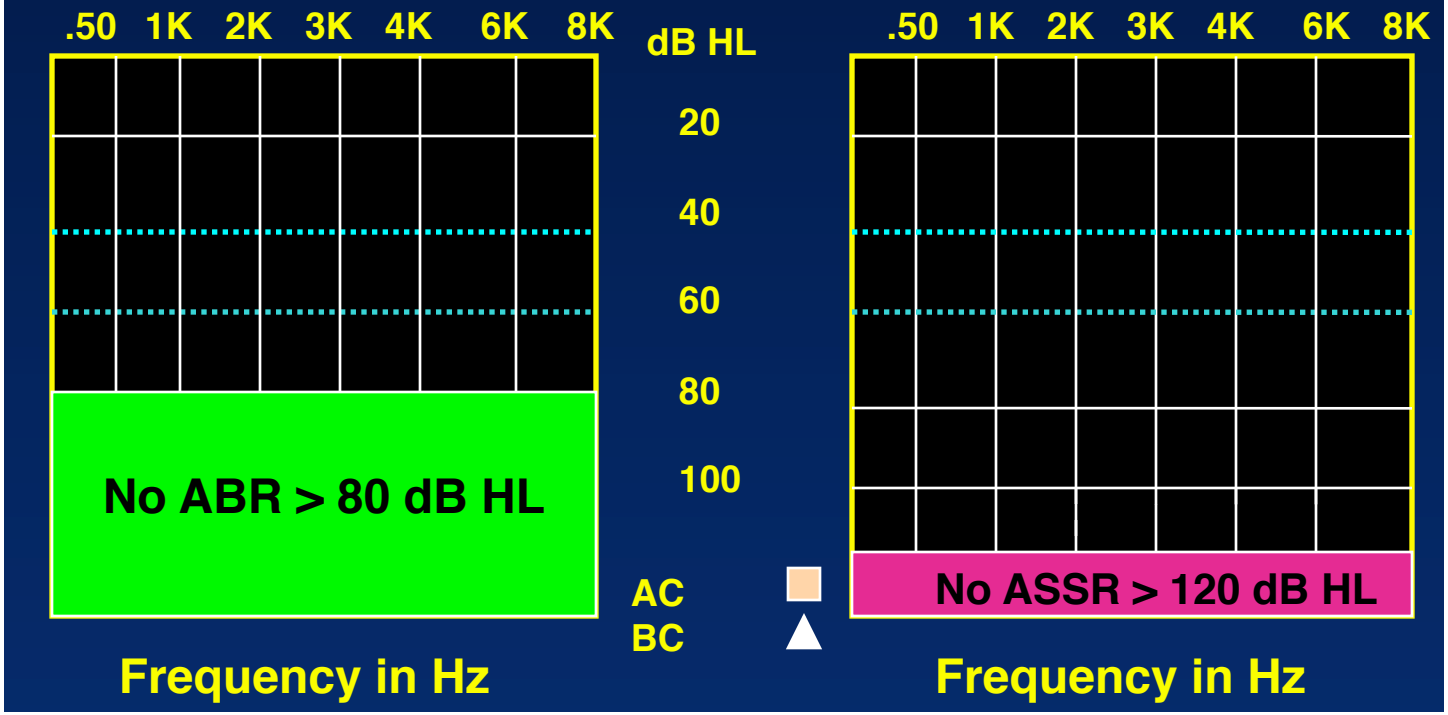
Application of ABR in Infants and Young Children

- Rationale
- Tone burst (frequency specific) ABR
- Bone conduction ABR
- Auditory steady state response (ASSR)
- Sedation and anesthesia

Limitation of Tone Burst ABR in Severe-to-Profound Hearing Loss



Diagnosis of Hearing Loss: Protocol for Confirmation of Hearing Loss in Infants and Toddlers (0 to 6 months)
Year 2007 JCIH Position Statement

- Child and family history
- Otoacoustic emissions
- ABR during initial evaluation to confirm type, degree & configuration of hearing loss
- Acoustic immittance measures (including acoustic reflexes)
- Supplemental procedures (insufficient evidence to use of procedures as "sole measure of auditory status in newborn and infant populations")
  - Auditory steady state response (ASSR)
  - Acoustic middle ear reflexes for infants < 4 months
  - Broad band reflectance
- Behavioral response audiometry *(if feasible)*
  - ✓ Visual reinforcement audiometry *or*
  - ✓ Conditioned play audiometry
  - ✓ Speech detection and recognition
- Parental report of auditory & visual behaviors
- Screening of infant's communication milestones

AUDITORY STEADY STATE RESPONSE (ASSR): Confusing Terminology

- Amplitude-modulation-following response (AMFR)
- Envelope -following response (EFR)
- Frequency-following response (FFR)
- Steady state evoked response (SSER)
- Steady state evoked potential (SSEP)
- 40 Hz response
- Auditory steady state response (ASSR)

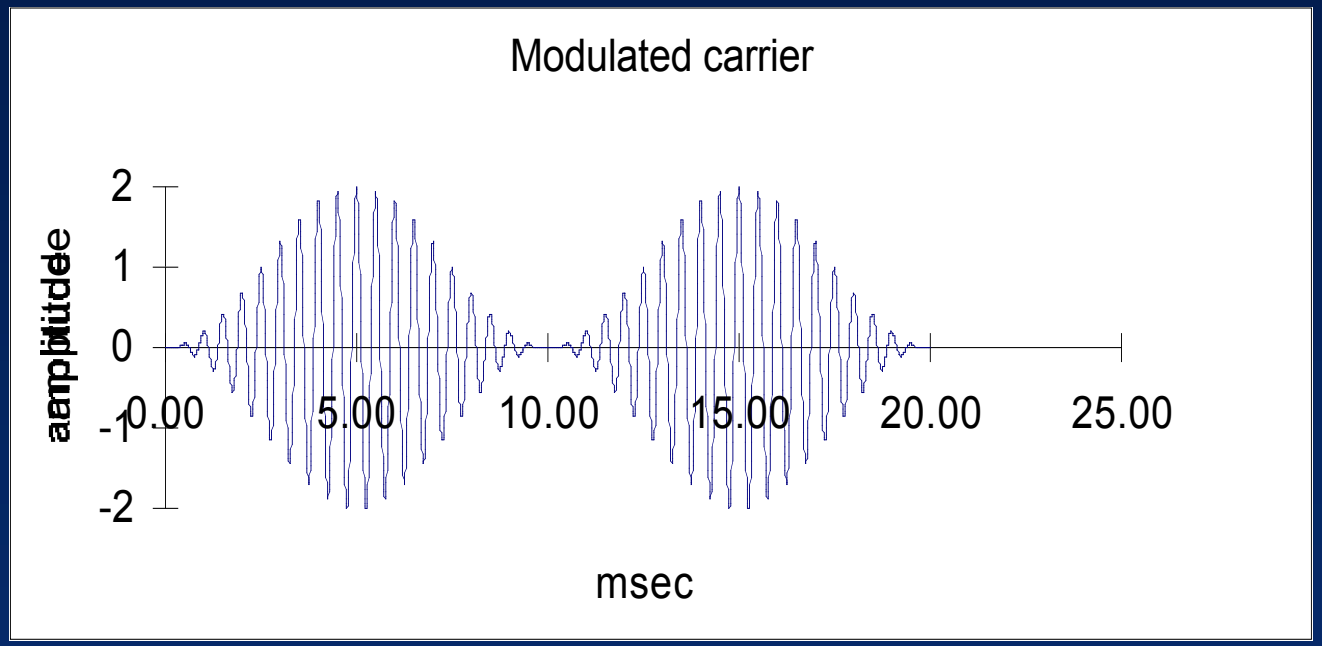
ASSR: General Principles

- An electrophysiologic response, similar to ABR.
- Instrumentation includes:
  - Insert earphones
  - Surface electrodes
  - Averaging computer
- Stimuli are pure tones (frequency specific, steady state signals) activating cochlea and CNS
- ASSR is generated by rapid modulation of “carrier” pure tone amplitude (AM) or frequency (FM).
- Signal intensity can be as high as 120 dB HL
- ASSR phase or frequency is detected automatically (vs. visual detection)

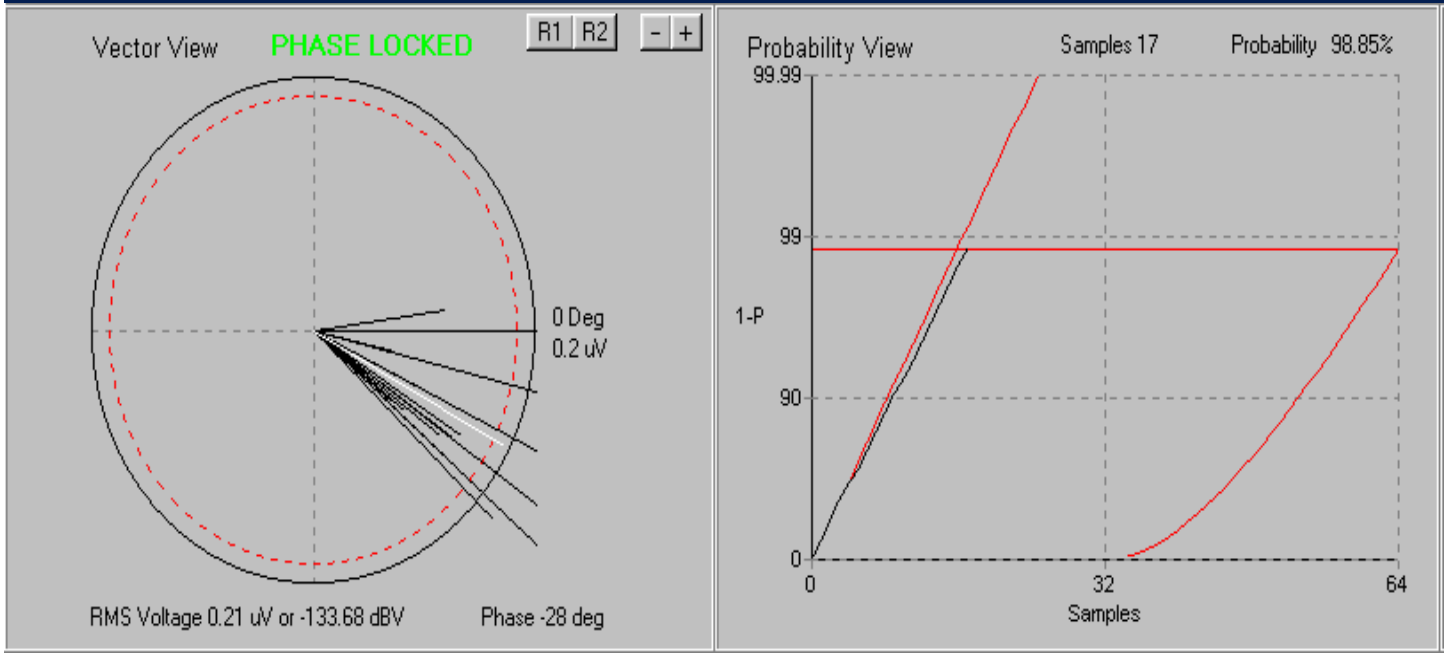
Auditory Steady State Response (ASSR): Clinical Devices

- GSI VIASYS
  - Audera
  - Descendant of Melbourne Australia system (Field Rickards, Gary Rance, Barbara Cone-Wesson, et al)
- Bio-Logic Systems Inc.
  - MASTER
  - Descendent of Canadian system (Terry Picton et al)
- ICS
- HIS
- Others?

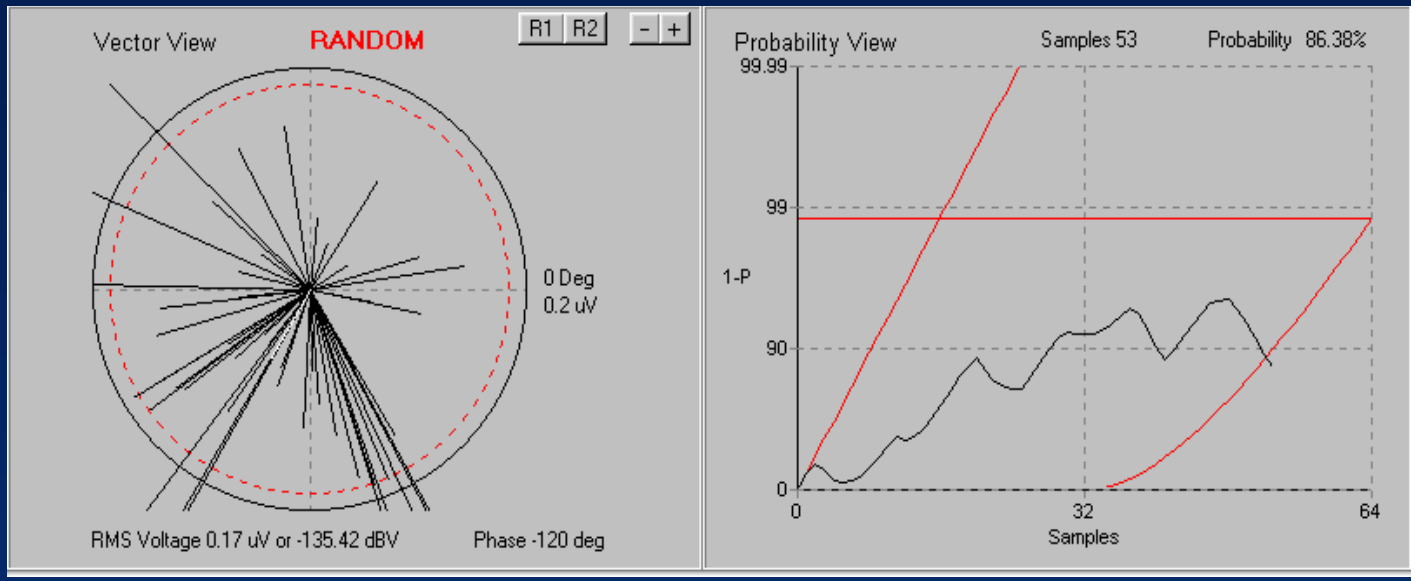
ASSR:
2000 Hz tone modulated at rate of 100 Hz



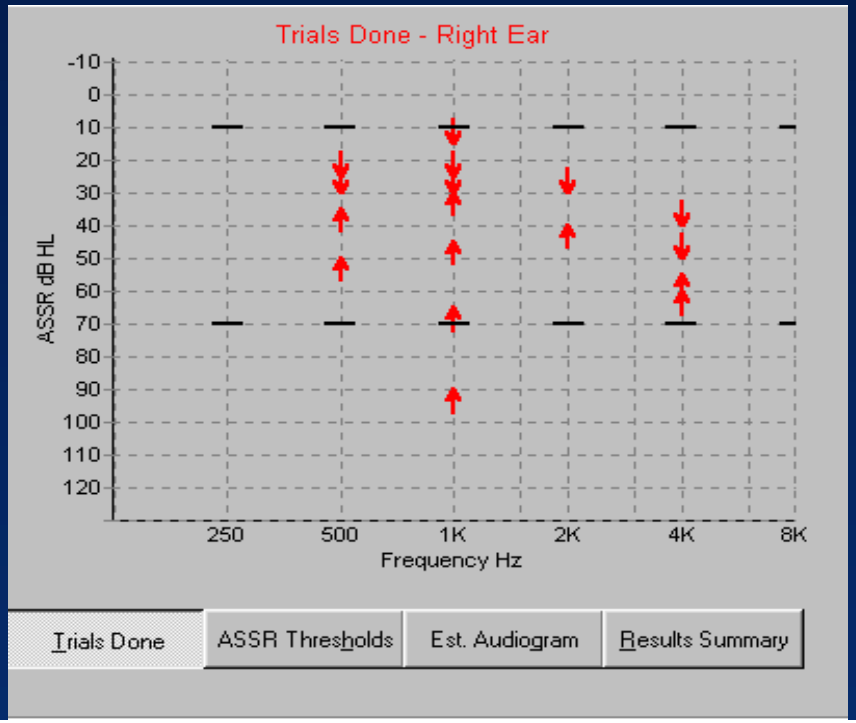
ASSR (Audera):
Significant phase coherence



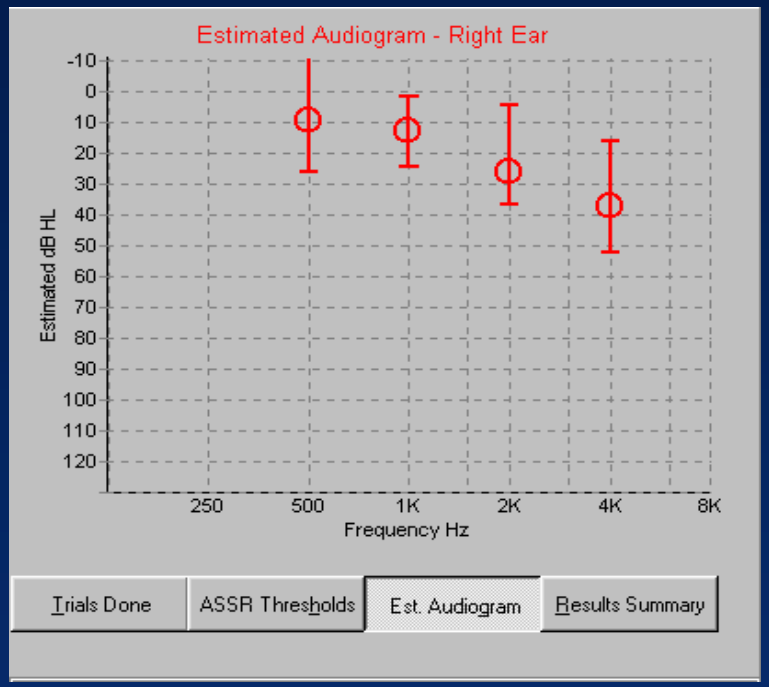
ASSR (Audera):
No Response Condition

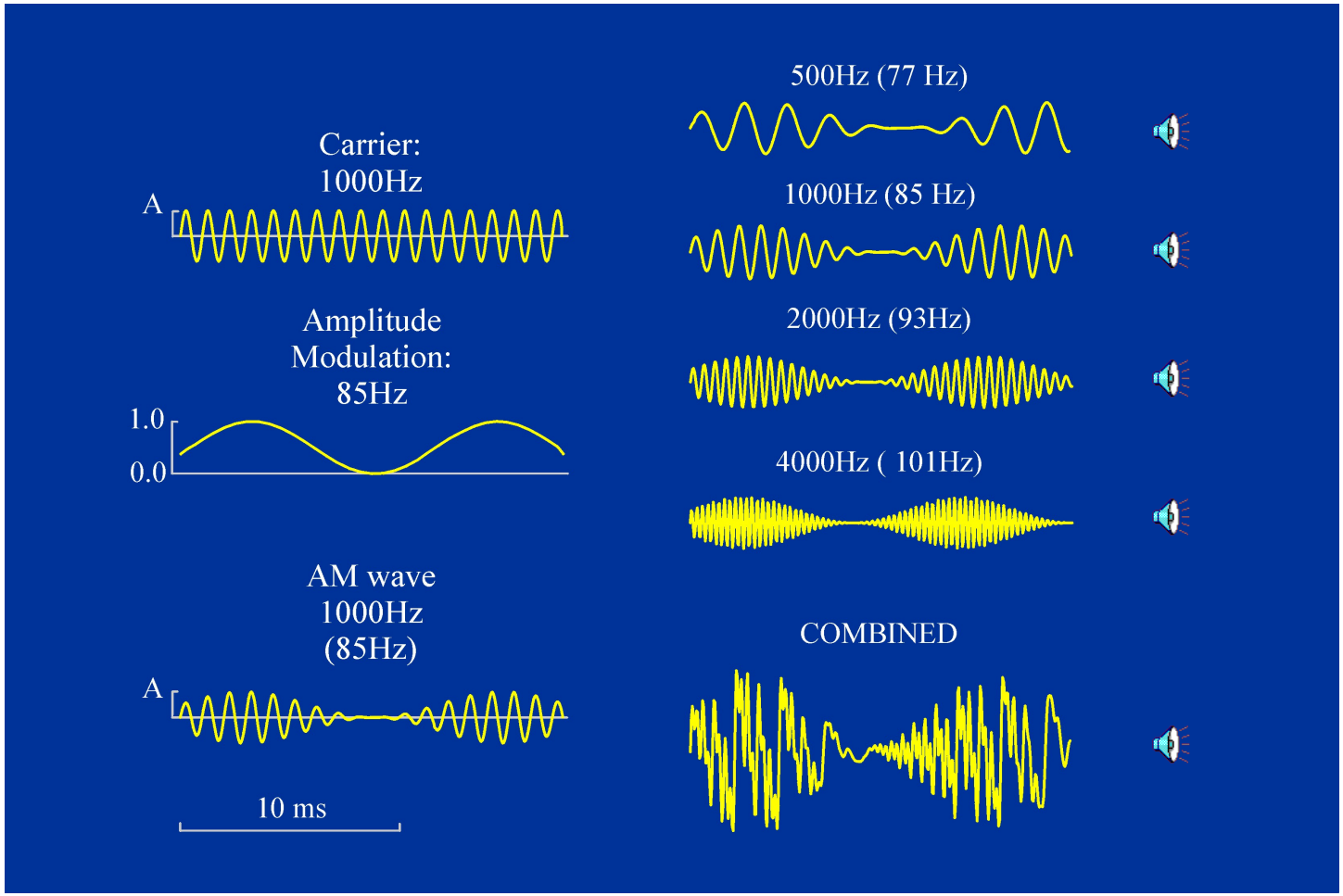


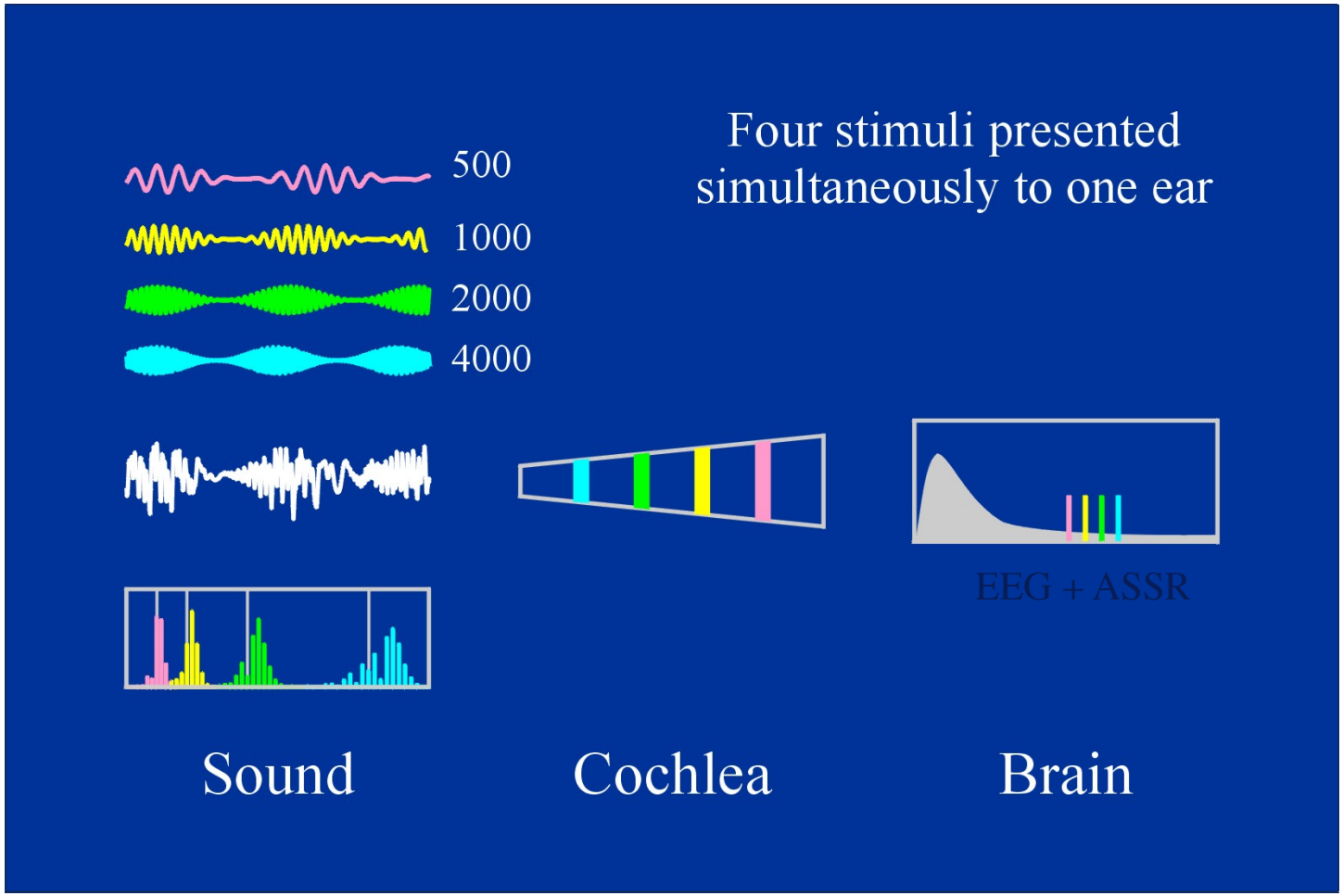
ASSR (Audera):
Test trials by frequencty



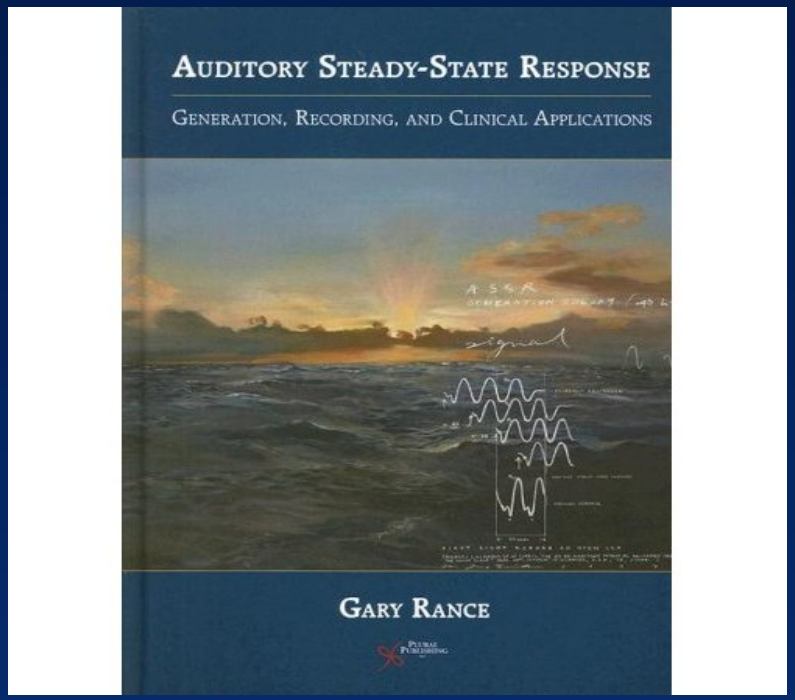
ASSR (Audera): Estimated Audiogram




Carrier:
1000Hz
A
Amplitude
Modulation:
85Hz
1.0
0.0
AM wave
1000Hz
(85Hz)
A
10 ms
500Hz (77 Hz)
1000Hz (85 Hz)
2000Hz (93Hz)
4000Hz (101Hz)
COMBINED


Four stimuli presented simultaneously to one ear
500
1000
2000
4000
EEG + ASSR
Sound
Cochlea
Brain

The Auditory Steady-State Response:
A New Book and > 400 Medline Hits (www.nlm.nih.gov)



ASSR, ABR, and Pure Tone Audiometry: Asking the clinically relevant question

Not:

Which frequency-specific electrophysiologic technique is best … tone burst ABR or ASSR?

But:

How does the ASSR technique complement click and tone burst ABR techniques in the infant test battery?

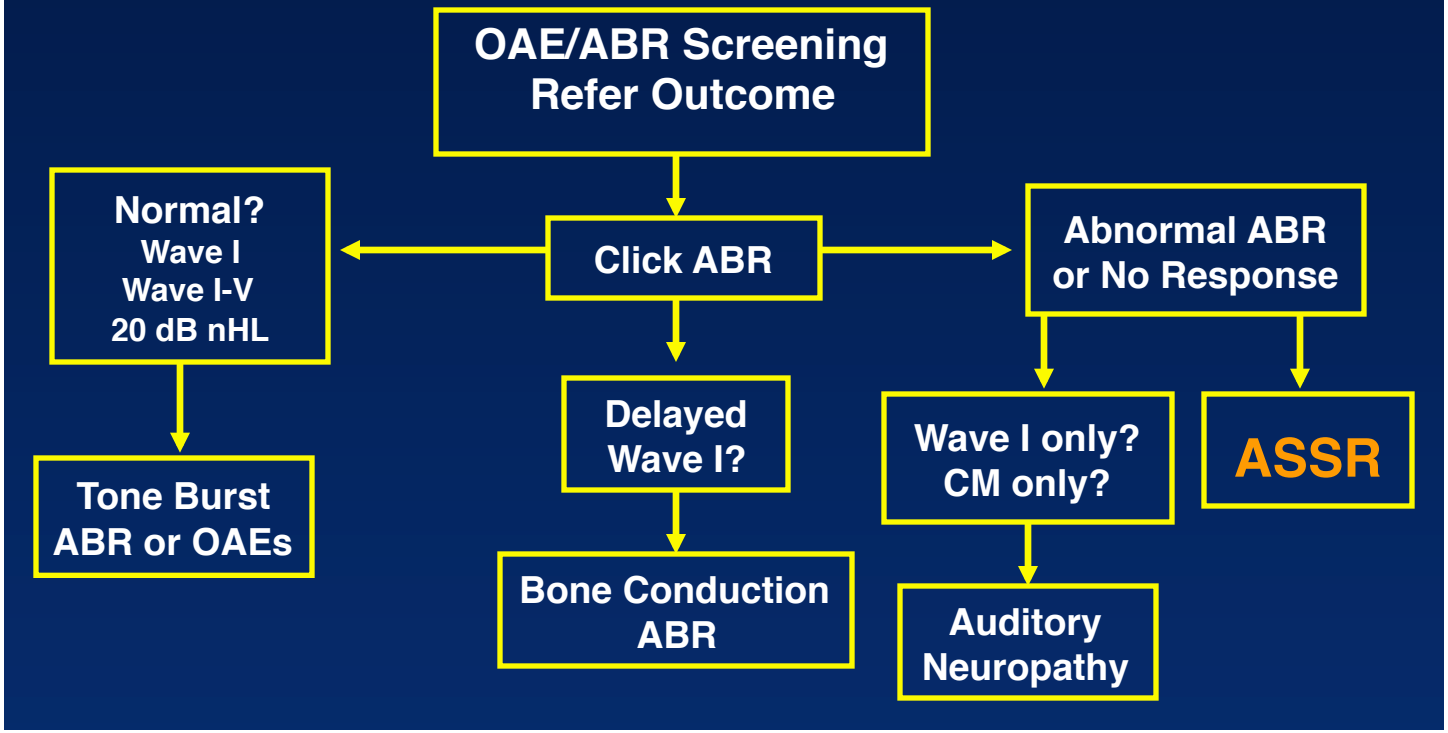
ABR (Click and Tone Burst) versus ASSR: Clinical Application

	Advantages	Disadvantages
ABR	◆ Estimates normal hearing thresholds ◆ Ear-specific BC findings ◆ Diagnosis of AN	◆ Can't estimate profound HL ◆ Skilled analysis required ◆ Limited BC intensity levels
ASSR	◆ Estimates severe-to-profound HL	◆ No ear-specific BC findings ◆ Requires sleep or sedation ◆ *Possible artifactual "response"*

ASSR:
Is it possible to mistake an artifact for a response?

- Literature: Air conduction
  - Gorga et al, 2004: found apparent ASSRs for stimulus intensity levels > 100 dB HL in patients with cochlear implants (disenabled)
  - Picton & John, 2004
  - Small & Stapells, 2004
- Literature: Bone conduction
  - Dimitrijevic et al, 2002
  - Small & Stapells, 2005
- Explanations and conclusions
  - Aliasing in measurement when signal is sampled at a rate less than twice its frequency
  - Problem was apparently limited to research or early clinical version of MASTER system
  - Based on clinical experience, it is clearly possible to perform ASSR measurement at intensity levels up to 120 dB HL without detection of a response (with Audera device)

Role of ASSR in Frequency-Specific Estimation of Hearing Sensitivity in Infancy



Auditory Steady State Responses (ASSRs): Pros and Cons for Clinical Use

- Advantages (Pros)
  - Reasonably frequency specific stimuli
  - Can be used for electrophysiologic assessment of severe to profound degree of hearing loss in infants and young children
  - Clinical devices now available
  - Automated analysis
- Potential disadvantages (Cons)
  - Require *very* quiet state of arousal
  - Less accurate in normal hearing (especially low frequencies)
  - Limited anatomic site specificity
  - Analysis difficult with bone conduction stimulation

ASSR:
Lingering Clinical Questions

- Are the neural generators for the ASSR well defined?
- Are there maturational effects on ASSR from premature infants through childhood?
- Is test time equivalent for ASSR vs. tone burst ABR?
- Can ASSR be recorded from non-sedated patients?
- What is the effect of sedation and anesthesia on ASSR?
- How closely correlated are ASSR and pure tone hearing thresholds?
- Can ASSR be used in estimation of *bone conduction* auditory thresholds?

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ABR in the Clinic with Conscious Sedation (e.g., chloral hydrate)

American Academy of Pediatrics Guidelines for Conscious Sedation (WWW.AAP.org/policy)

Pediatrics 89, 1992, p 1110-1115

Guidelines for Monitoring and Management of Pediatric Patients During and After Sedation for Diagnostic and Therapeutic Procedures

Pediatrics 110, 2002, pp 836-838

Guidelines for Monitoring and Management of Pediatric Patients During and After Sedation for Diagnostic and Therapeutic Procedures: Addendum

ABR in the Operating Room with Light Anesthesia (e.g., propofol)

SEDATION OPTIONS:
Clinic versus Operating Room

Setting	Advantages	Disadvantages
Clinic	Less expensive Near or in audiology Scheduling ease	Limited sedation options Limited medical support Increased liability Uncertain success/> time
O.R.	Medical (ENT) support Ideal patient state Controlled sedation Limited liability	More expensive Remote location Noisy environment Complicated scheduling

Disadvantages of Anesthesia for in ABR Assessment of Children

- Delayed diagnosis (many months) due to problems with scheduling time in the operating room with medical support team (e.g., anesthesiologist)
- Ten fold increase in cost (>$4000 versus $400) associated with services in the operating room
- Medical risk of anesthesia and related procedures (e.g., intubation)
- Possible secondary neurological and cognitive deficits of anesthesia in children at risk for learning problems
- Inability to conduct a full auditory assessment in remote location outside of the audiology clinic

Thank you!
Questions?