Optimizing Diagnostic Auditory Brainstem Response and DPOAE

Lisa Hunter, PhD, Scientific Director, Cincinnati Children's Hospital Medical Center, University of Cincinnati

- Newborn is referred for repeated OAE or ABR failure:
  - Is hearing loss present?
  - If so, sensorineural, conductive or neural?
- Possible sources of information:
  - Otoscopy
  - Toneburst Air/Bone ABR
  - 1000 Hz Tympanometry
  - Acoustic Reflexes
  - TE or DPOAEs

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Baby State

Natural Sleep

- ABR testing ideal conditions
  - During natural sleep
  - Under sedation if they have prior failure or older than 5 months
  - Can be done in most infants under 5 months of age
  - Practice is to try without sedation up to 6 months, then try behavioral first

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Ideal Testing Condition

Appropriate Conditions for Testing

- Ensure infant arrives for testing in an appropriate state
- Instructions critical
- Infant should be tired (not overtired)
- *Delay sleep*
  - Hungry on arrival
  - Keep infant awake for at least 1 hour prior to testing
  - Provide accommodations for breast or bottle
  - Rocking chair, infant swing or seat

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Infant support to encourage sleep

Recommended Test Sequence

- Upon arrival:

  –Do otoscopy first

  - Put on electrodes

  - Feed child

- Do tympanometry and OAEs

  -wait……

Never wake a sleeping infant!

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Click ABR

- Useful for hearing screening
- Neurological evaluation, diagnosing auditory neuropathy spectrum disorder
- Misses hearing loss when there are frequencies with normal sensitivity.
- Equal contributions from 500Hz to 4000Hz

Tone ABR

- Used for threshold evaluation
- Useful for determining frequency-specific hearing levels to fit HAs
- Stimuli from 500 Hz to 4000 Hz

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Hand-held versus headband for bone conduction ABR???

Person holding the bone oscillator must be well trained in applying a constant and appropriate force.

No significant difference in adult behavioral or infant ASSR BC thresholds using the two techniques.

Compare benefits:
elastic band - an assistant is not required.

hand-held - faster and more comfortable for the infant
-much less likely to wake up the infant.

So, use what works best for you!

Small, Hatton & Stapells, 2007

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Residual Noise

- **RN measure** is an online measure of the largest peak-to-peak amplitude
- Present in the noise estimate (the "+/-" response is used as the noise estimate)
- As such it is somewhat conservative, overestimating the noise present in the response.

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Residual Noise

- May be used several ways
- The best way is to *always* record to a specific RN level that is quiet enough to be confident that IF a response were present, you would be able to see it because you recorded a quiet wave.
- Reasonably quiet = value of **0.15-0.20μV**
- *If the RN is not below the criterion (such as 0.15μV), one can't say "no response".*

Stapells, 2004

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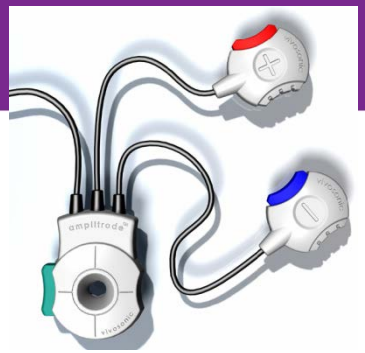
Toneburst ABR Protocol



- System : Vivosonic Integrity V500
- Stimulus rate: 37.1(stimuli/s)
- Windowing: Blackman 2-0-2
- Averaging : Kalman weighted
- High pass filter cutoff frequency: 30 Hz
- Low pass filter cutoff frequency : 3000 Hz
- Tone-burst frequencies 0.5, 1, 2, 4 kHz.
- Cond/ Rare with correlation ≥ 0.7 for wave V threshold.

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Bone Conduction Recording

- High forehead to ipsilateral mastoid recording montage.
- ER-3A insert earphones.
- Hand-held B-71 vibrator at temporal bone, contralateral masking.

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Air and Bone Conduction Click and Tone-Burst Auditory Brainstem Thresholds Using Kalman Adaptive Processing in Nonsedated Normal-Hearing Infants

Alaaeldin M. Elsayed,[1] Lisa L. Hunter,[1] Douglas H. Keefe,[2] M. Patrick Feeney,[3,4] David K. Brown,[5] Jareen K. Meinzen-Derr,[1] Kelly Baroch,[1] Maureen Sullivan-Mahoney,[6] Kara Francis,[1] and Leigh G. Schaid[1]

- Ear and Hearing, March 2015
- Normative study using Kalman weighted adaptive processing
- 145 Infants who passed newborn screening and follow-up DPOAE
- Includes air and bone conduction norms for clicks, 500, 1000, 2000 and 4000 Hz tonebursts
- Shows no effect of sleep state in **quiet** infants

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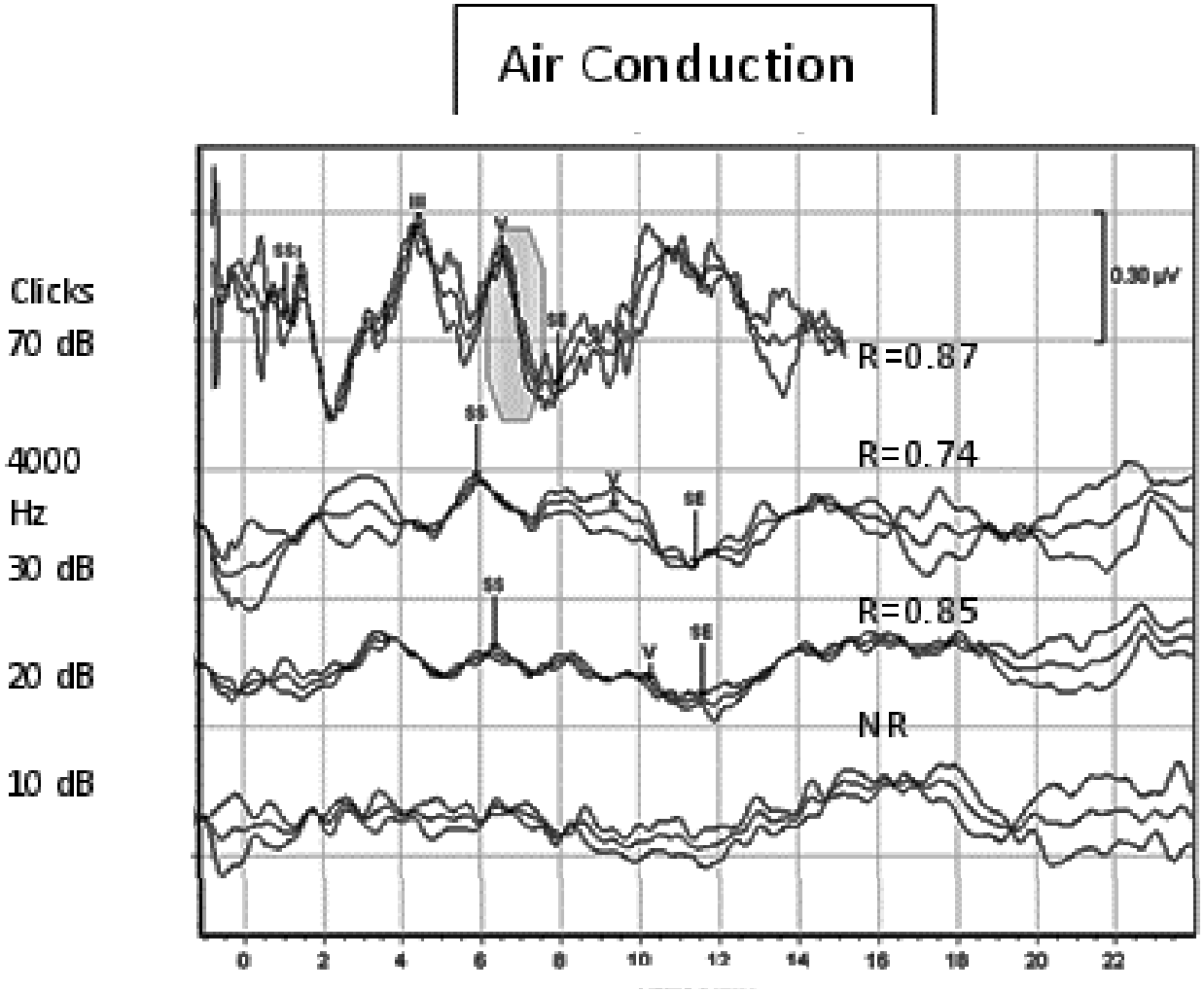
Air Cond Toneburst– Clicks and 4000 Hz



Modified from Elsayed, Hunter, Keefe et al, 2015

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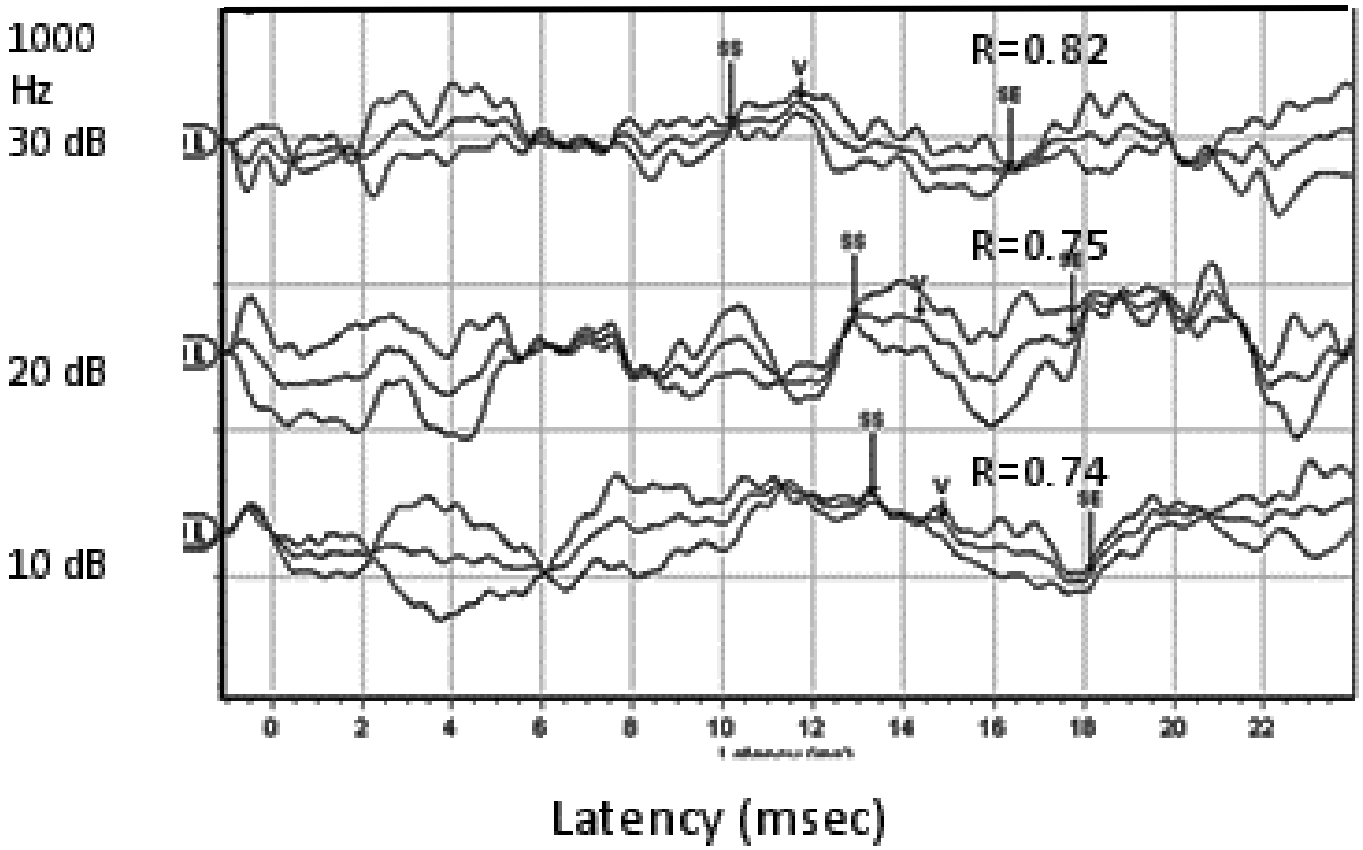
Air Cond Toneburst– 1000 Hz



Modified from Elsayed, Hunter, Keefe et al, 2015

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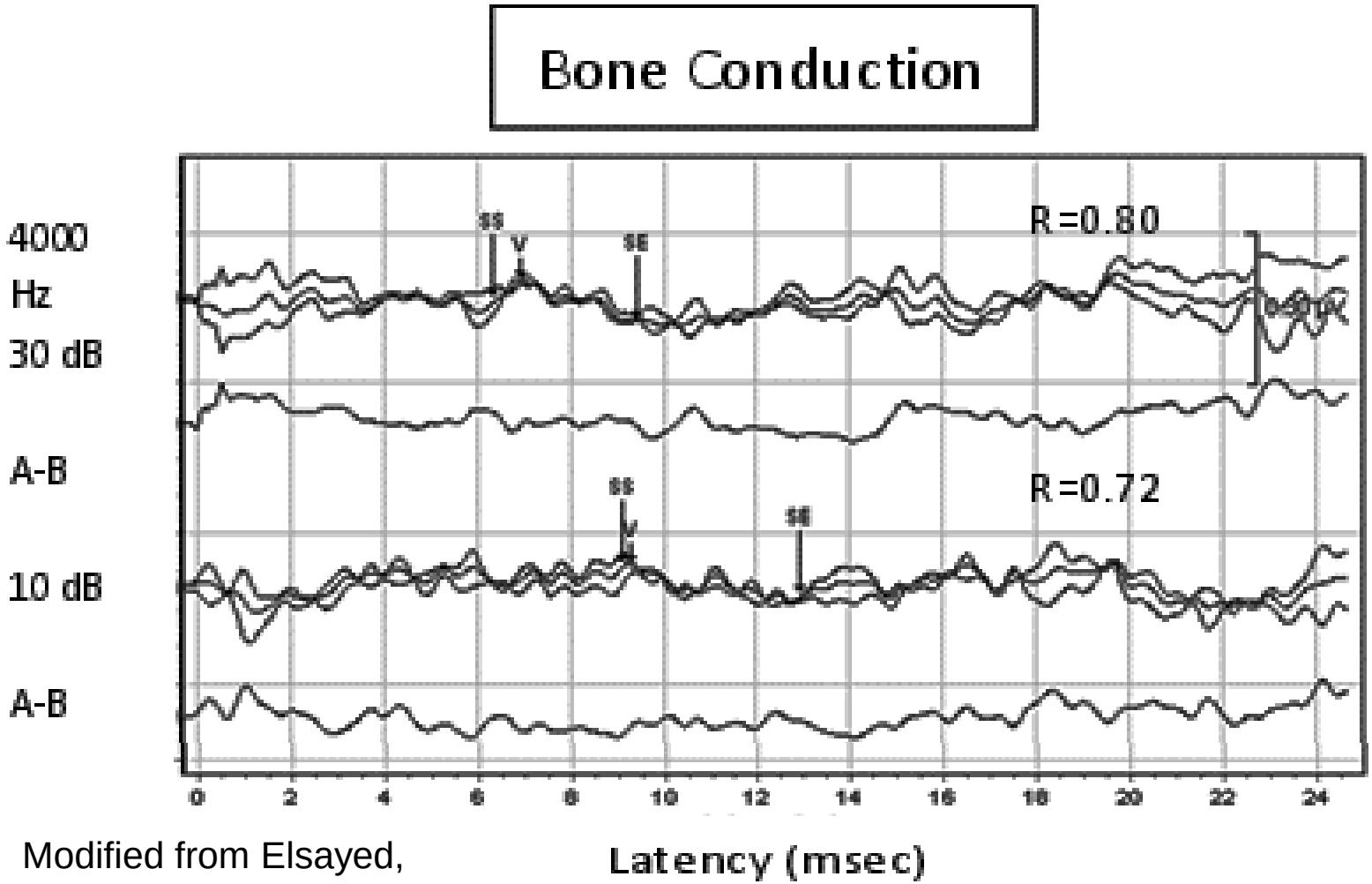
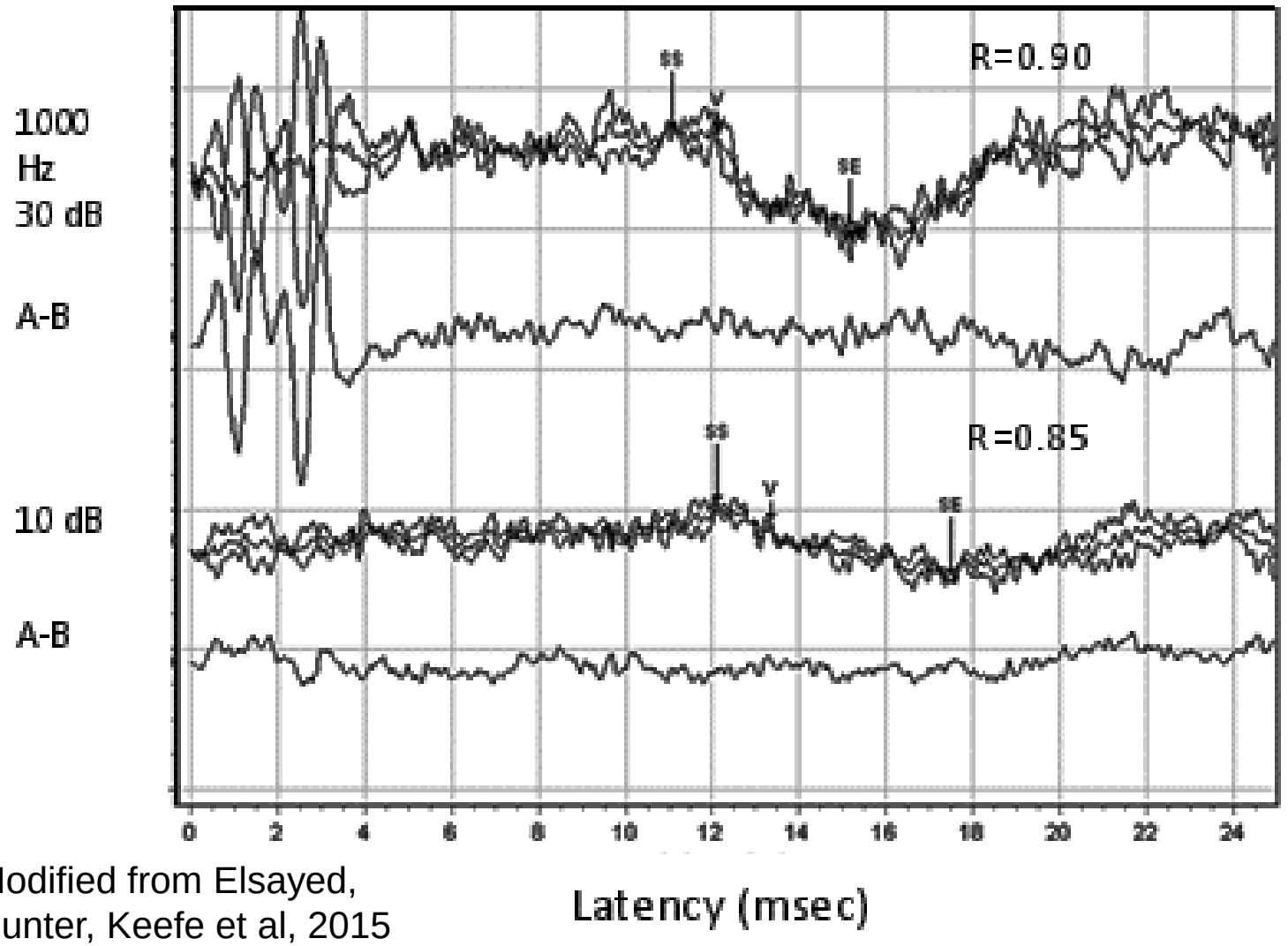
Bone Cond Toneburst– 4000 Hz



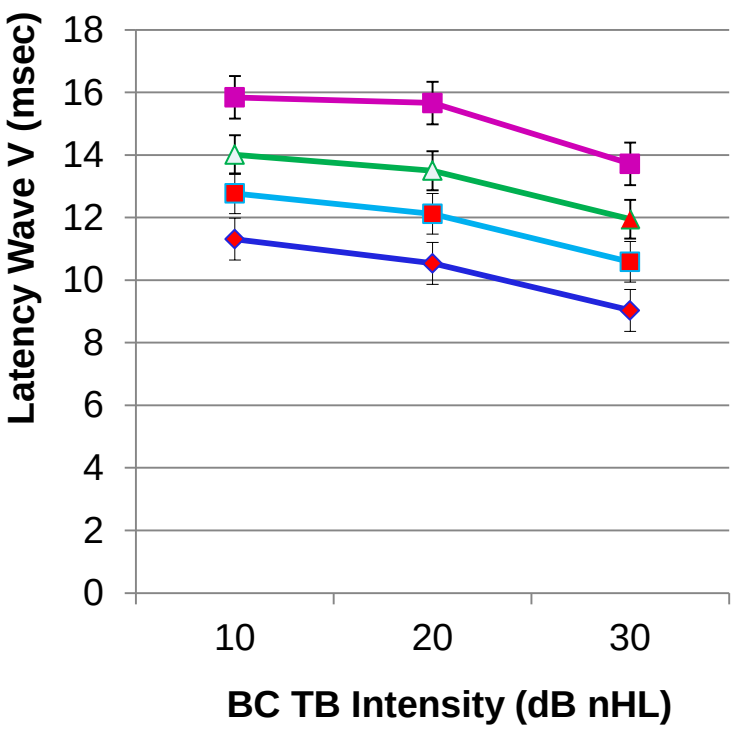
Modified from Elsayed, Hunter, Keefe et al, 2015

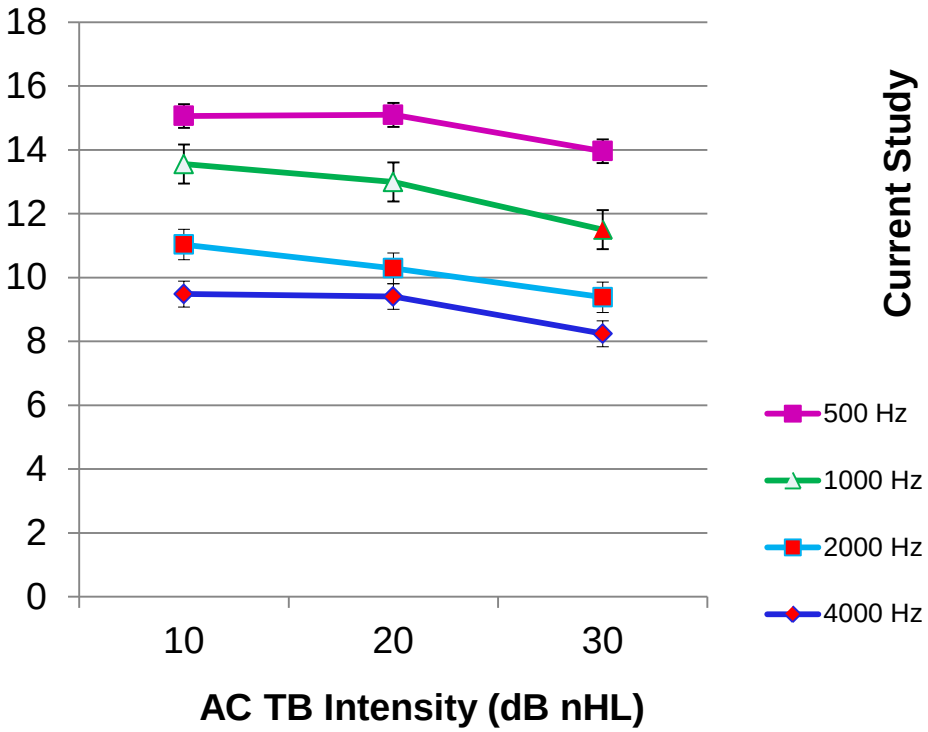
Bone Cond Toneburst – 1000 Hz



Modified from Elsayed, Hunter, Keefe et al, 2015

Average AC & BC TB-ABR latencies





- 500 Hz: no significant difference between AC and BC latencies.
- 1000 Hz: no significant difference except at 30 dB nHL.
- 2000 and 4000 Hz: significant differences at 10-30 dB nHL.

Modified from Elsayed, Hunter, Keefe et al, 2015

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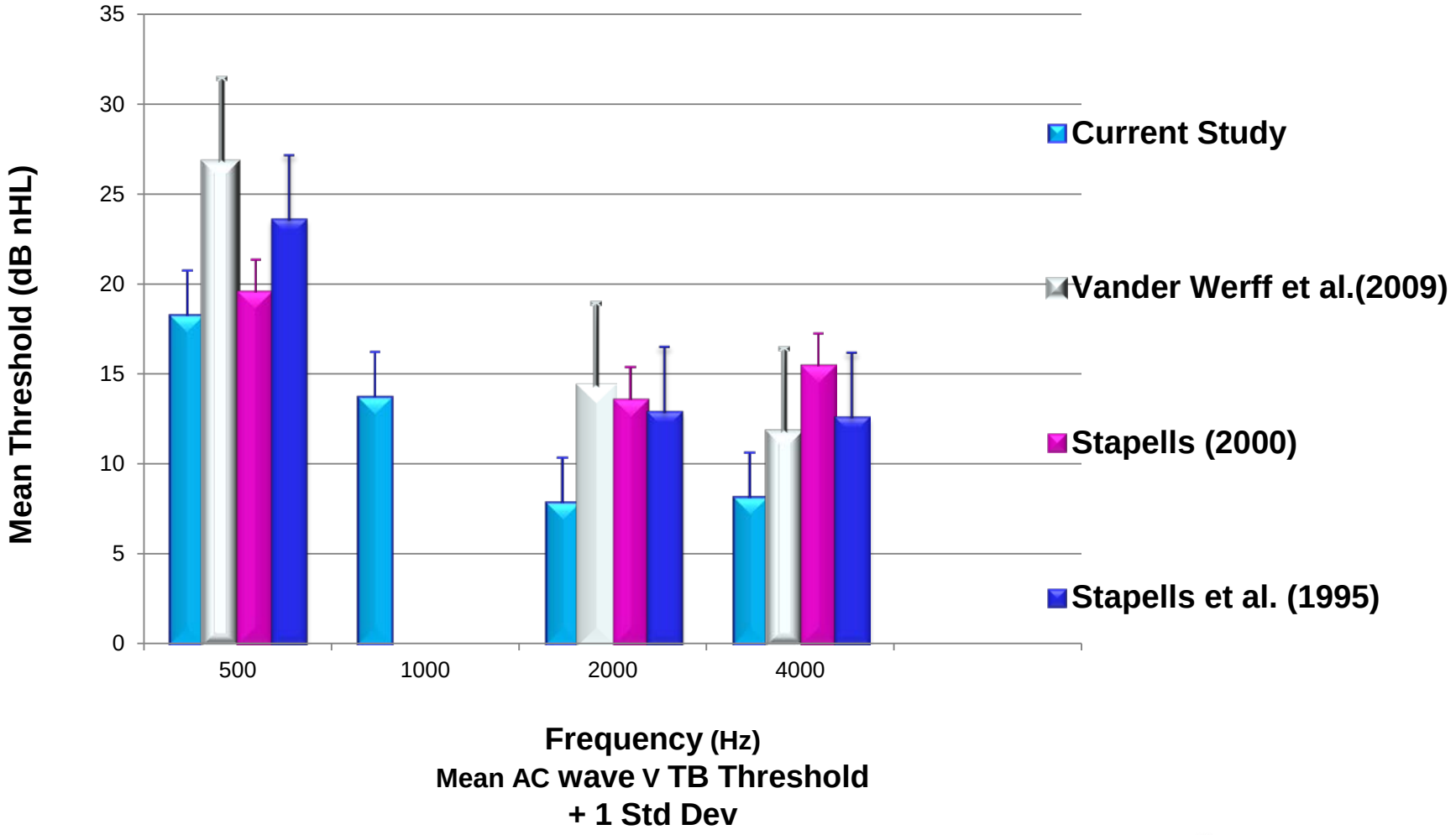
Comparison of AC thresholds



Modified from Elsayed, Hunter, Keefe et al, 2015

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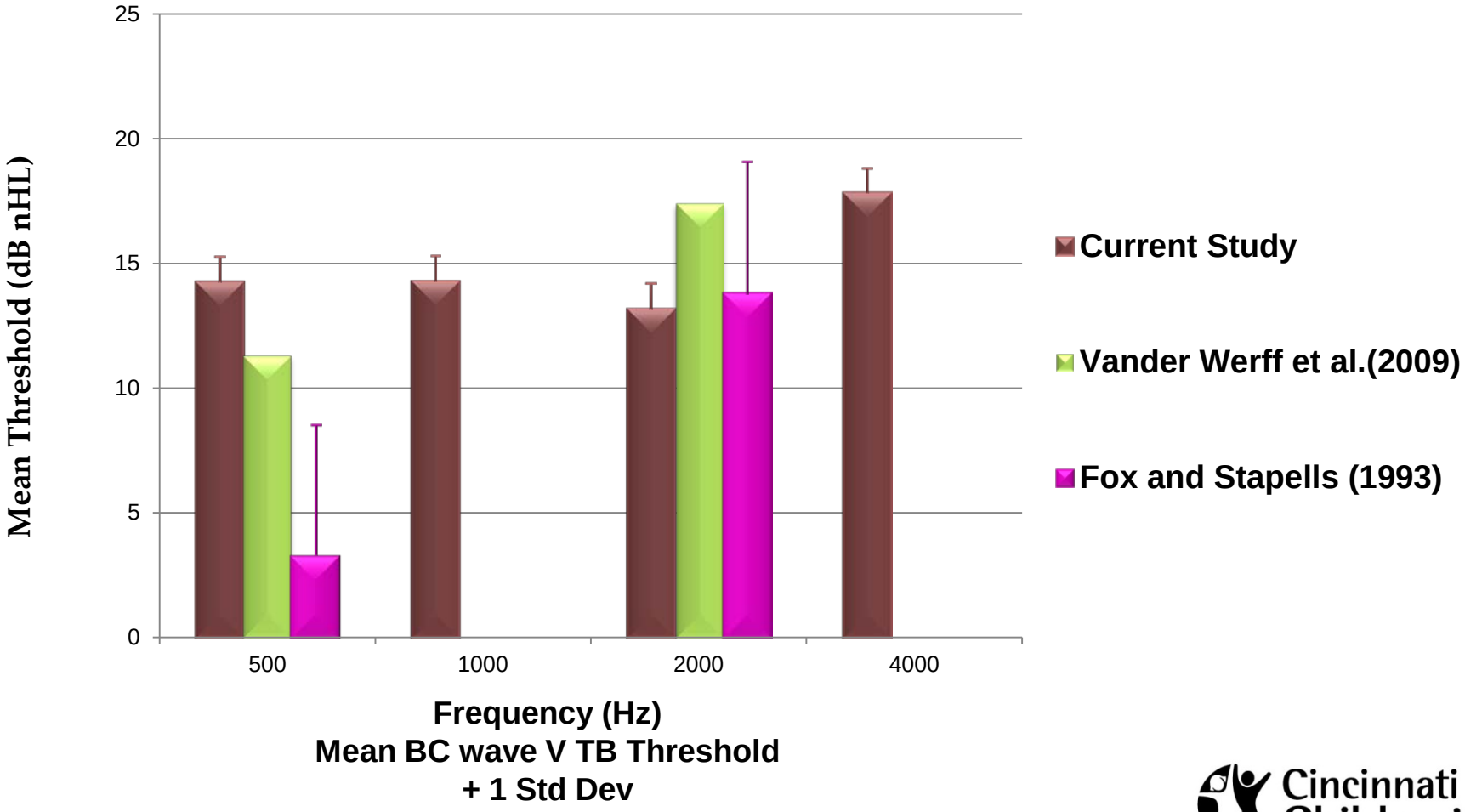
Comparison of the BC thresholds with previous studies in infants



Modified from Elsayed, Hunter, Keefe et al, 2015

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Summary – Tone Burst ABR

- Normative newborn threshold study completed using Kalman weighting and Bluetooth pre-amplifier.
- Low intensity thresholds successfully obtained for masked BC with hand-held bone vibrator over the temporal bone in infants.
- Large sample size across frequencies (500 Hz-4000 Hz).
- AC and BC TB-ABR were easily recorded in infants 2-12 weeks old under natural sleep.

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DPOAE in Infants

- Normative DPOAE data are not available for infants after birth and up to one year of age.
- Normative data currently used clinically are based on studies in older children and adults (1-90 years of age), established by Gorga and colleagues
- The majority of these norms are for adults.

Study Goals

- To provide normative DPOAE data for infants from birth to 18 months age.
- The study differs from others in that it provides longitudinal data over the first year of life.
- Outcome variables were distortion product level (DP), noise floor (NF), and signal-to-noise ratio (SNR).
- Age, risk factors, ear, birth weight, birth type, race, and gender were studied as covariates.

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Methods

- 110 infants were included in the study.
- All infants passed newborn screening, diagnostic ABR at ≤ 30 dB nHL, and visual-reinforced audiometry at ≤ 25 dB nHL.
- DPOAE testing was performed at average ages of 1, 6, 9, and 12 months of age.
- Vivosonic Integrity DPOAE system was used with stimuli of 65 & 55 dB SPL between 1-8 kHz.

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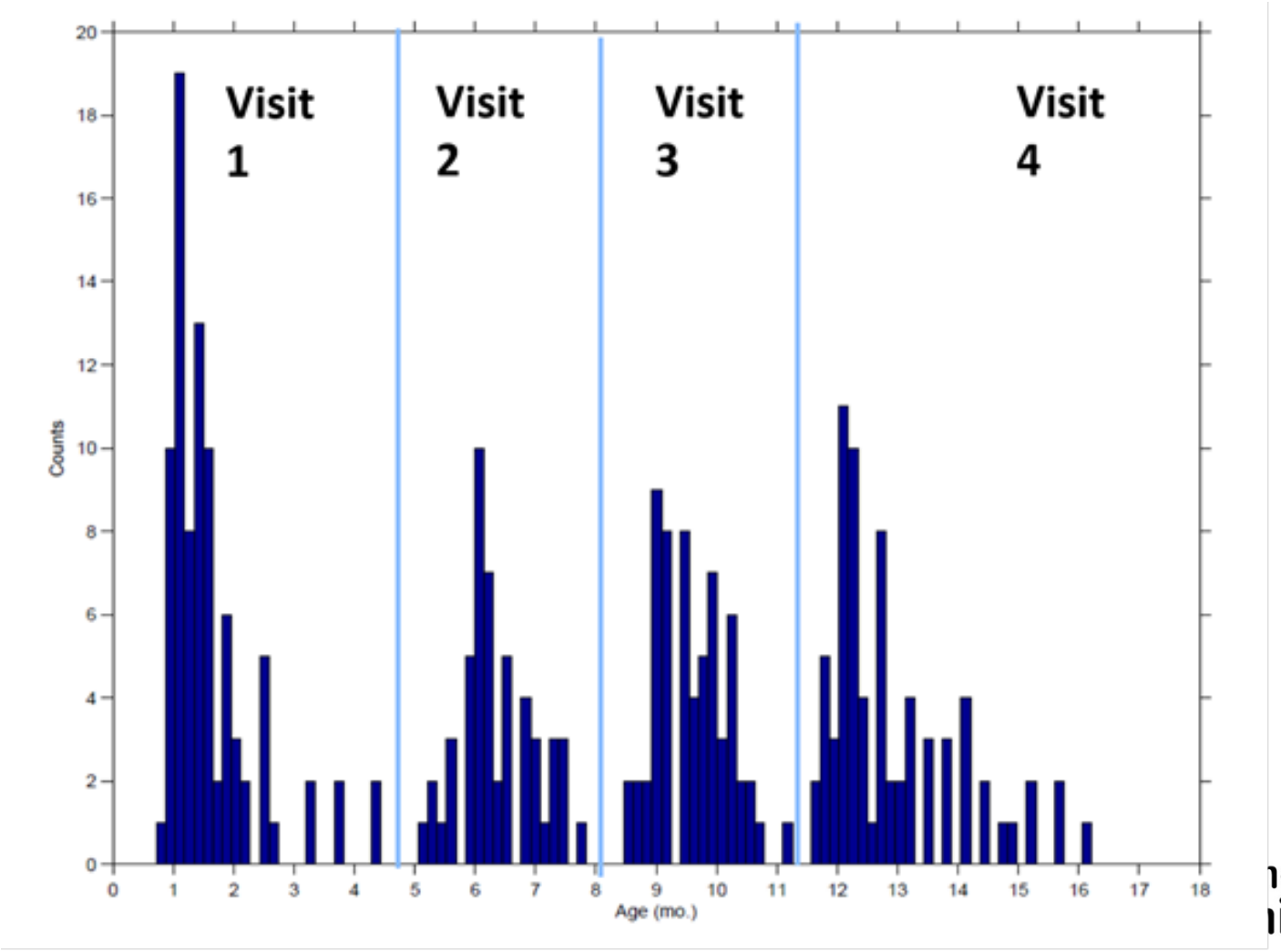
Age at Follow-up Visits



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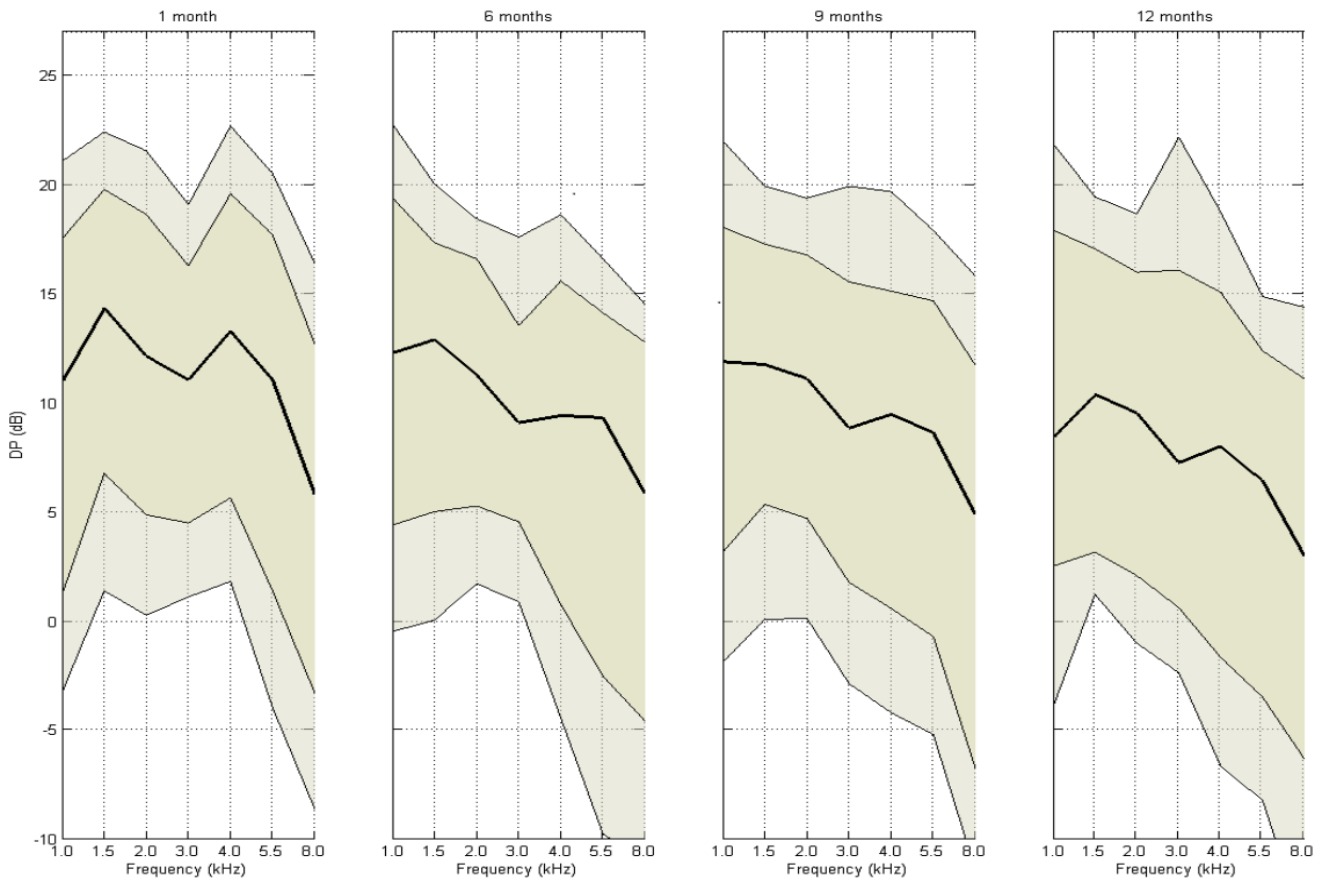
DPOAE Level Decreases from Birth to 12 Mos



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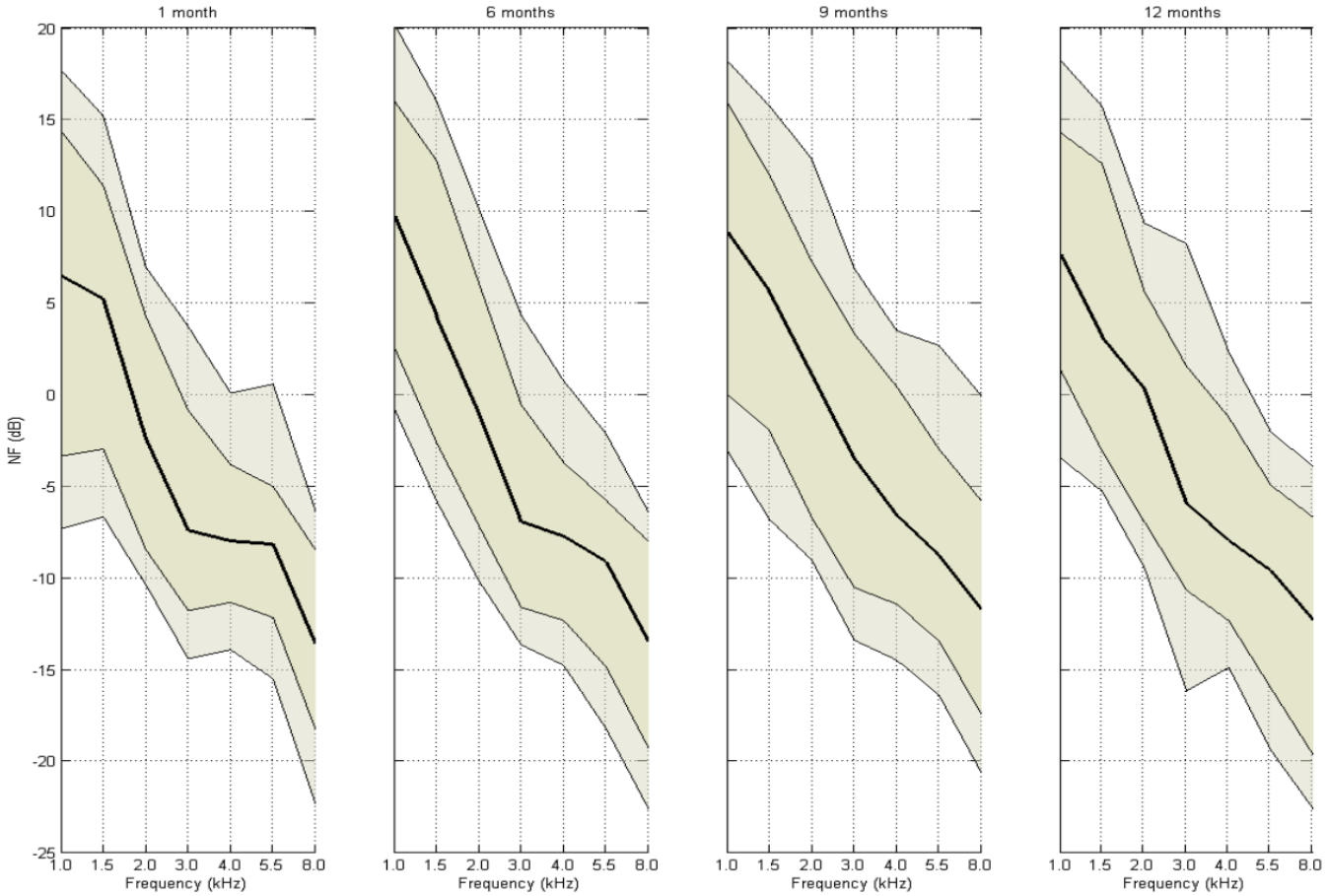
Noise Level Increases from Birth to 12 Mos



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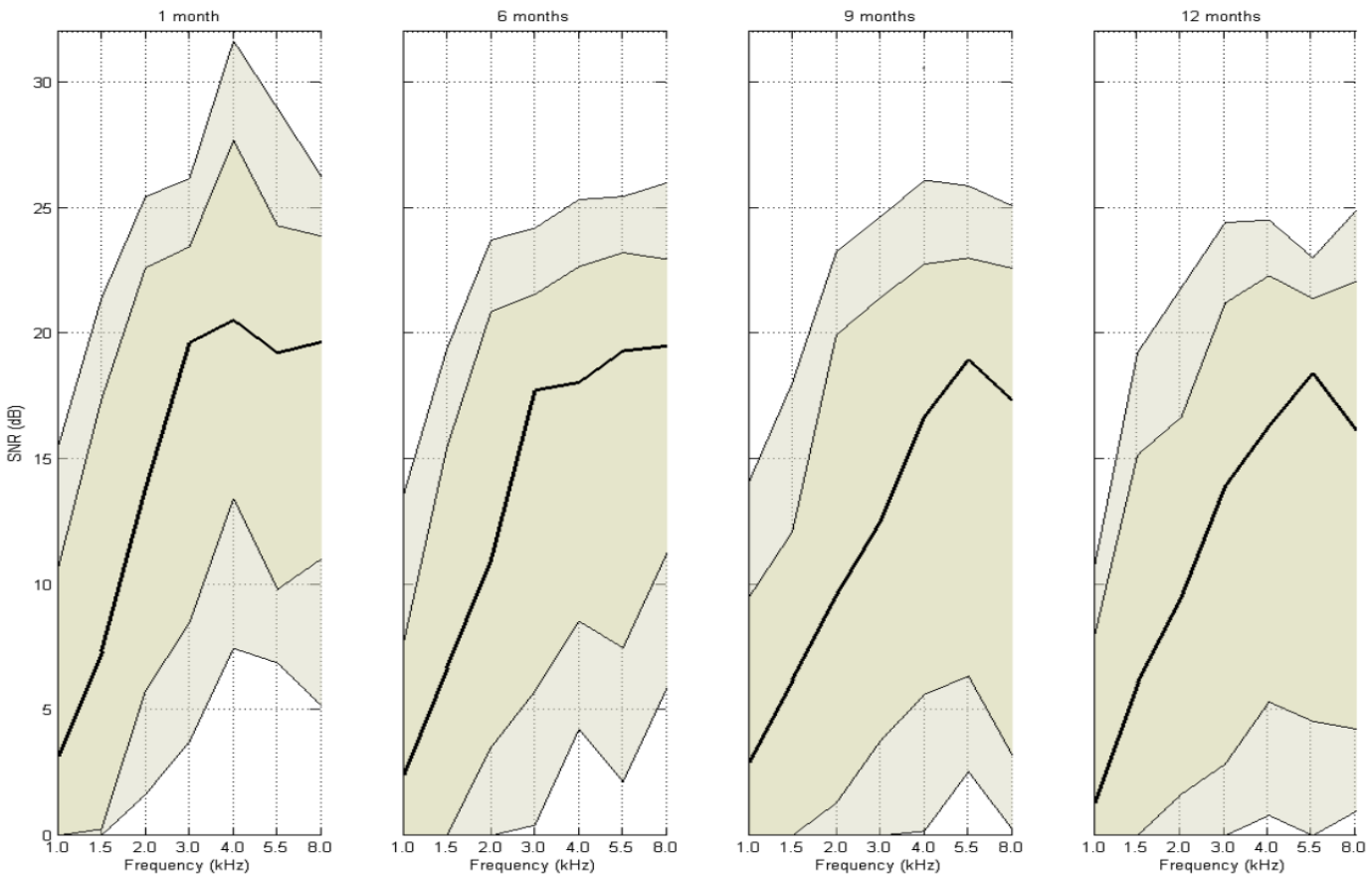
SNR decreases from birth to 12 Mos



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DPOAE SUMMARY

- **This study has implications for diagnosis of hearing in infants birth to age 16 months.**
- DP SNR is only valid for frequencies at 2 kHz and above due to high noise floor in lower frequencies.
- Acceptable SNR of at least 3 dB at each frequency is needed to ensure an interpretable response.
- DP levels should fall above the 20th percentile for at least 3 out of 5 frequencies between 2 and 8 kHz.

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Case Study: Baby Girl 2003

- Enrolled from NICU, 38 week gestational age, >3000 gms
- Treated with Gentamicin
- Screening in NICU:
- Referred on ABR and OAE Left Ear
- Passed ABR and OAE Right Ear

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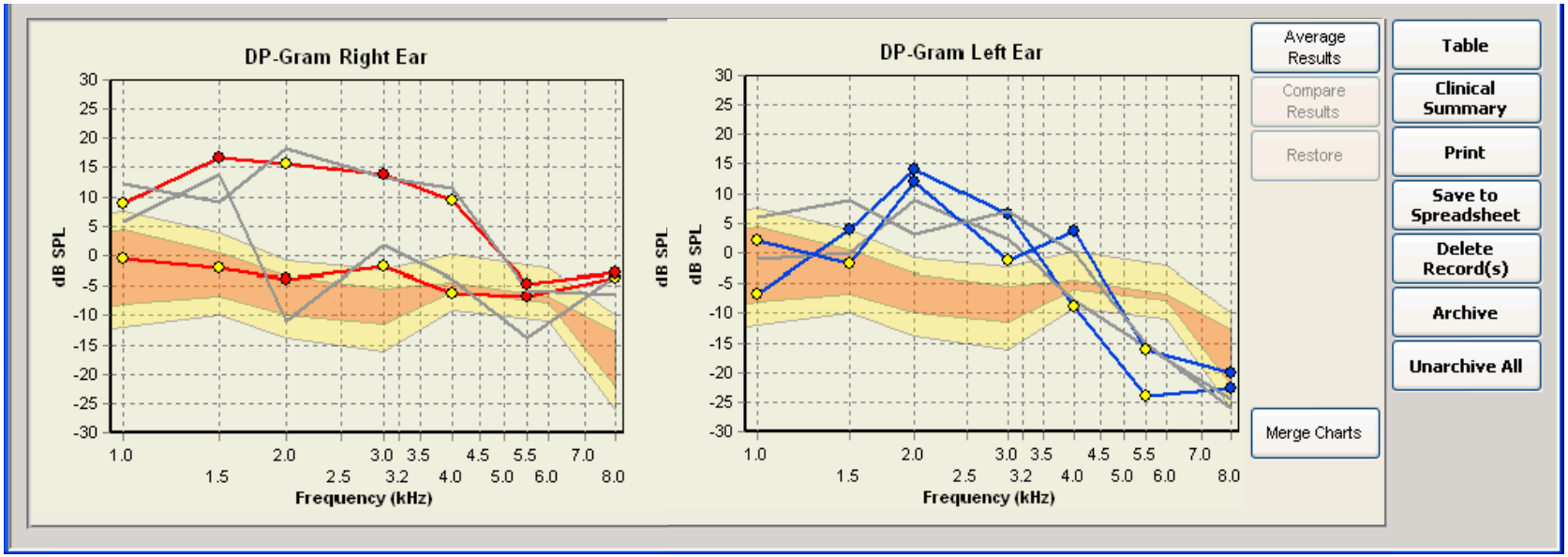
DPOAE: High noise level, both ears
No significant S/N Ratio at any frequency



What are some possible reasons for the absent OAEs?

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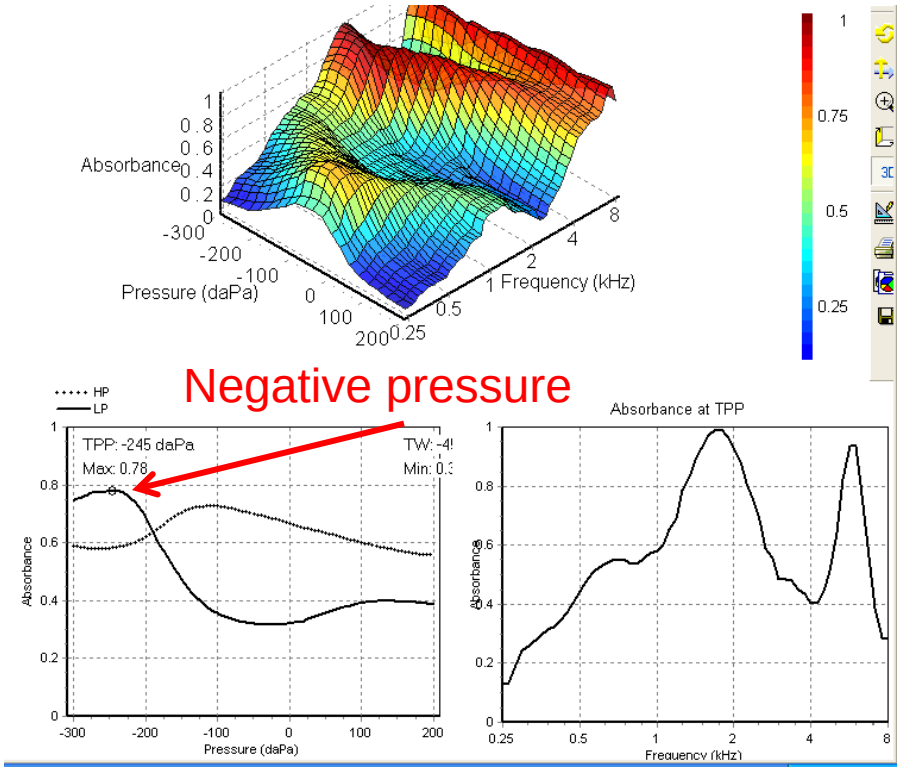
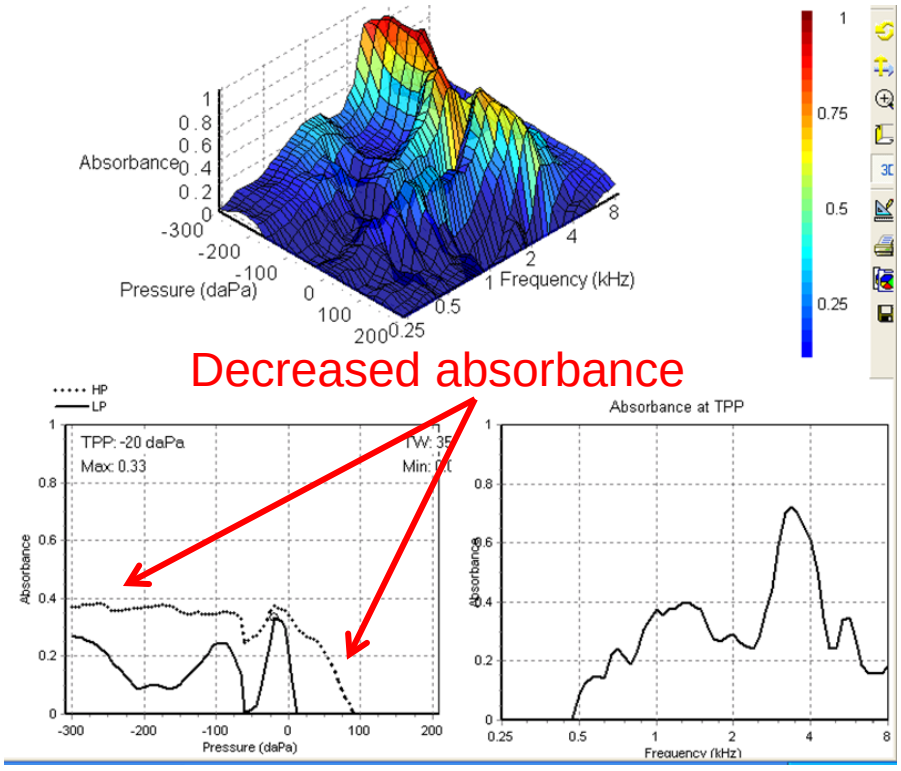
Wideband Tympanograms

Normal Right Ear



Abnormal Left Ear



Right Ear has negative pressure. Absent OAE in left associated with abnormal absorbance.

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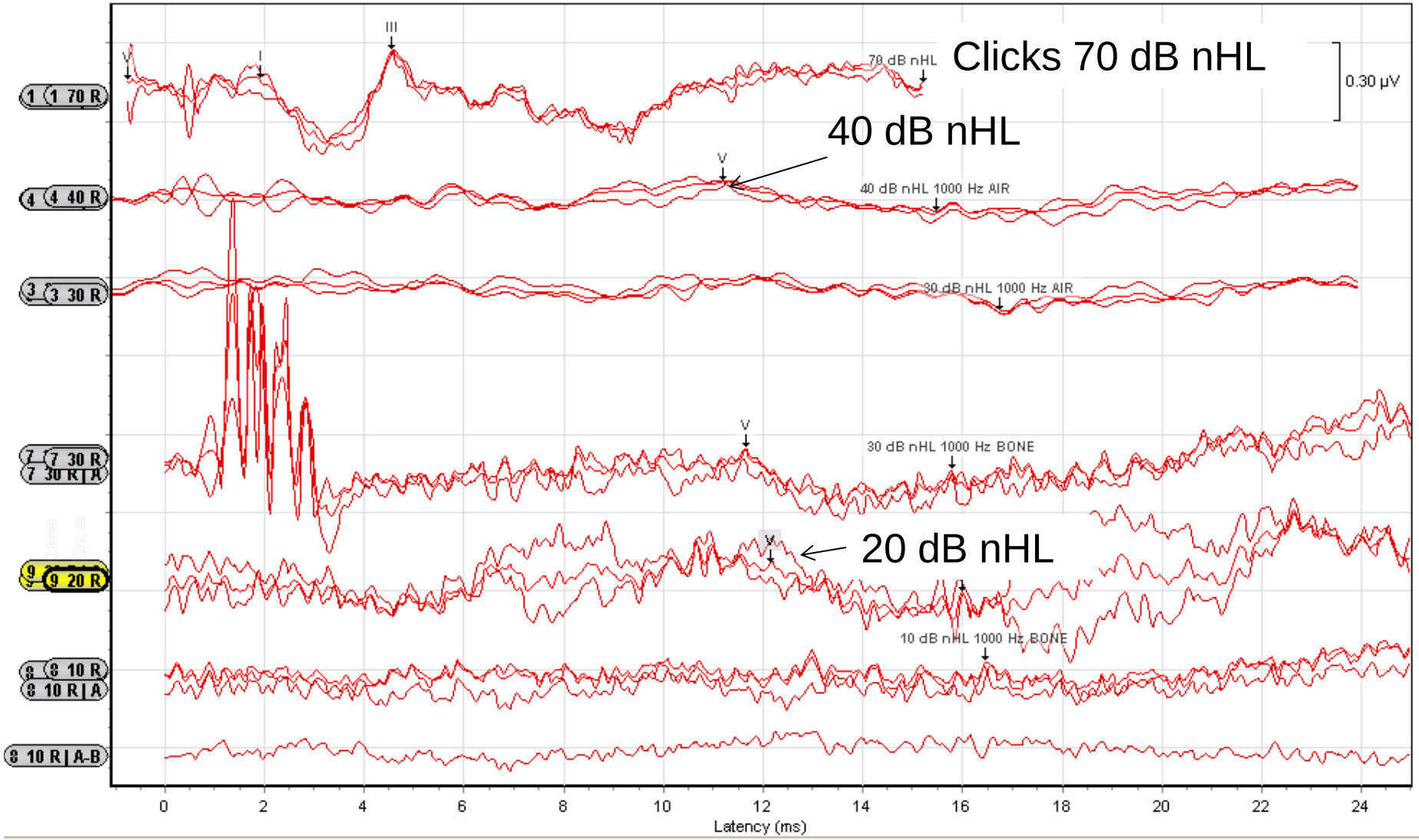
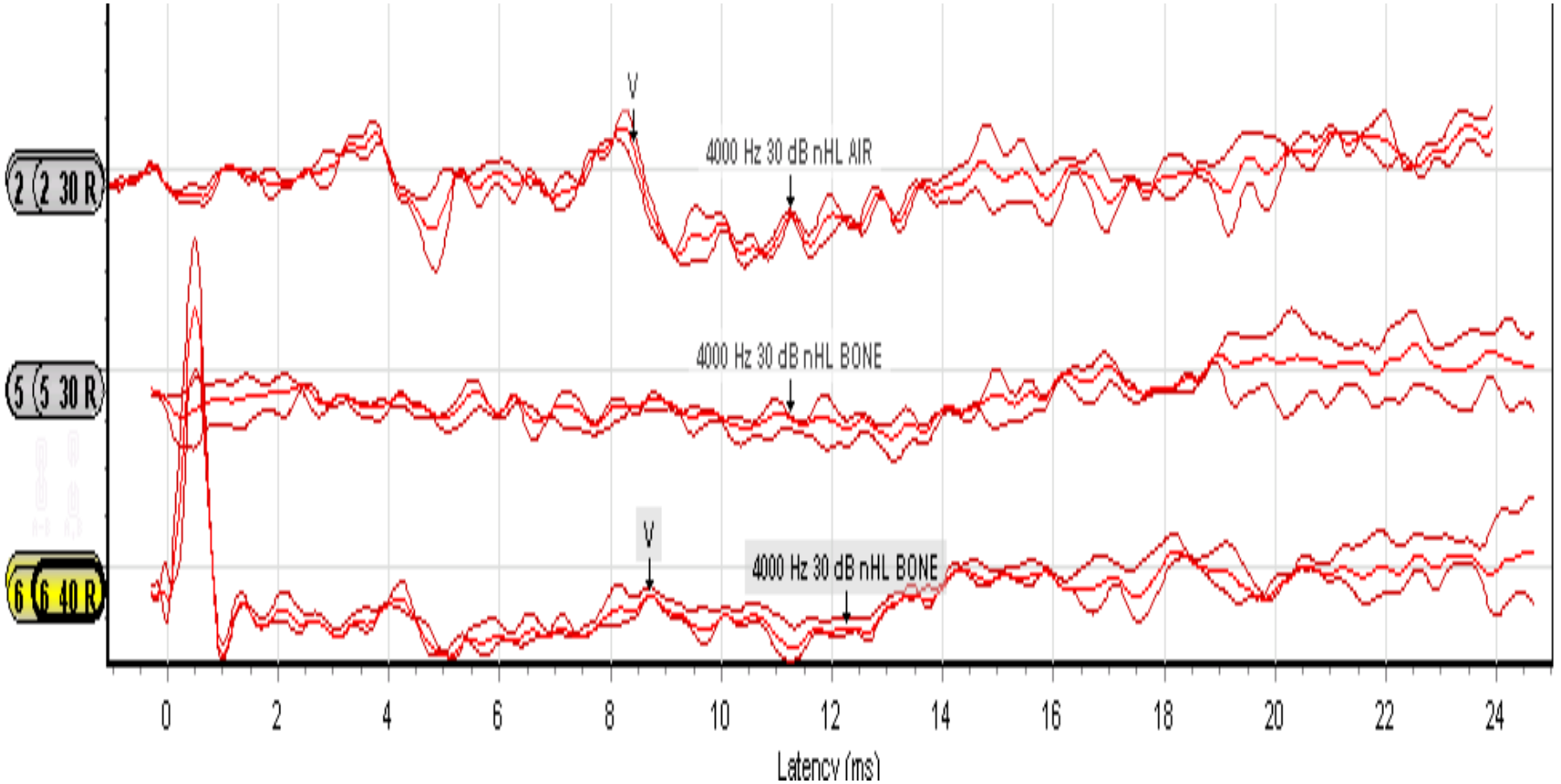
Air (top) and Bone (bottom) Conduction 1 kHz Toneburst ABR

1000 Hz: Air-Bone Gap = 20 dB



Air and Bone Conduction Toneburst ABR

4000 Hz: Air-Bone Gap = 0 dB



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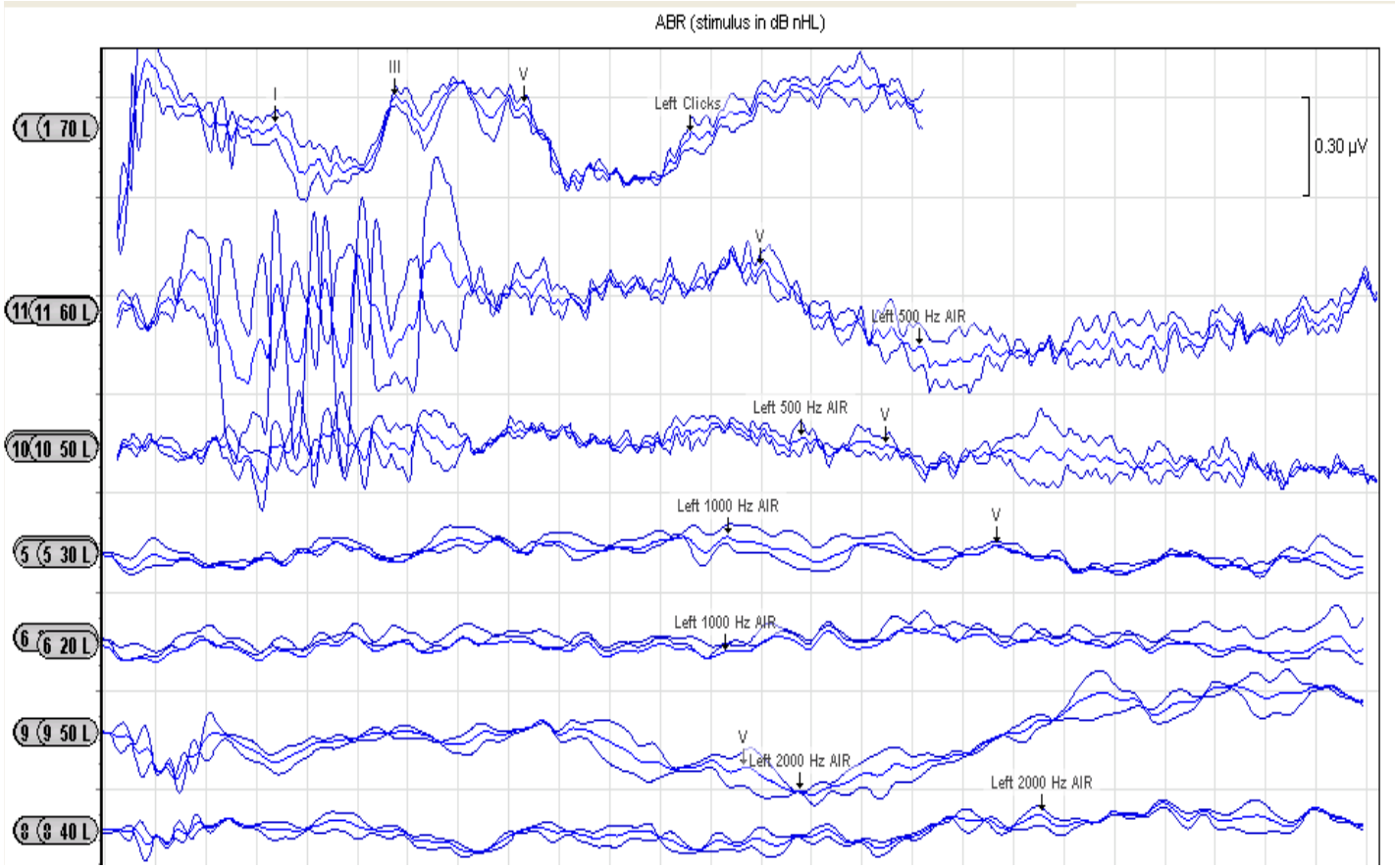
Left Air Conduction ABR

500 Hz = 50 dB, 1000 Hz = 30 dB, 2000 Hz = 50 dB



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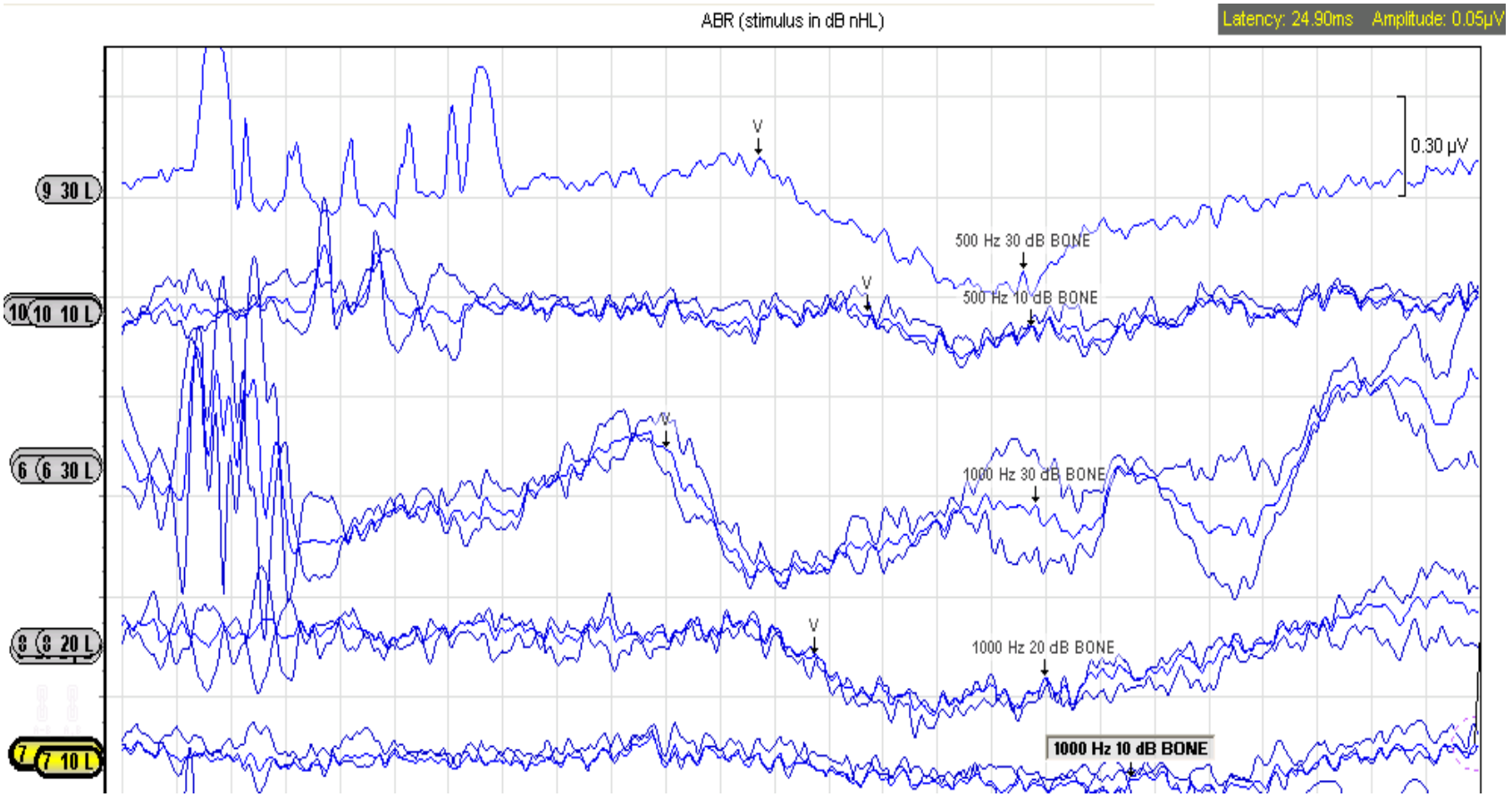
Left Bone Conduction ABR

500 Hz ABG = 40 dB, 1000 Hz ABG = 10 dB



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Take Home Messages

- Normative data with Kalman filtering shows slightly better thresholds than published studies
- No effect of sleep state in quiet infants
- DPOAE testing needs to use age-appropriate norms for infants
- Combination of DPOAE and wideband tympanometry is a powerful diagnostic tool for audiologists

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