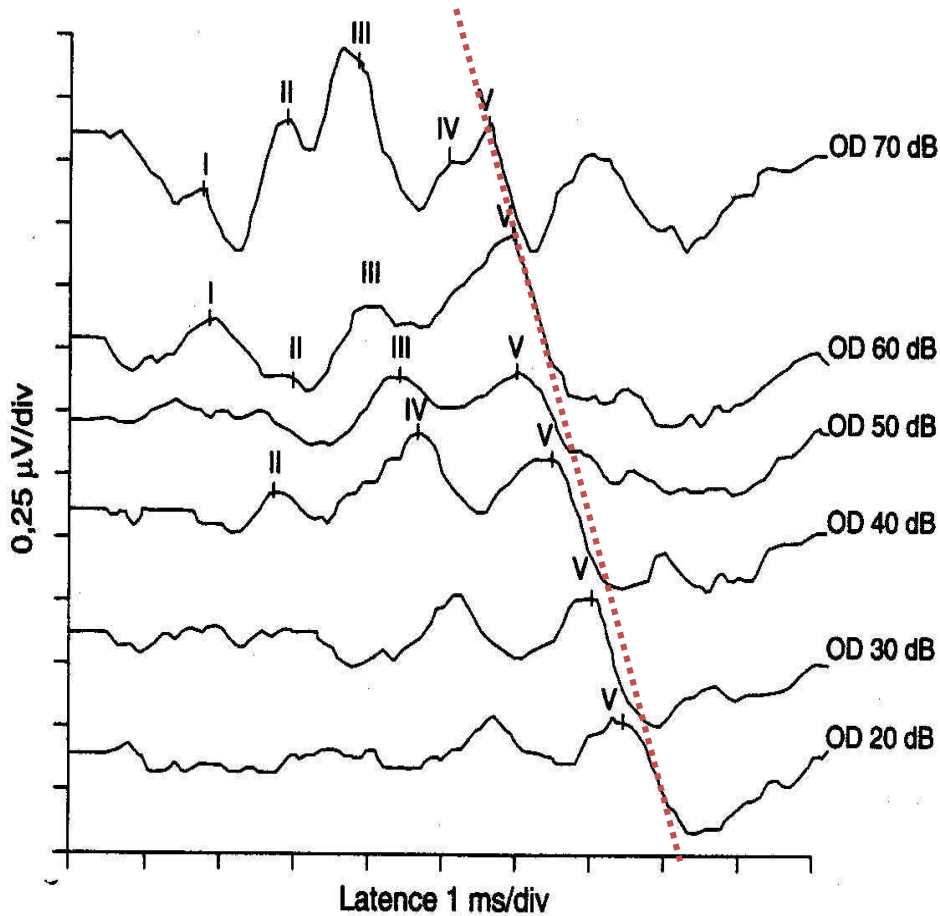


**Start at 70 dB
then diminish stim level
(10-20 dB steps)**

Normal ABRs (20 dB-threshold)

ABR information

What does it tell you?

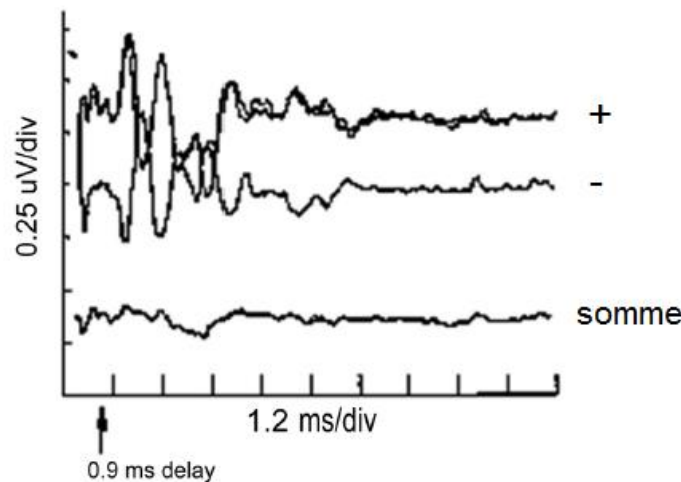
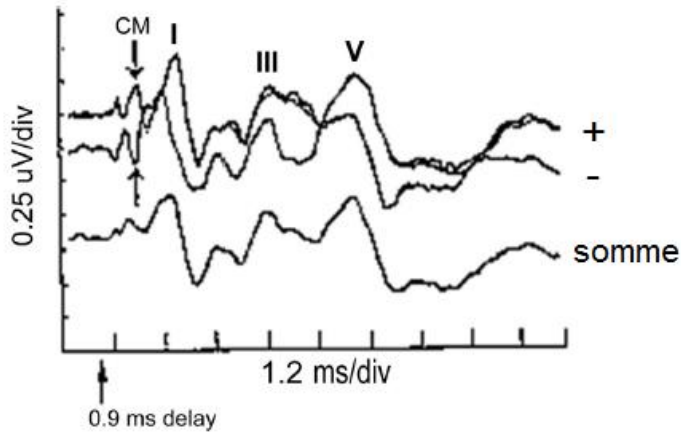


- ✓ **Well-defined waveforms**
- ✓ **CNS maturity**
- ✓ **Topodiagnosis in conjunction with TEOAEs**
- ✓ **Auditory neuropathy diagnosis**

Auditory Neuropathy Diagnosis

- TOAEs are present
- ABRs are absent
- Cochlear microphonic potential (CMP) must be looked for

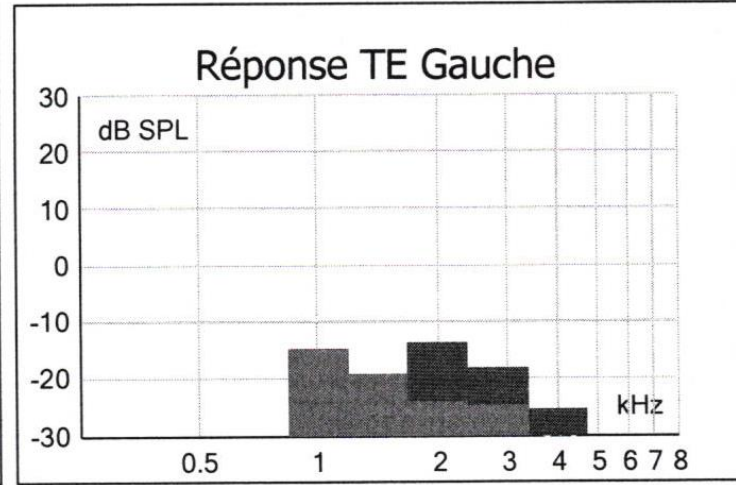
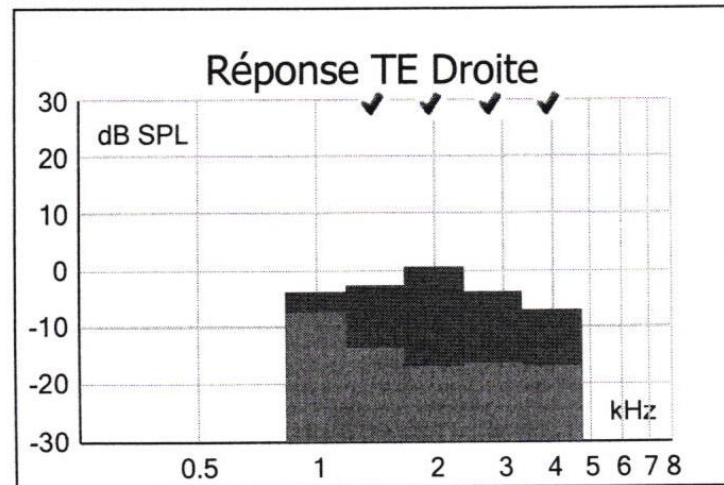
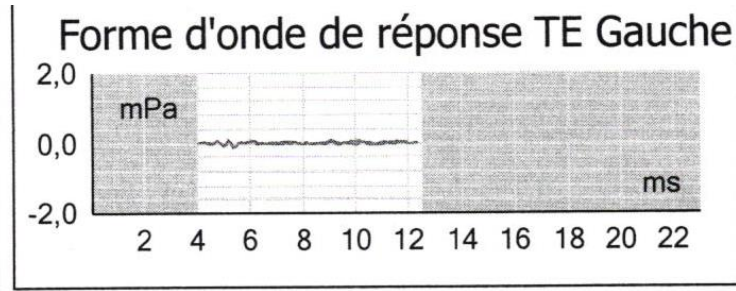
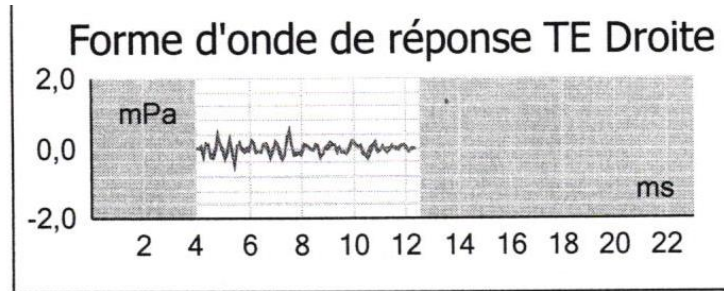
Cochlear Microphonic Potential (CMP)



- Low amplitude response just a few msec after the click
- Latency does not change with intensity level
- Receptor potential of hair cells
- Follow stimulus polarity (either rarefaction or condensation click)

(Starr et al., 1996 ; Starr et al., 2001 ; Buchman et al, 2006 ; Berlin et al., 2010)

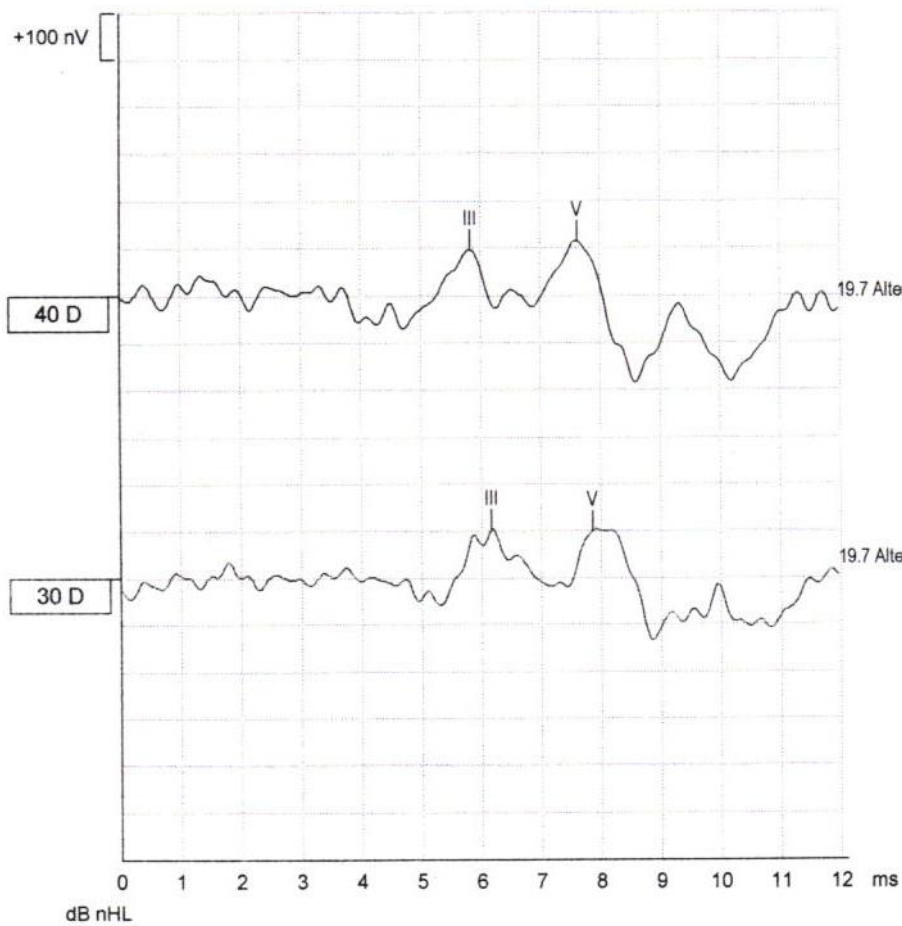
Case Report – 2 month-old preterm birth (36 weeks)



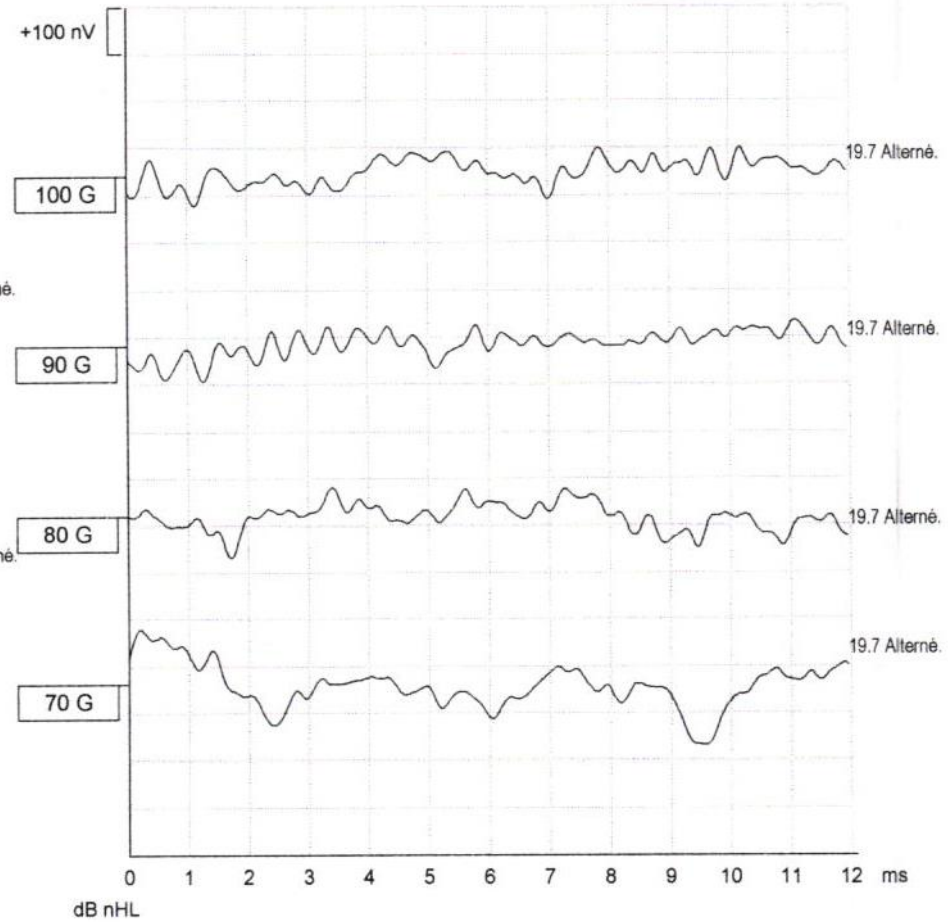
OEA present

OEA absent

Case Report – 2 month-old preterm birth (36 weeks)

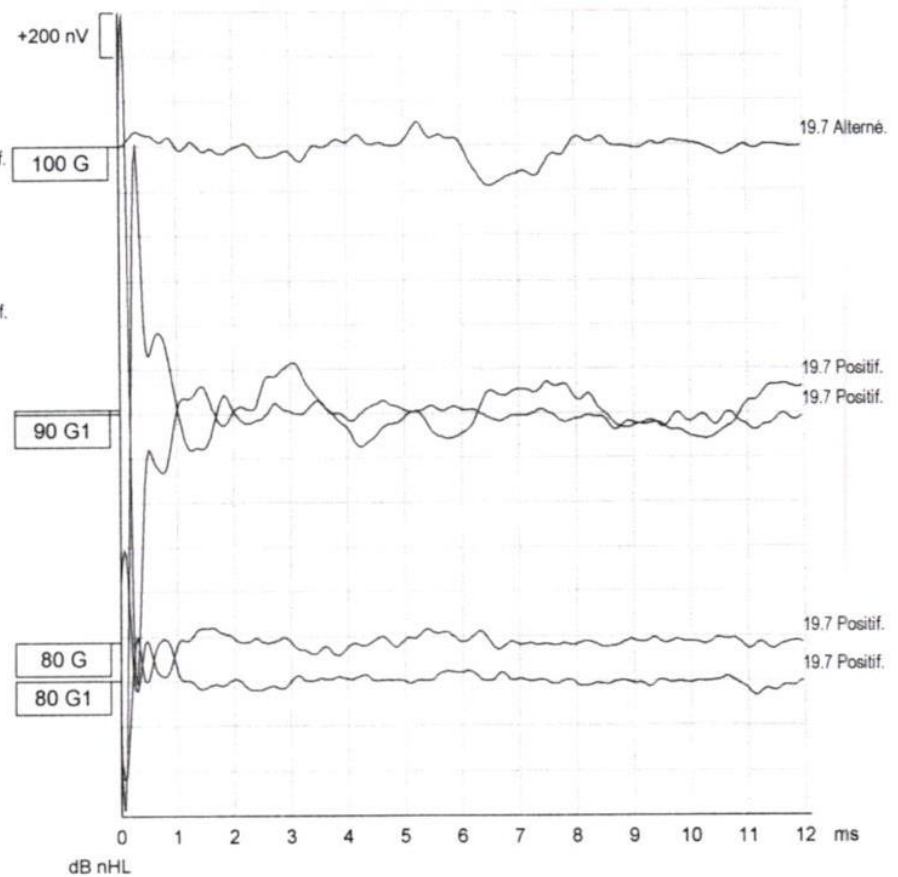
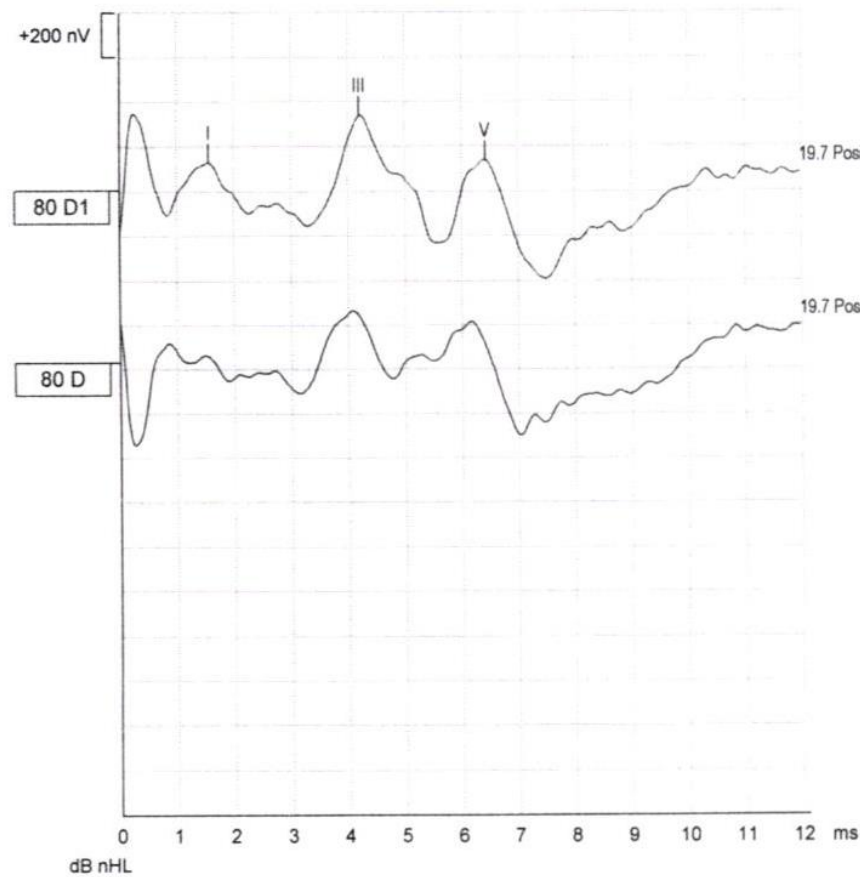


ABR present
Alternating Polarity click



ABR absent
Alternating Polarity click

Case Report – 2 month-old preterm birth (36 weeks)



CMP present

Rarefaction / Condensation clicks

Auditory Evoked Potentials (AEP)

- I) CLICK ABRs
- II) **FREQUENCY-SPECIFIC DIAGNOSIS**
- III) HOW TO GET RID OF CONDUCTIVE HL

Tone-Burst ABRs

informa
healthcare

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*Hospital São Luiz, São Paulo, Brazil

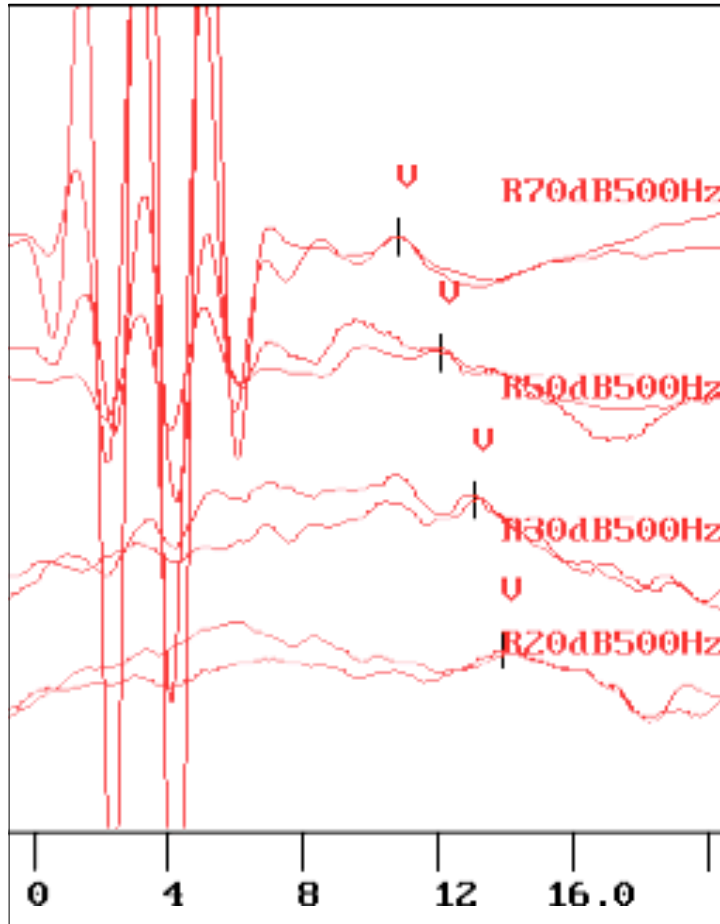
†School of Medicine, São Paulo
University, Brazil

Original Article

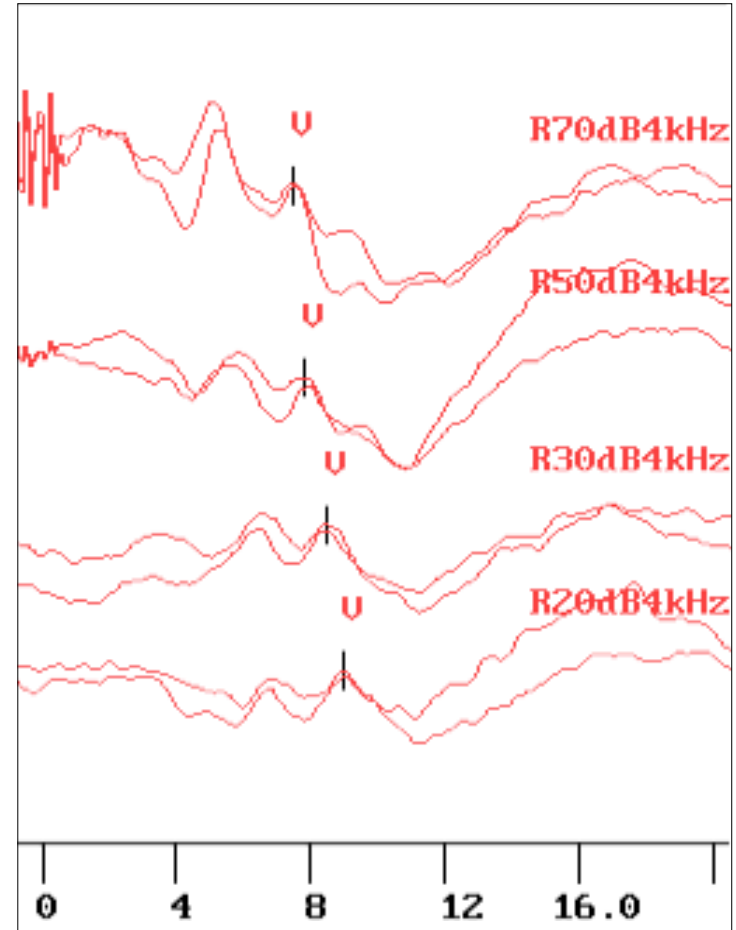
International Journal of Audiology 2007; 00:1–9

Tone-evoked ABR in full-term and preterm neonates with normal hearing

Tone-Burst ABR



500 Hz

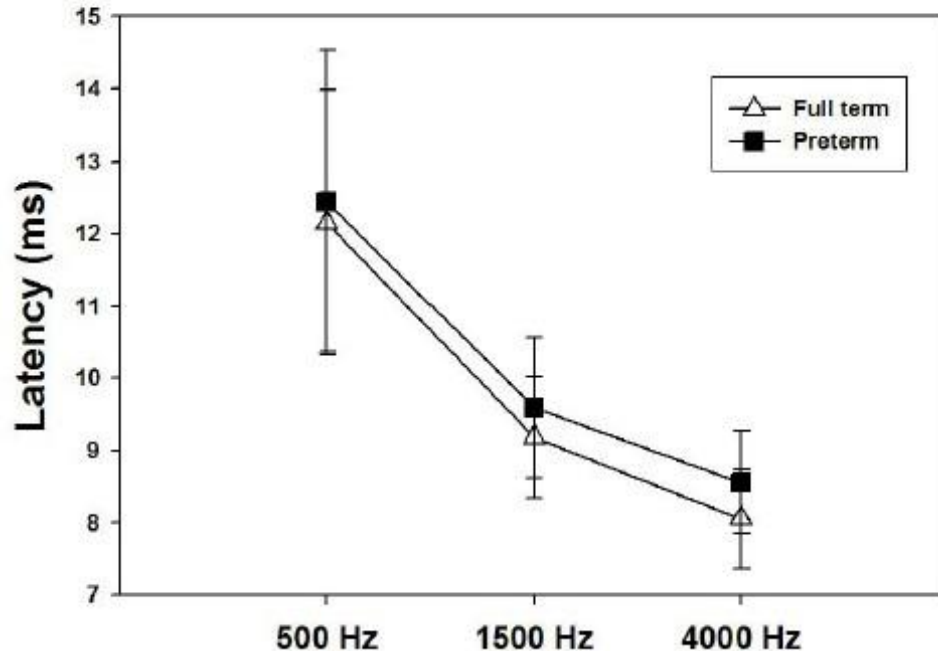


4000 Hz

Tone-Burst ABR

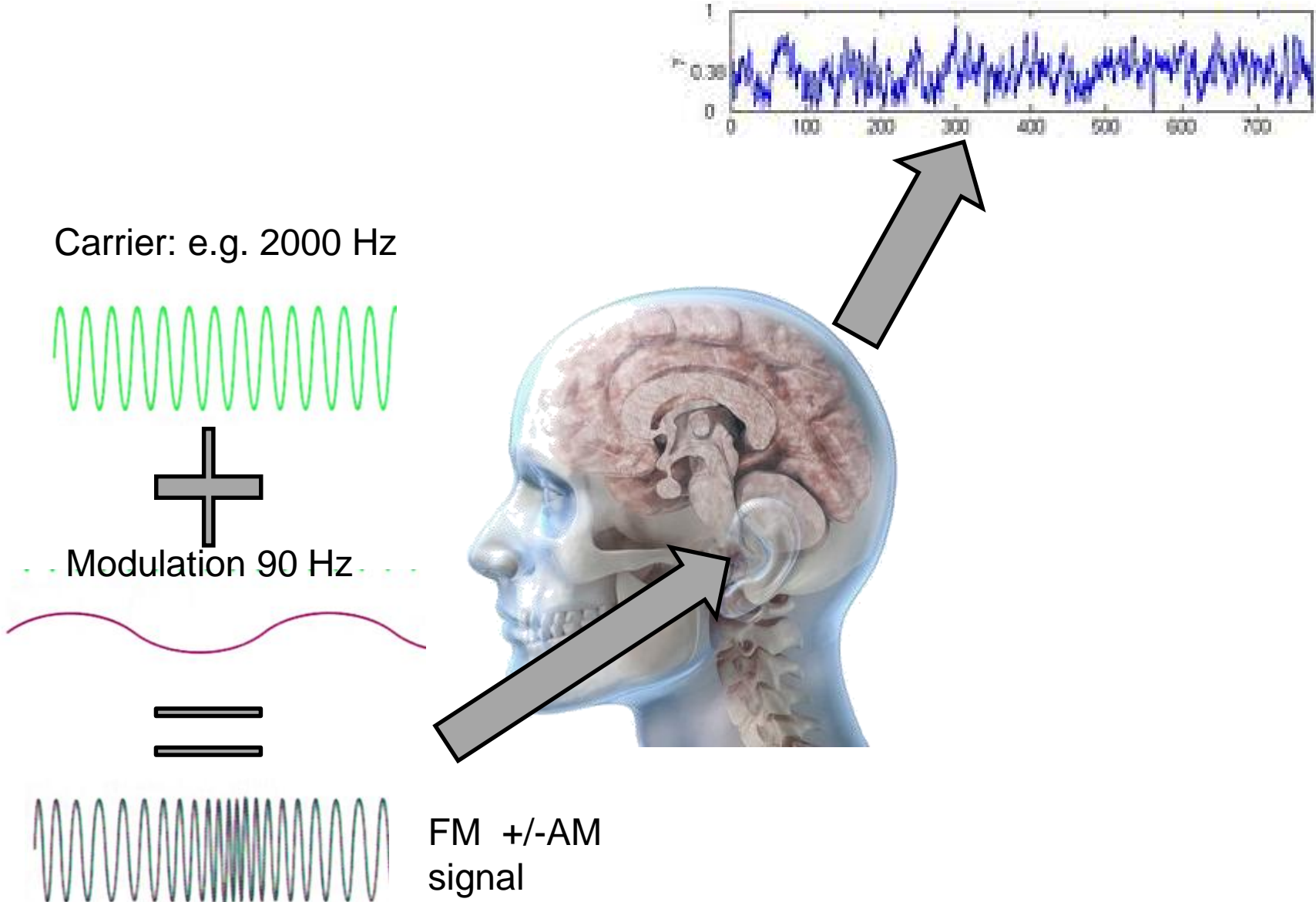
Ribeiro FM, Carvalho, RM; 2007

Figure 2: Wave V latency for three frequencies across groups.



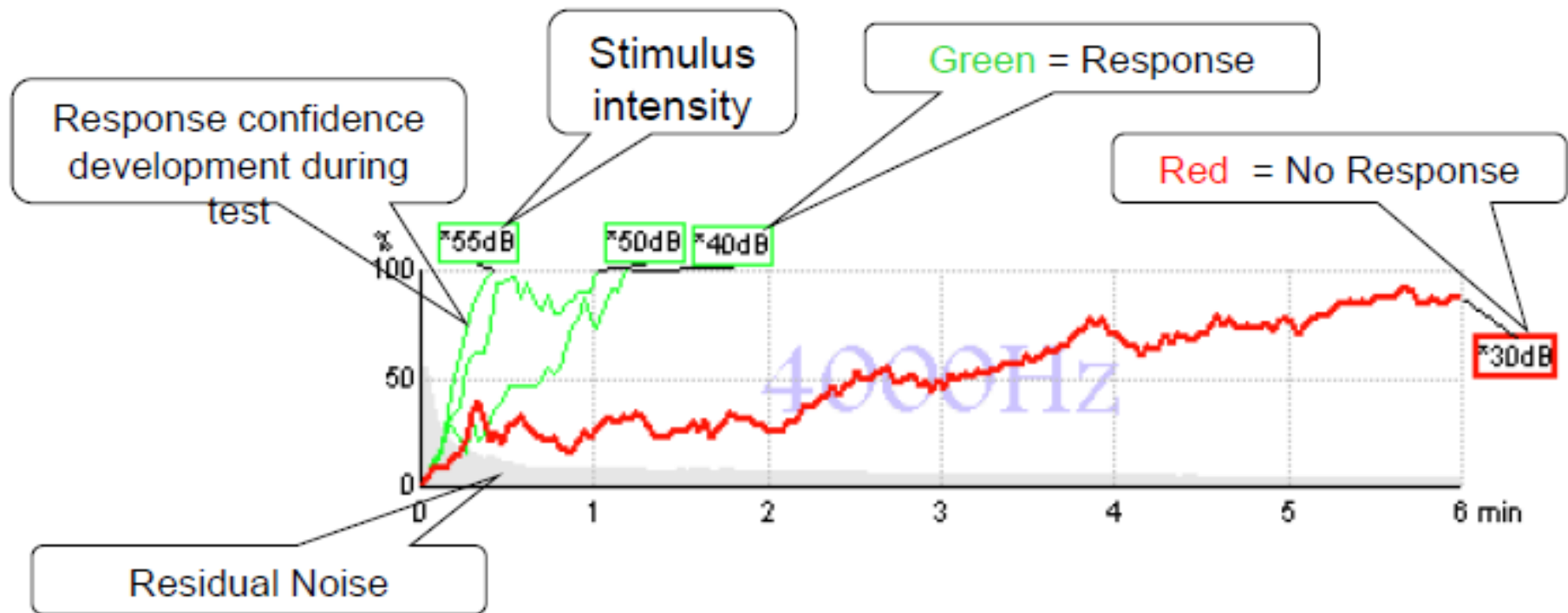
- ✓ **Global neurodevelopment delay**
- ✓ **No collaboration at behavioral audiometry**
- ✓ **Need for frequency specific diagnosis**

Auditory steady state response (ASSR)



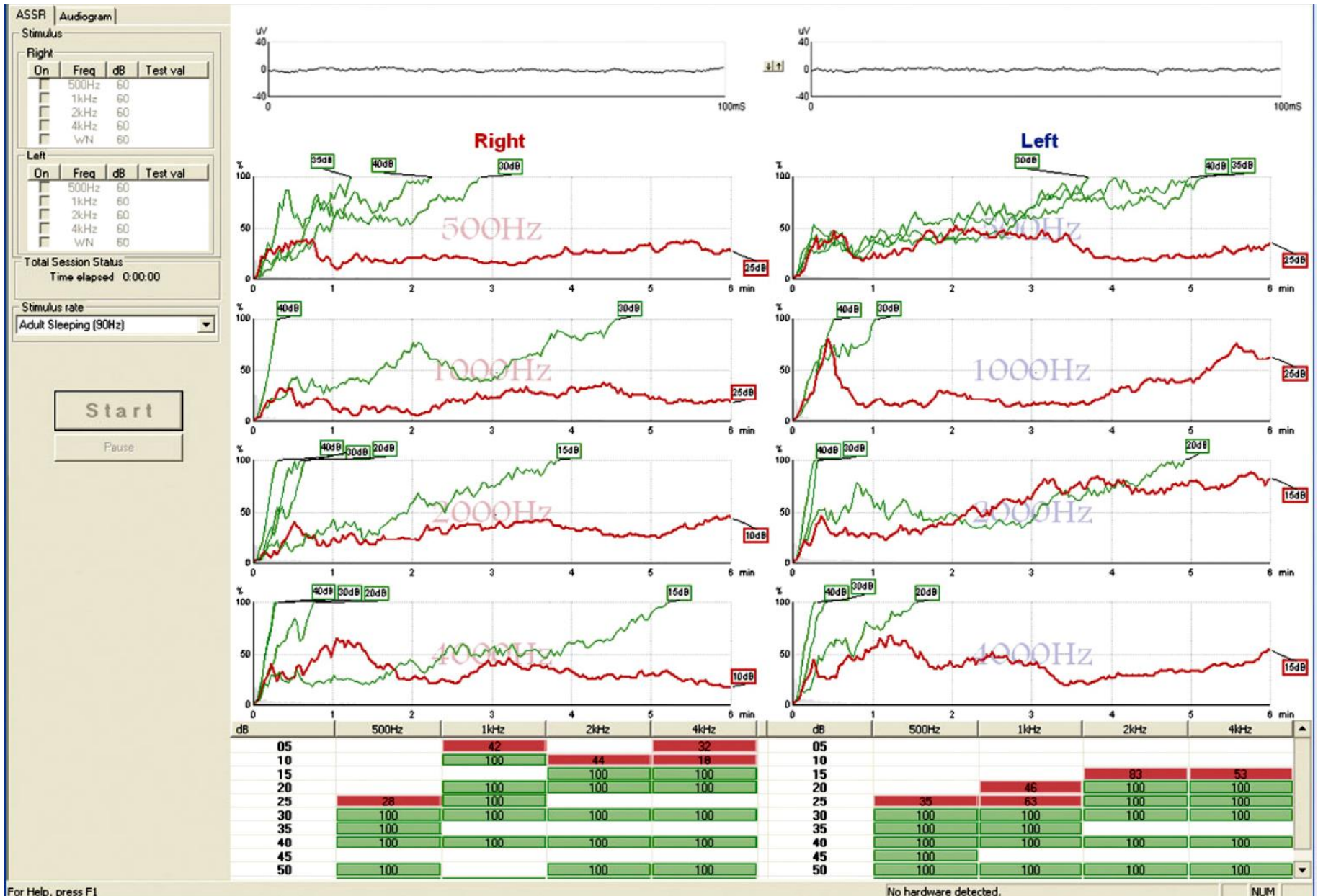
Auditory steady state response (ASSR)

- Carrier Frequencies (FP) : 500, 1000, 2000, 4000 Hz
- Modulation Frequencies (FM) : 90 Hz

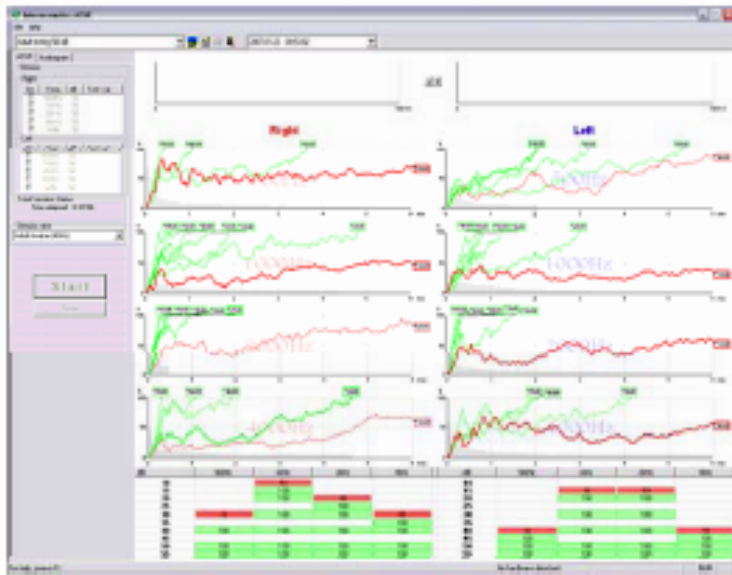


To optimize session strategy decisions as test progresses, the response confidence is tracked over time for each test frequency

Testing 4 frequencies in both ears at a time!

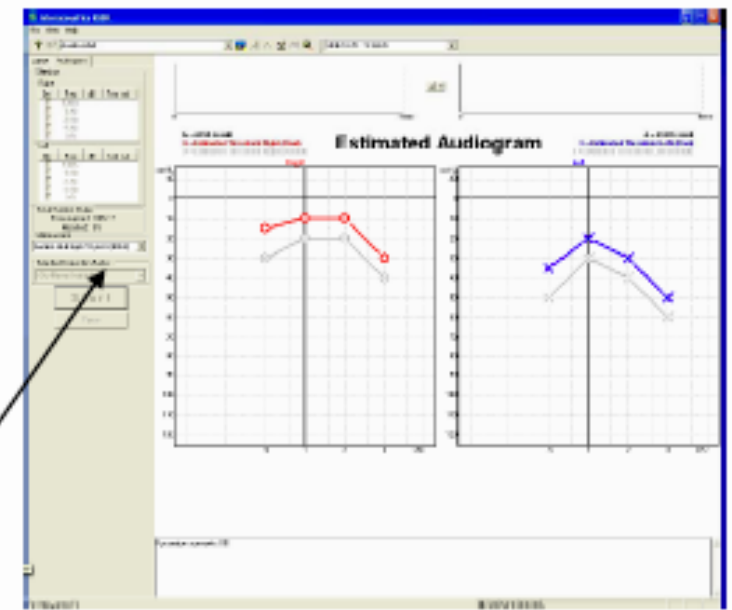


ASSR provide objective audiogram

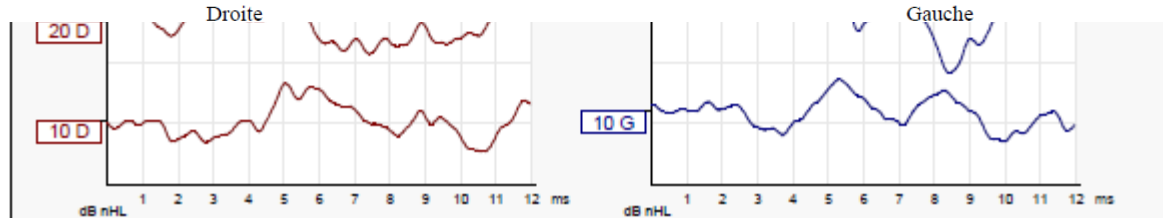
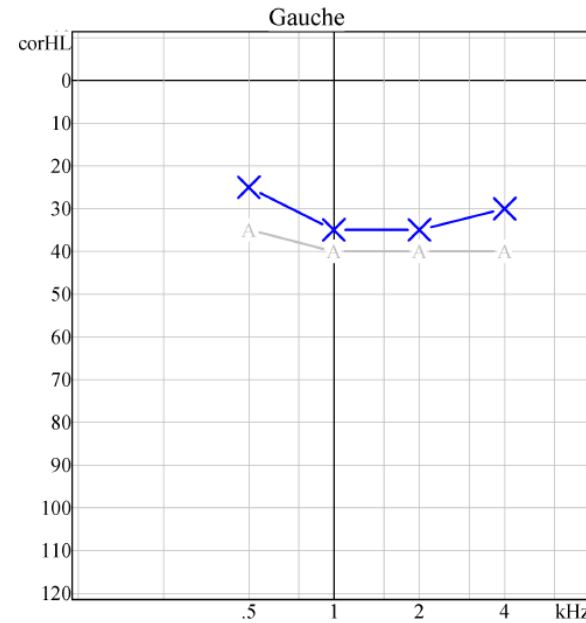
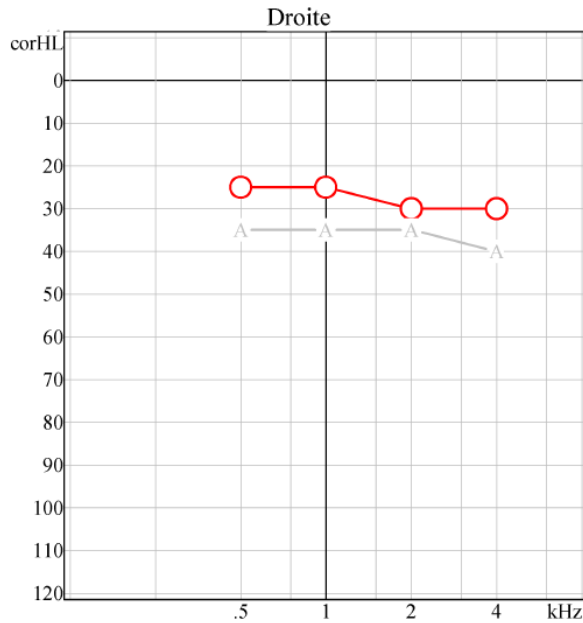
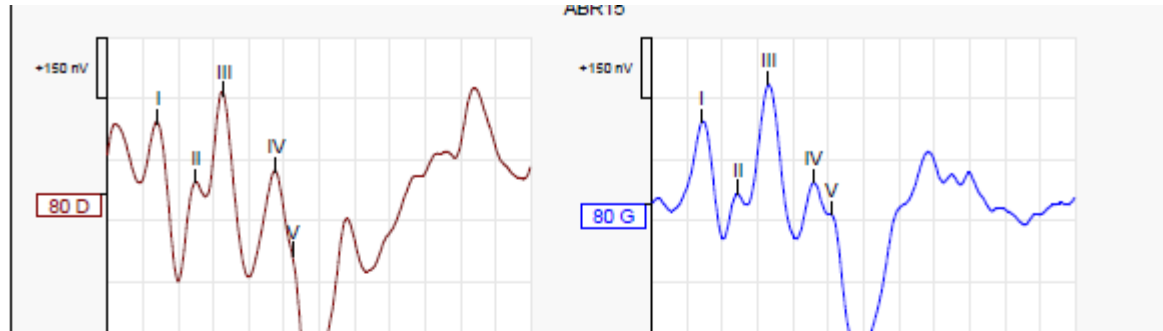


Press one button for Audiogram anytime

Apply appropriate correction table



Click-ABR vs ASSR threshold

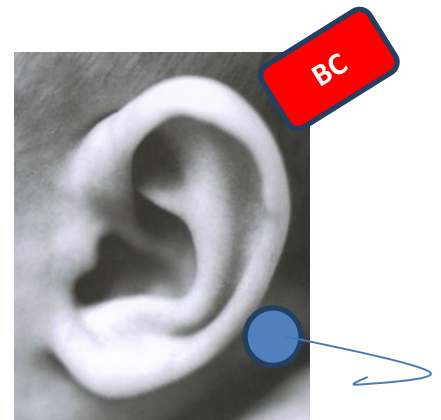
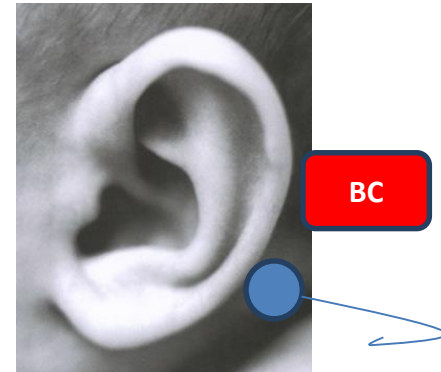
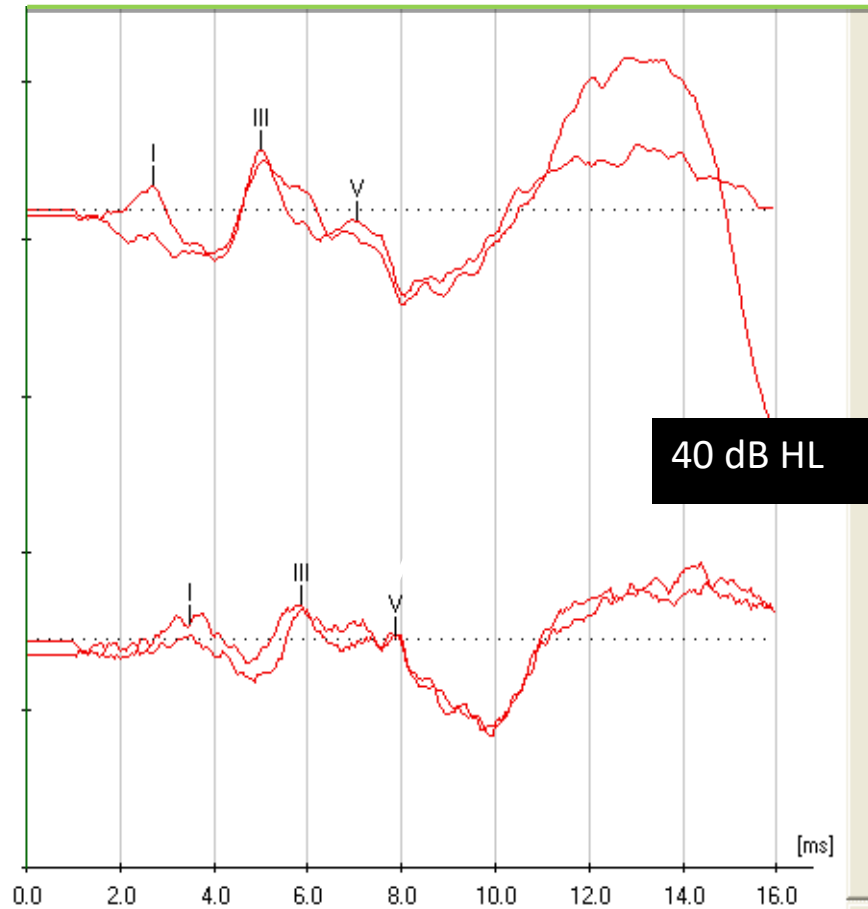




Auditory Evoked Potentials (AEP)

- I) CLICK ABR
- II) FREQUENCY-SPECIFIC DIAGNOSIS
- III) HOW TO GET RID OF CONDUCTIVE HL

BC ABR



With permission from Ribeiro & Chapchap, Hospital Sao Luiz - Sao Paulo

Behavioral Audiometry: when and how

Objective measures: what is child specific?

Diagnostic strategy



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TAKE HOME MESSAGES

- **Combine otoscopic, endocochlear and afferent auditory pathway examination**
- **It's always nice to see the ABR traces**
- **If you can't get a precise idea of middle ear status, go for Bone conduction testing**
- **Frequency-specific diagnosis can be done at follow-up**

Thank you!



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