



School of Audiology and Speech Sciences

Blending real-life learning with sound science.

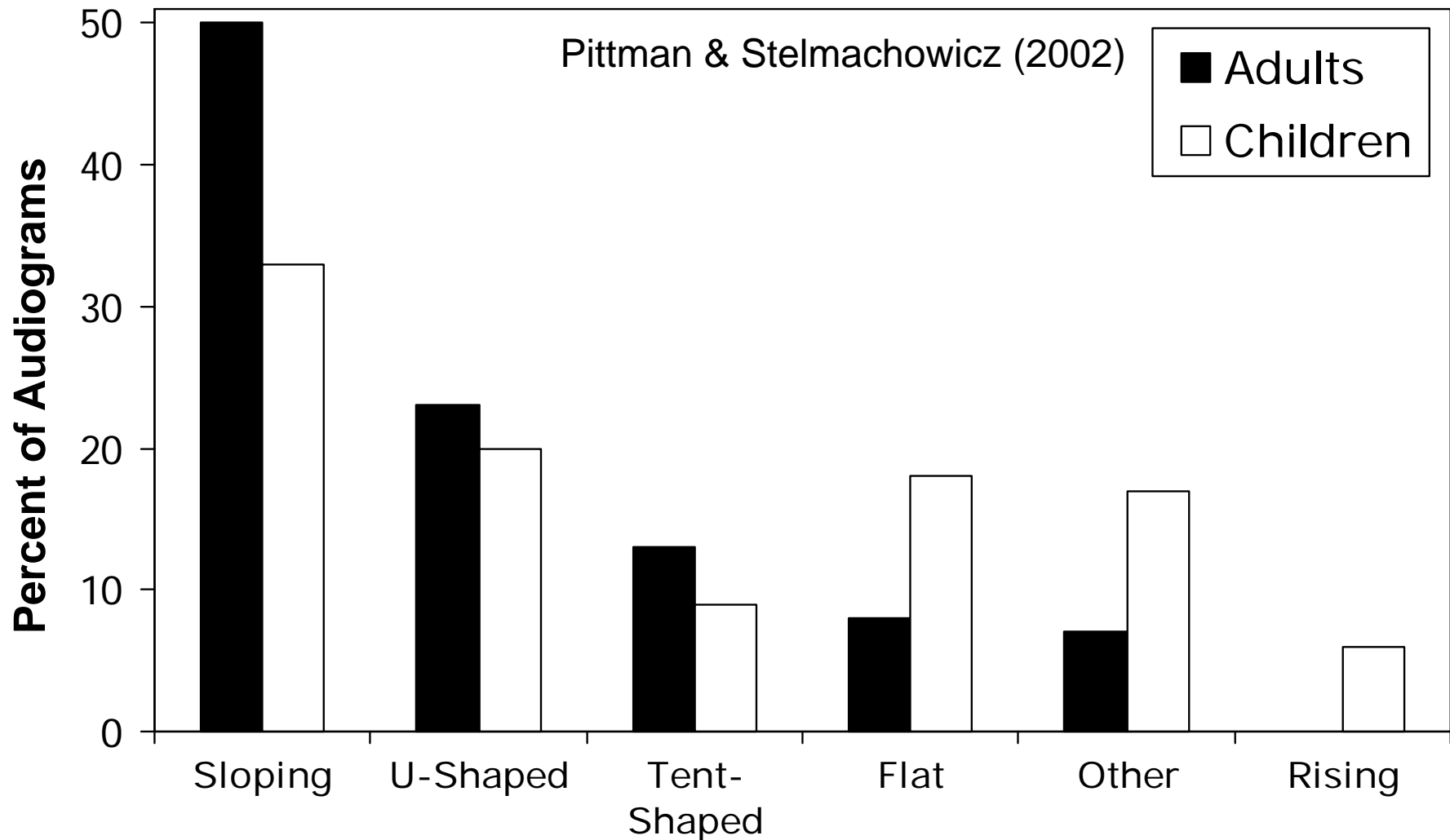
UPDATE ON ELECTROPHYSIOLOGIC MEASURES OF HEARING SENSITIVITY IN INFANTS

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The University of British Columbia, Vancouver, Canada



Why do we need frequency-specific stimuli?



- *Most (>80%) SNHL does NOT have flat configuration*
- *Children have a wider variety of configurations than adults*

AUDITORY STEADY-STATE RESPONSES (ASSRs)

- The technique
- Current status/New data
- What's needed

Multiple-ASSR: Multiple Simultaneous Stimuli May Be Used

INDIVIDUAL STIMULI

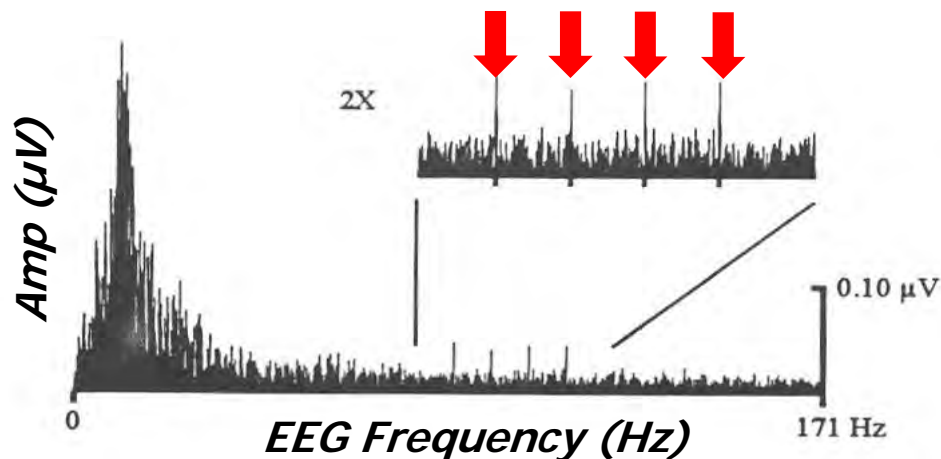
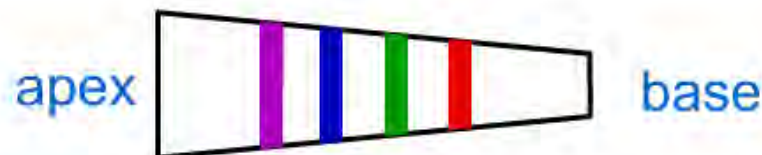
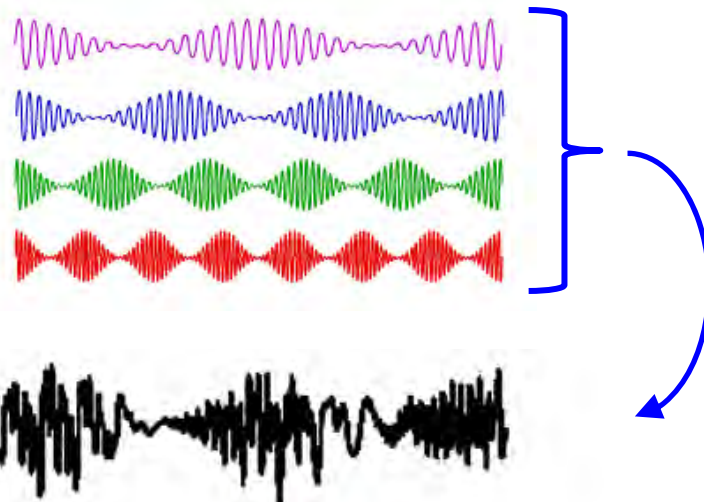
each with own f_{mod}

STIMULI ADDED TOGETHER

each with own f_{mod}

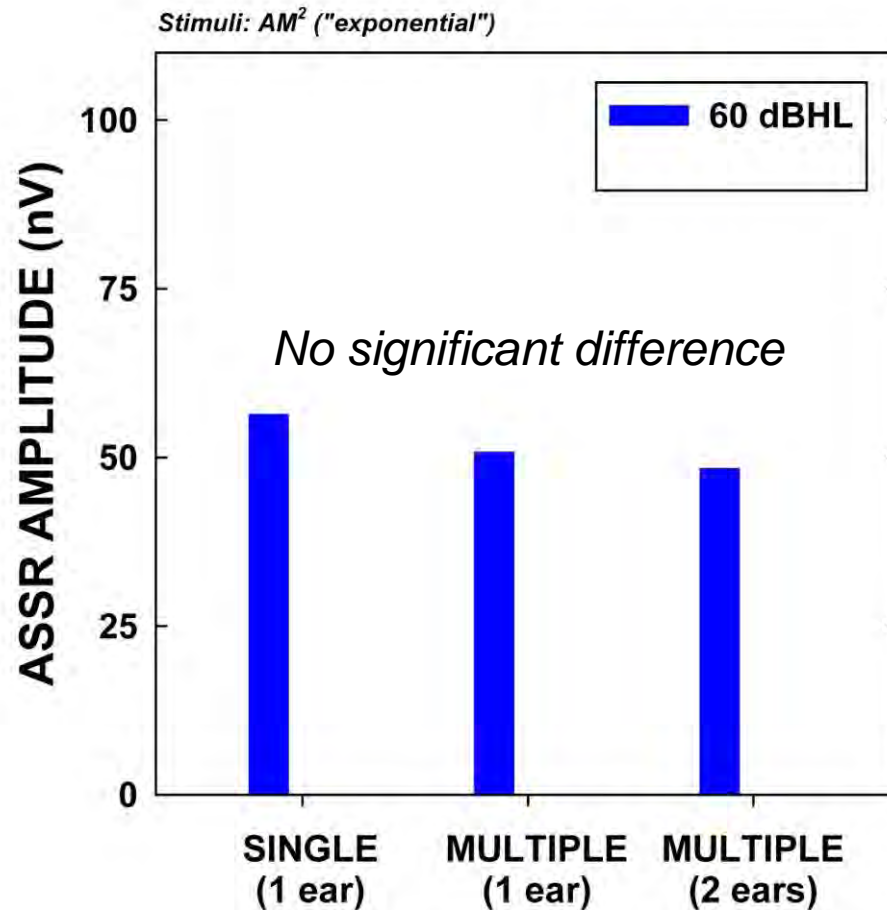
stimuli are processed
by the cochlea

A. Dimitrijevic



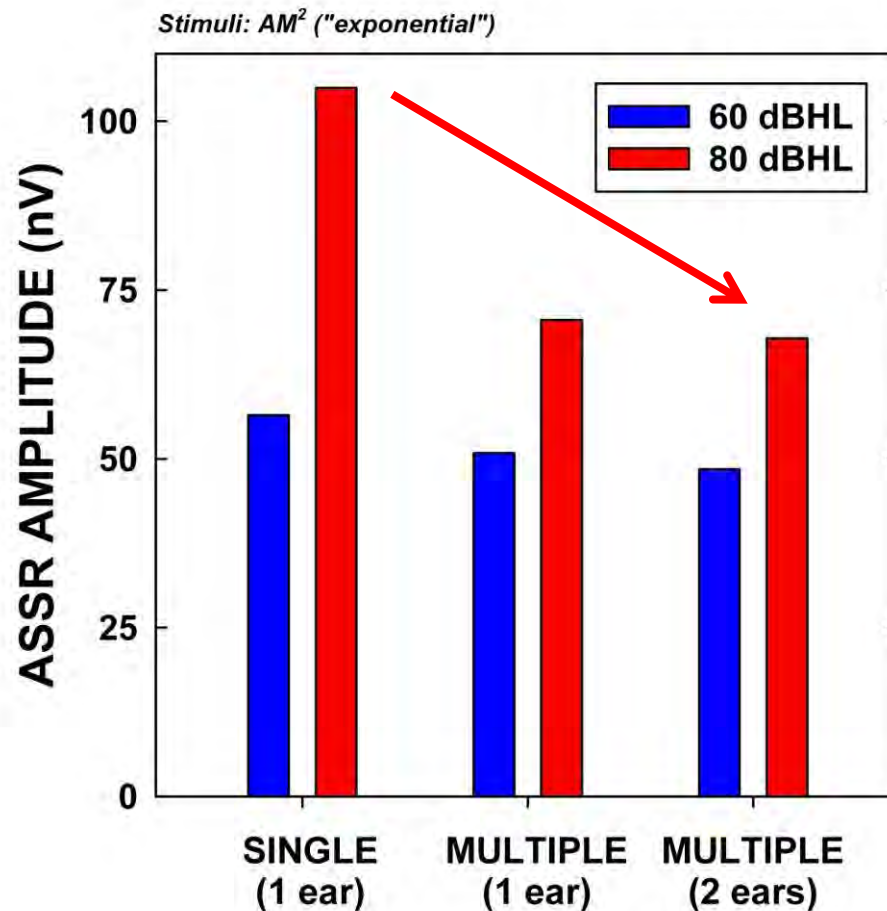
EEG analysis – computer
automatically determines
if significant energy at
modulation rates for
each carrier frequency

DO ASSR AMPLITUDES DECREASE WITH MULTIPLE STIMULI?



**NOT FOR 60 dBHL STIMULI (OR LOWER) -- NO "INTERACTIONS"
MULTIPLE THUS FASTER!**

DO ASSR AMPLITUDES DECREASE WITH MULTIPLE STIMULI?



FOR 80 dBHL STIMULI: YES! → SIGNIFICANT “INTERACTIONS”

MULTIPLE MAY NOT BE FASTER!

EFFICIENCY OF MULTIPLE-ASSR AUDIOMETRY: IS MULTIPLE FASTER THAN SINGLE?

**AT LEAST IN NORMAL ADULTS, EVEN WITH INTERACTIONS,
MULTIPLE 80-Hz ASSR REMAINS MORE EFFICIENT
(FASTER) THAN SINGLE ASSR, AT LEAST FOR LOW-
MODERATE INTENSITIES**

**SURPRISINGLY, THIS QUESTION NOT FORMALLY TESTED
IN (i) INFANTS OR (ii) INDIVIDUALS WITH SNHL**

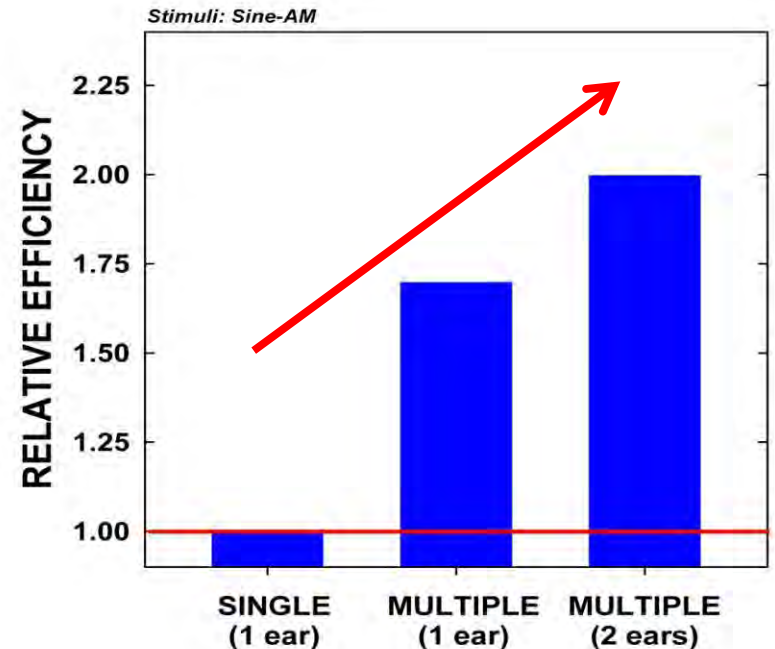
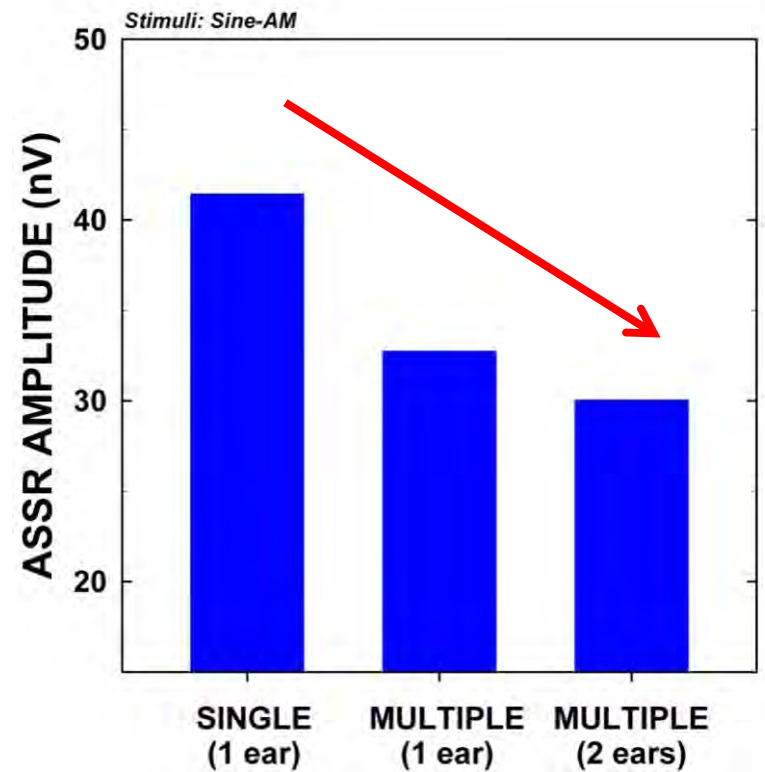
**YET MANY MANUFACTURERS ARE MARKETING MULTIPLE-
ASSR SYSTEMS AND MANY CLINICIANS ARE JUMPING TO
MULTIPLE ASSR**



INTERACTIONS: WHAT ABOUT INFANTS?

Hatton & Stapells (in press)

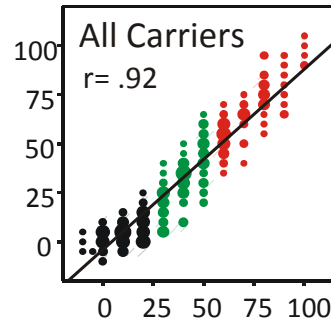
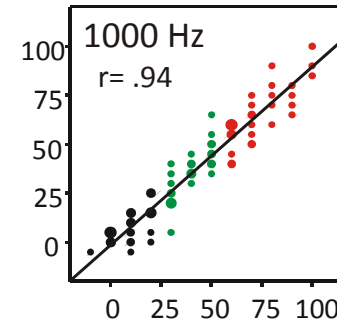
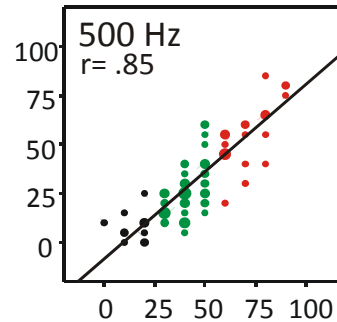
- In contrast with adults, infants show significant interactions at 60dB SPL (i.e., smaller amplitudes for multiple stimuli)
- However, even with smaller amplitudes, the **multiple-ASSR method remains significantly more efficient (faster) than single stimulus ASSR**
- Also, no significant difference in threshold single vs multiple ASSR
- However, we do not know whether multiple is better for infants/adults with SNHL



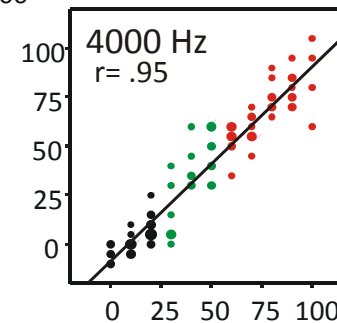
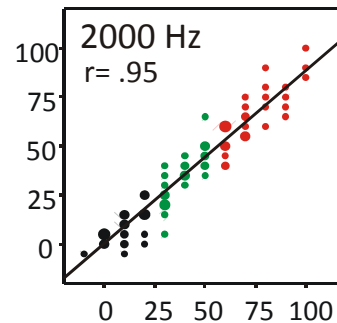
80-Hz ASSR ESTIMATION OF AC THRESHOLD

Many studies in adults indicating good accuracy estimating pure-tone behavioural threshold

Multiple-ASSR & SNHL
(ADULTS)



Behavioural (dB HL)
↑
Thresholds
→ Physiological (dB HL)

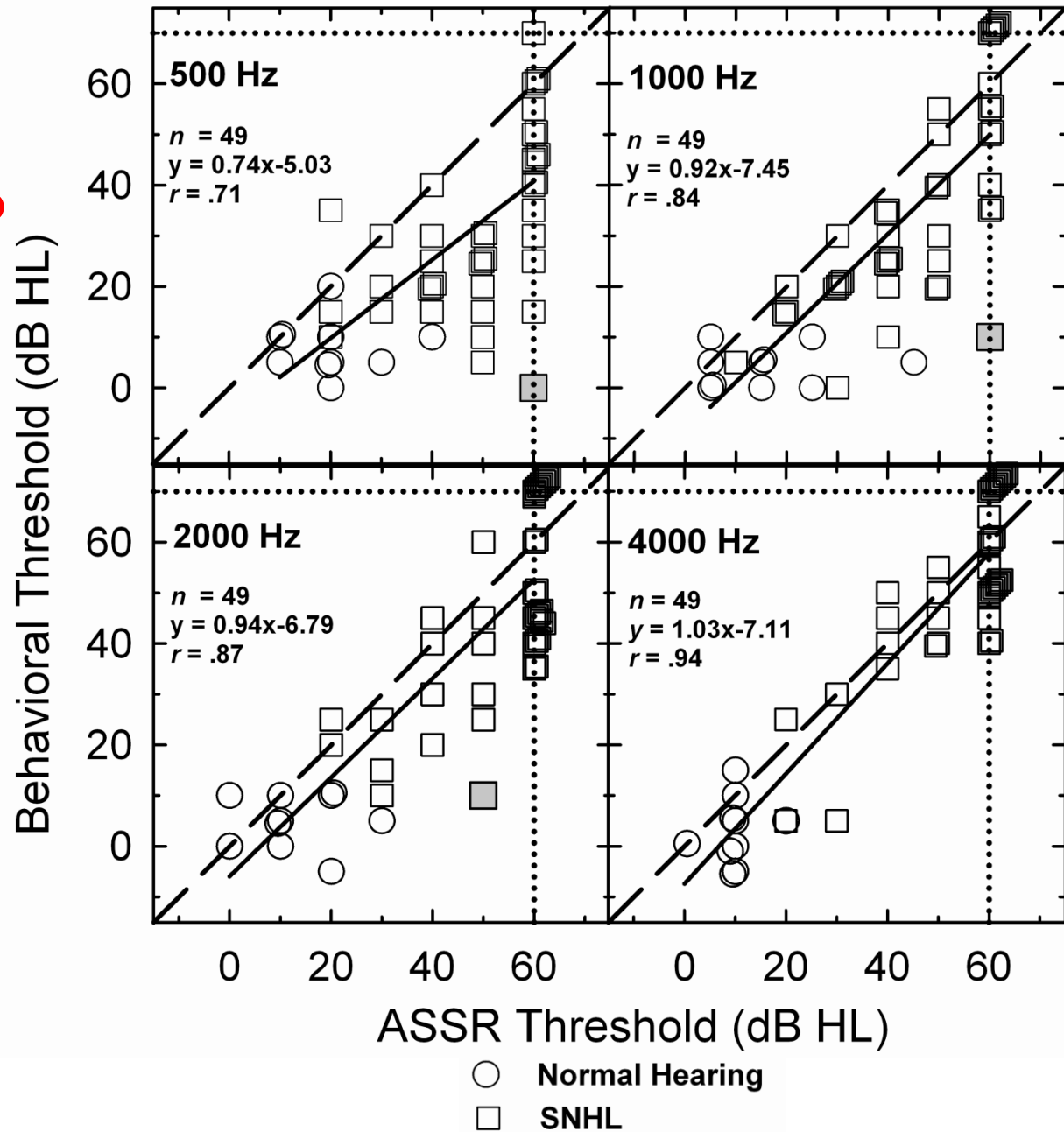


Dimitrijevic et al., 2002

Very similar to tone-ABR results

Bone-Conduction ASSR: Adults with SNHL?

VERY FEW DATA!



- Results are promising (esp. 1000-4000 Hz)
- 89% of thresholds accurately classified as “normal” or “elevated” (92% 1k-4k)



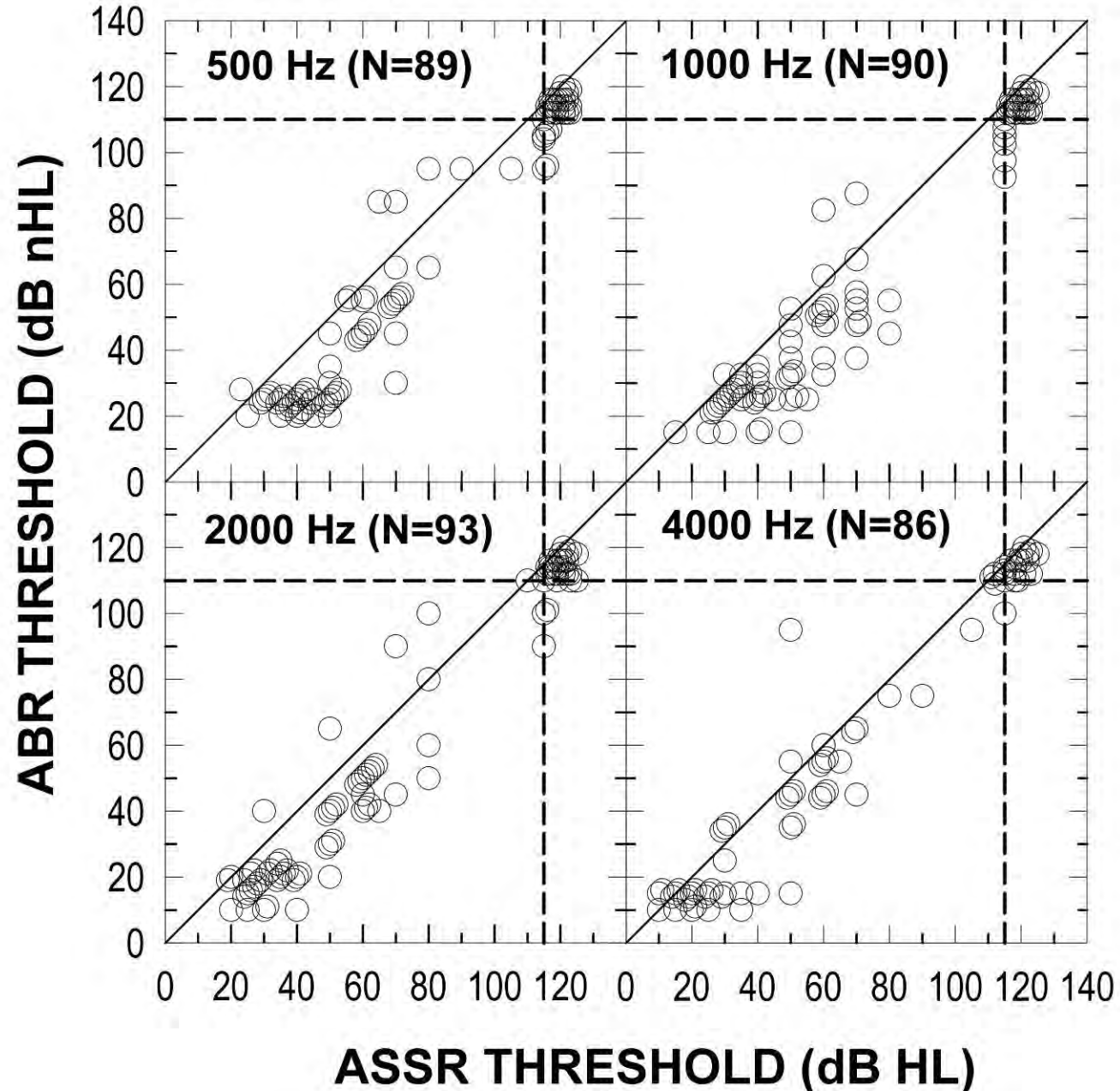
What about me?

Multiple ASSR (AC) vs tone-ABR in infants with hearing loss

CORRELATIONS

ALL: $r = .97-.98$

EXCLUDE "NR":
 $r = .75$ (1k) to $.87$



ASSR IN INFANTS/YOUNG CHILDREN:

WHAT'S MISSING?

Too few multiple-ASSR data for infants with *documented* HL

- Only 3 studies! Hot off the press! 4th study just published (Alaerts et al., 2010)
- Several other studies with only AC click-ABR
- Many studies with older children and adults, but few with infants/young children

No AC-ASSR results (single or multiple) in infants with *documented* conductive/mixed HL

- Only 1 study in children (BUT: no bone conduction; only AC click-ABR)

No BC-ASSR results (single or multiple) in infants with *documented* SNHL or conductive loss

- Only 1 study in children (BUT: no bone conduction; only AC click-ABR)

BUT: WE DO KNOW WHAT IS NORMAL FOR INFANT ASSR THRESHOLDS (AIR-CONDUCTION STIMULI)

Based on at least 8 studies, we now have a good idea about what a "normal" AC ASSR threshold is in an infant

“Normal AC Levels” → *Maximum intensity to be considered normal (i.e., must be present at):*

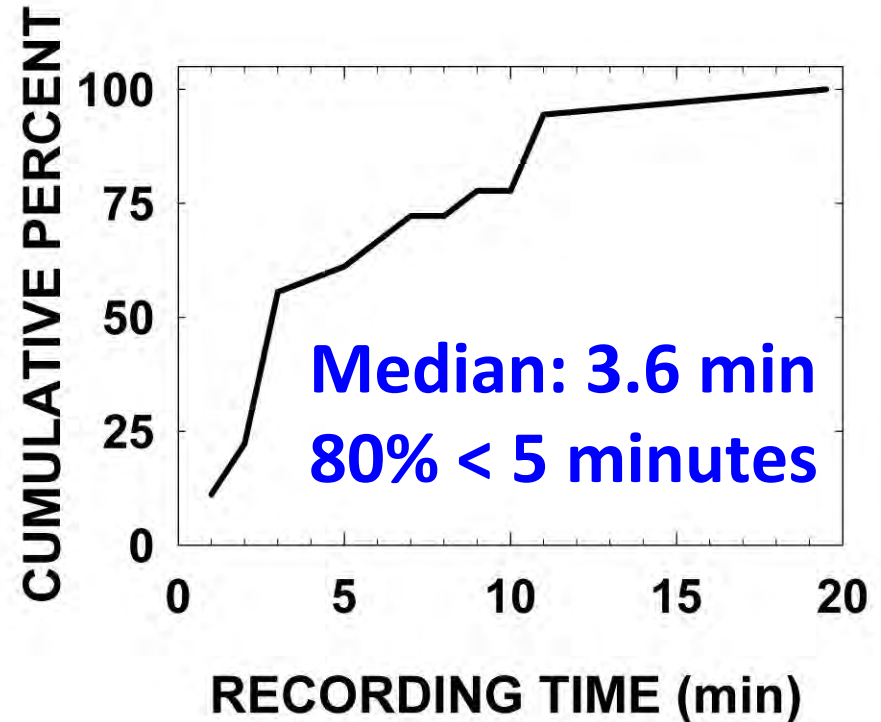
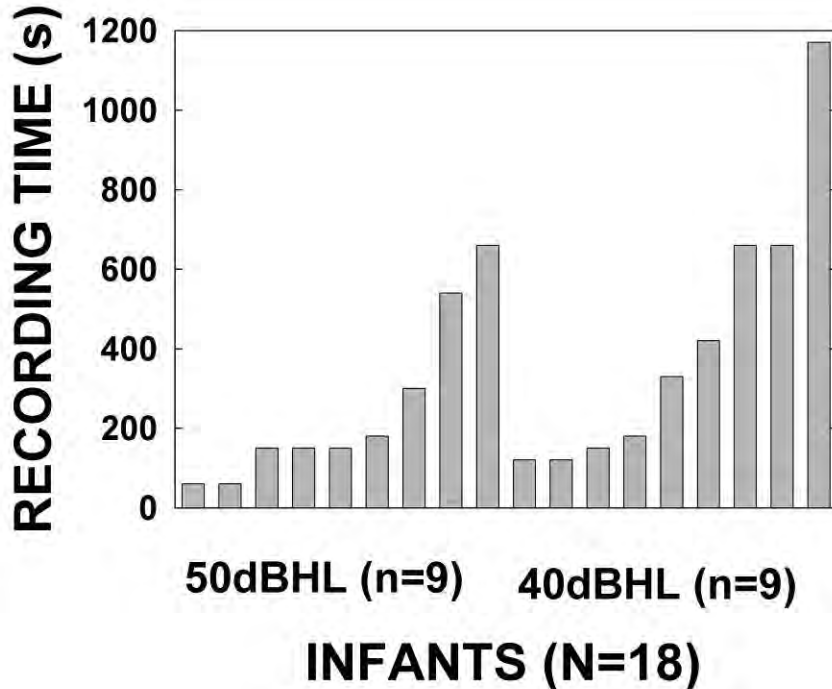
<u>FREQ</u>	<u>dBHL</u>
500 Hz:	50
1000 Hz:	45
2000 Hz:	40
4000 Hz:	40

Van Maanen & Stapells, 2009

CLINICAL IMPLICATION: AC multiple-ASSR could be used to quickly establish whether "normal" or "elevated" simultaneously for both ears & four frequencies

Multiple-ASSR (4 frequencies to each ear) can quickly determine if “normal” or “elevated”

RECORDING TIME FOR “NORMAL” BOTH EARS (40-50 dBHL)



Do these AC-ASSR “normal” levels miss hearing loss?

Table 3. Accuracy of “normal” multiple-ASSR levels for classification of “normal” versus “elevated” threshold

		ASSR THRESHOLD	
		Normal	Elevated
ALL	Normal	136 (20%)	22 (3%)
	Elevated	22 (3%)	501 (74%)

(N=34 normal; N=98 hearing loss)

ANSWER: No.

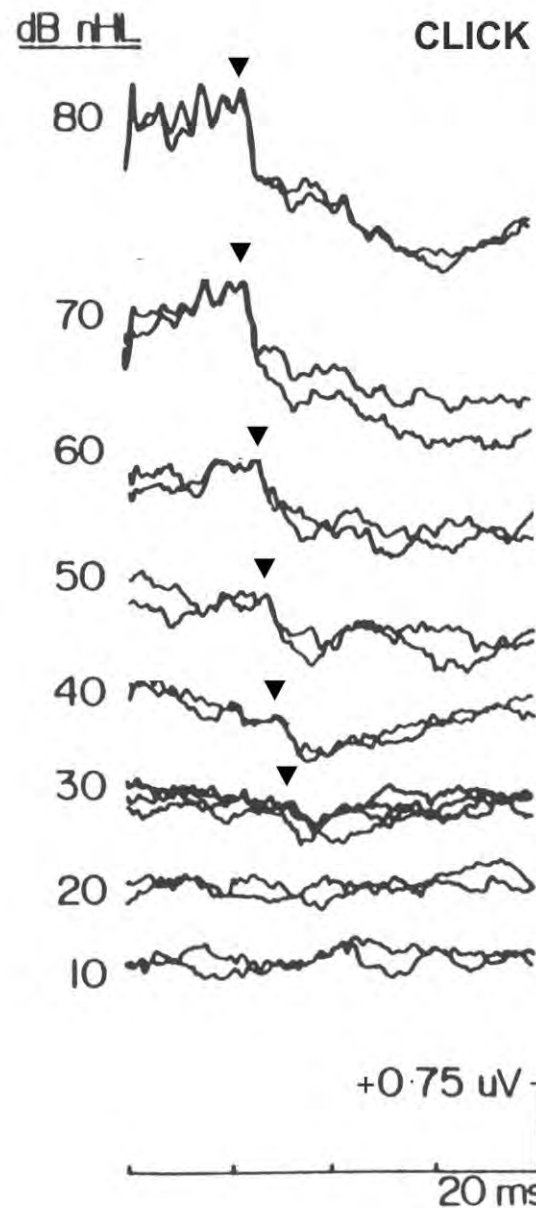
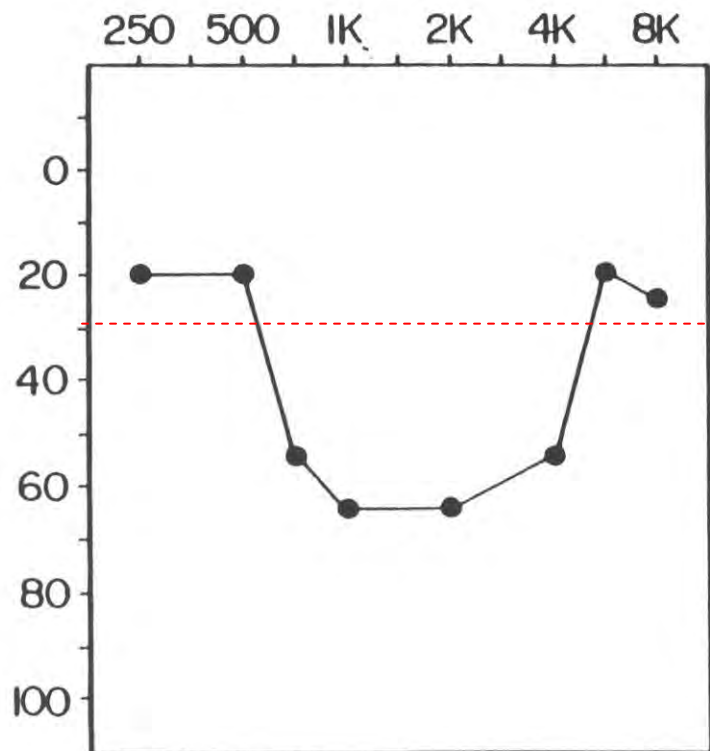
Even the few (3%) that were “missed” were not really “lost” because other frequencies were elevated

FREQUENCY-SPECIFIC THRESHOLDS IN YOUNG INFANTS:

TONE-EVOKED AUDITORY BRAINSTEM RESPONSE

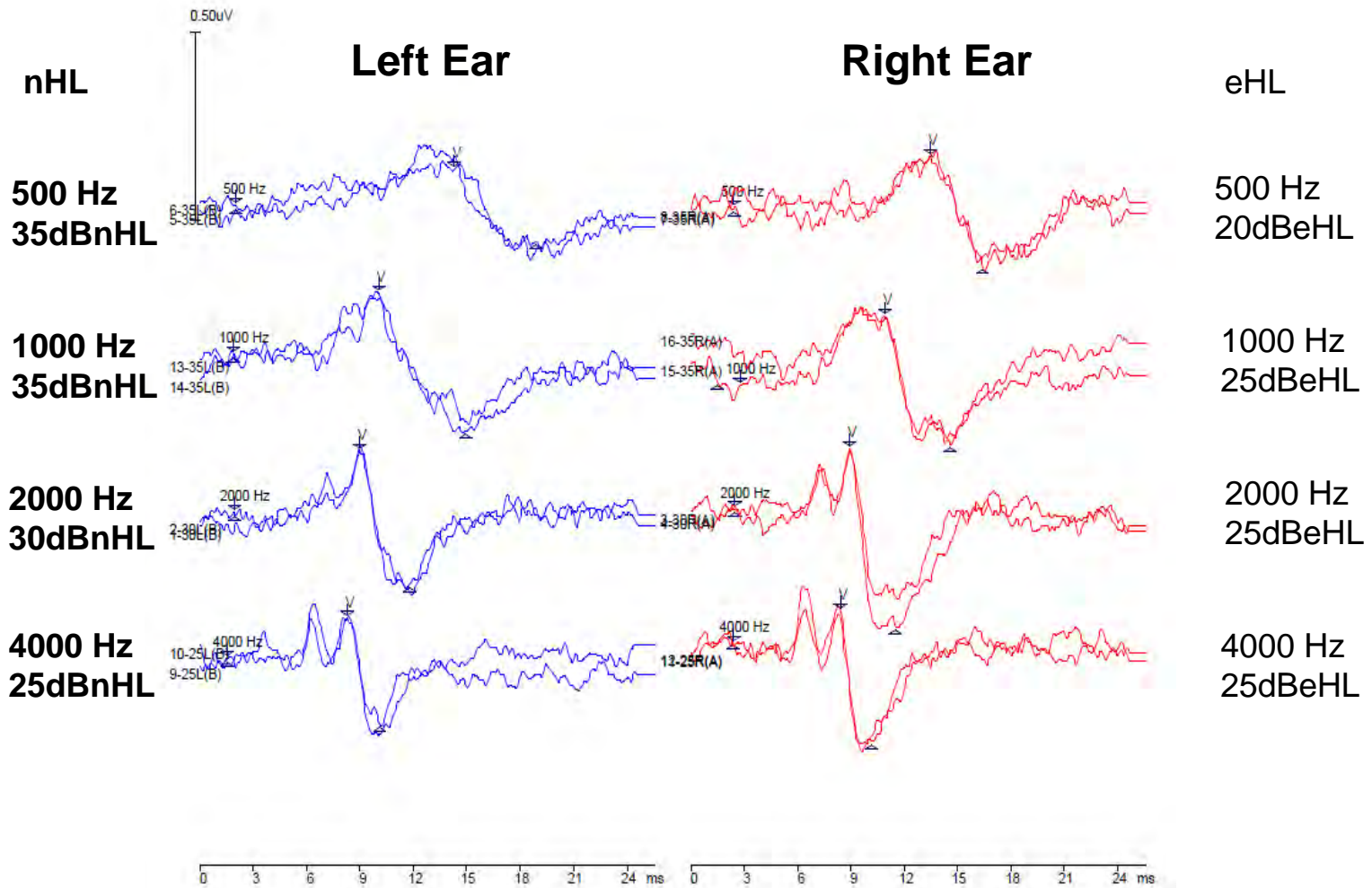
- The current “gold standard”
- Air- and Bone-Conduction tone-ABR
- Protocols

A REMINDER: ISSUES WITH CLICKS (Click-ABR)



TONE-ABR REQUIRED!

Infant Tone-ABR @ “normal” intensities*



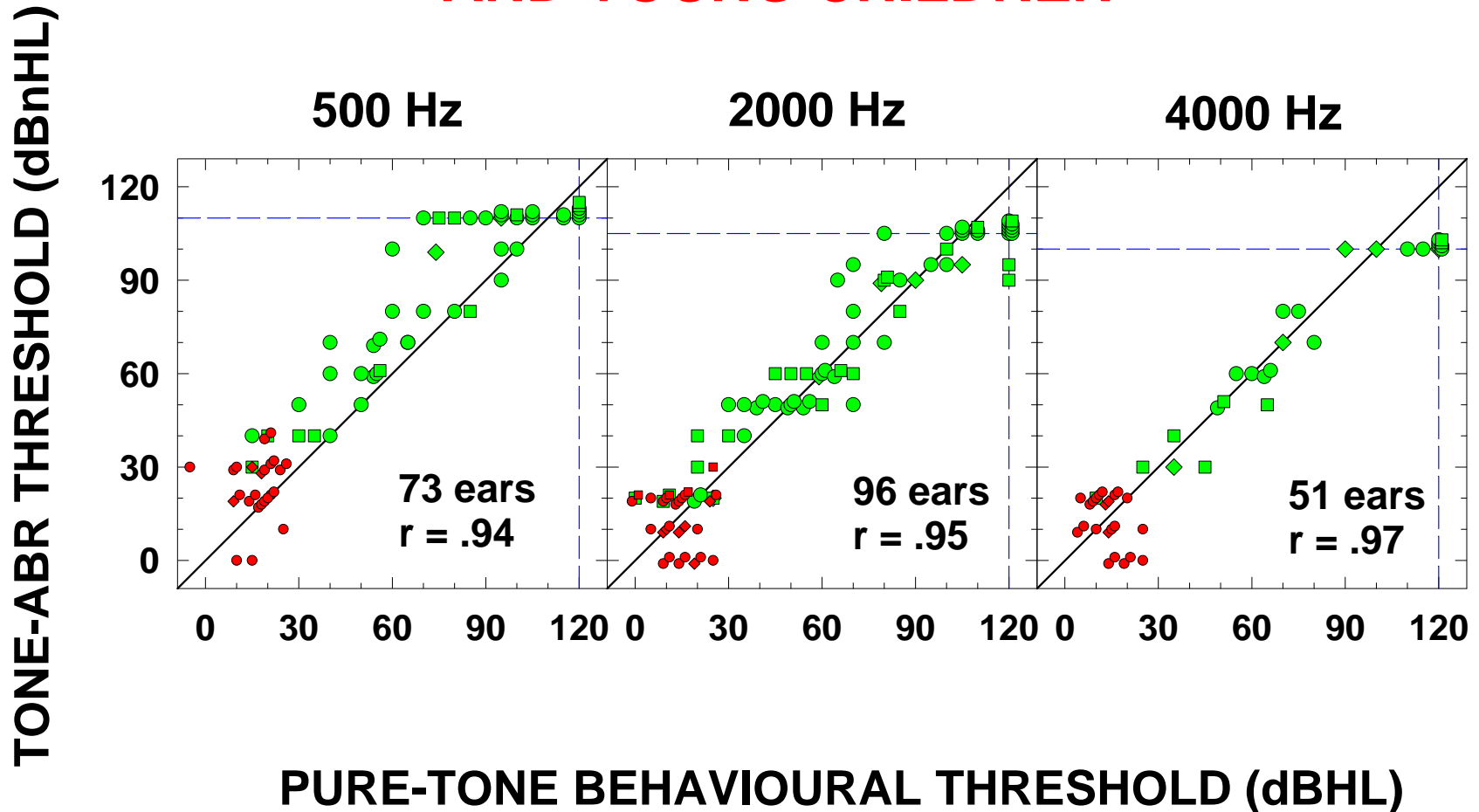
* Infant hearing considered “normal” if responses present at these intensities (BCEHP)



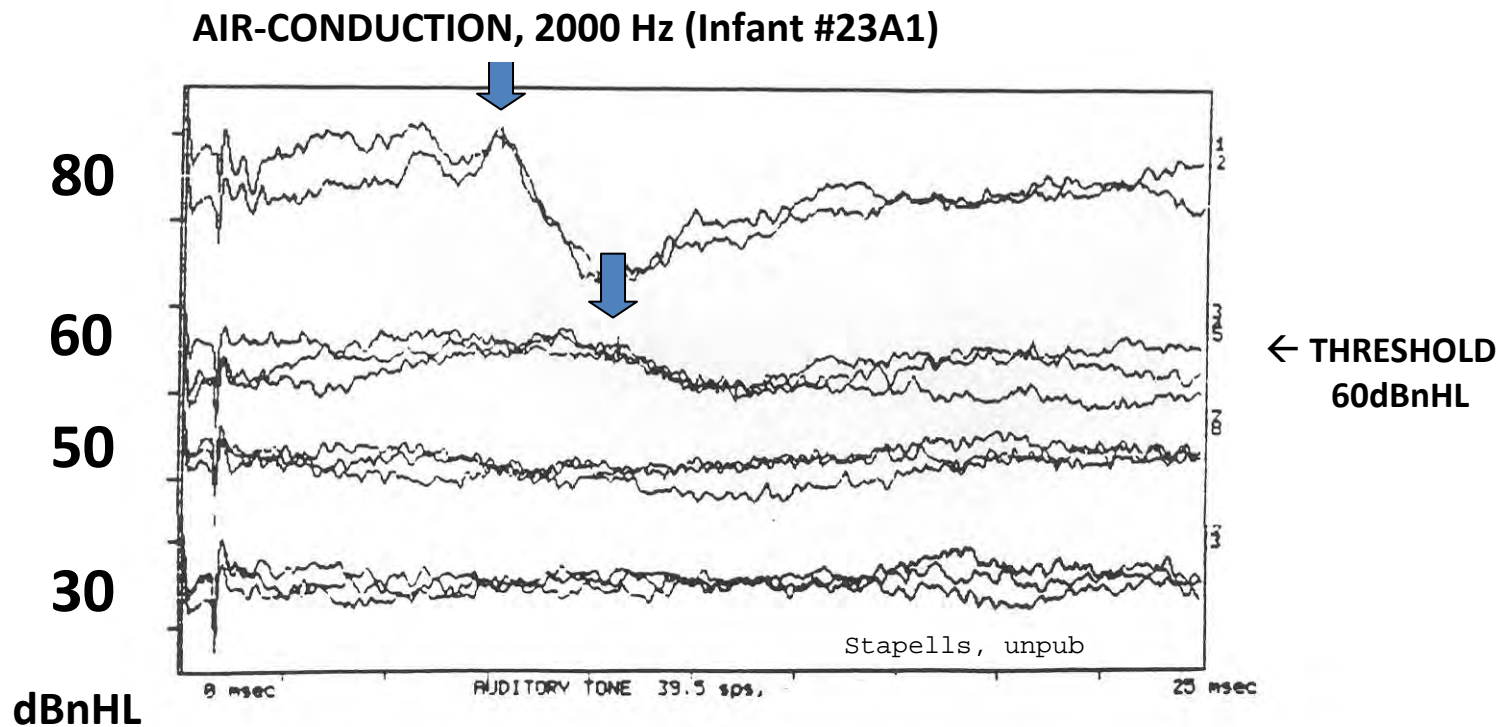
Great!

*But what about thresholds
if I have a hearing loss?*

MANY STUDIES AND CLINICAL EXPERIENCE HAVE SHOWN TONE-ABR PROVIDES GOOD ESTIMATION OF PURE-TONE BEHAVIOURAL THRESHOLD IN INFANTS AND YOUNG CHILDREN



Infant ABR threshold assessment



Flat tympanogram
Absent OAE

HOWEVER: Too commonly, clinicians have stopped here...

Nature of threshold elevation? Management? Info for parents?

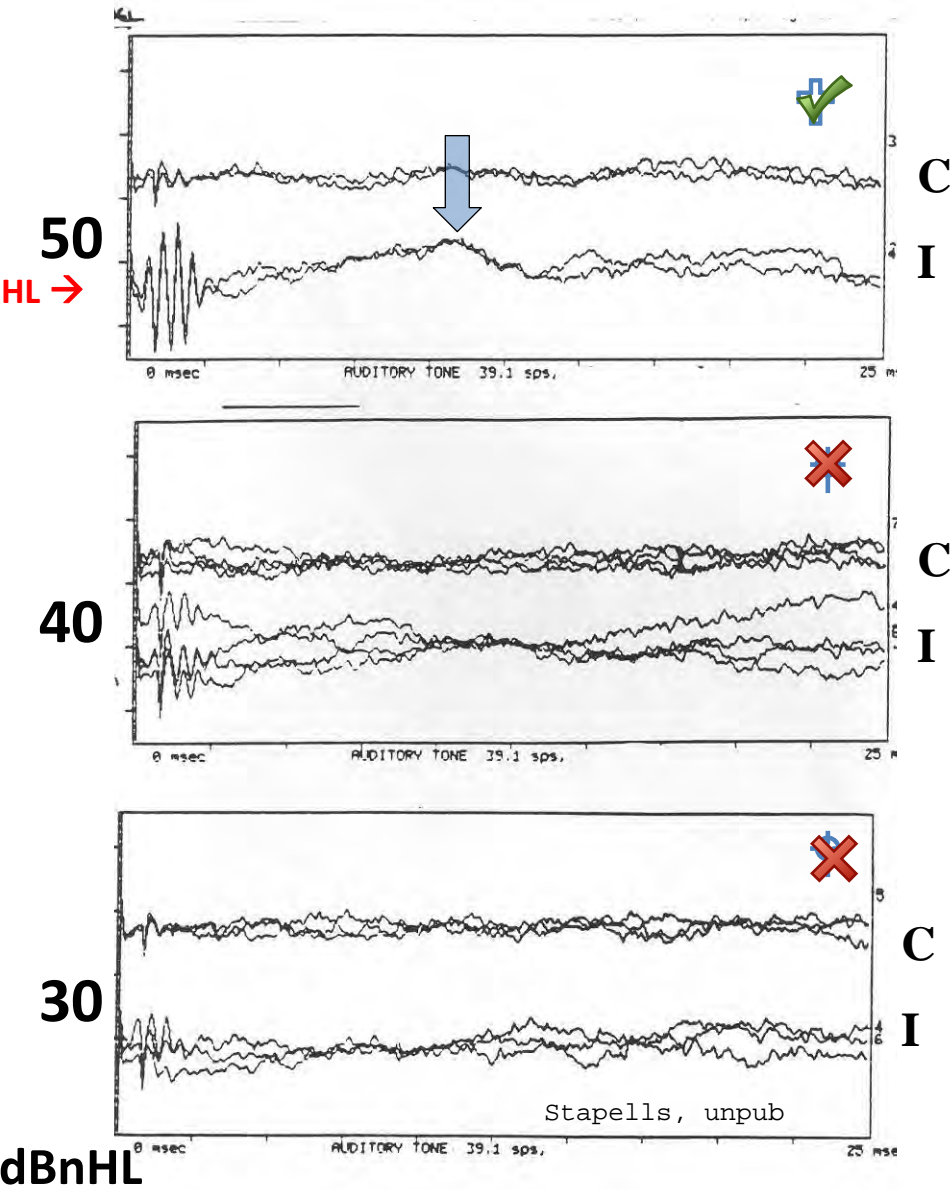
BONE-CONDUCTION ABR (2000 Hz)

CONCLUSION: BC THRESHOLD = 50dBnHL →
SENSORINEURAL LOSS

- AC 2k ABR = 60dBnHL
- Flat tymps
- Absent OAEs
- BC 2k ABR = 50dBnHL

**BONE CONDUCTION ABR
REQUIRED FOR ALL
INFANTS WITH ELEVATED
AC ABR!**

(similar to older children and adults)



SUMMARY: TONE-EVOKED ABRs

- Tone-ABR provides good estimate of audiogram in infants & young children
- Results for young children are different from adults (*smaller* difference scores) – *must use infant corrections*
- ABR to air- and bone-conducted stimuli allow differentiation of conductive and sensorineural hearing loss
- *Tone-ABR requires clinician experience and skill with ABR waveforms and use of fast, efficient protocols. Not all clinicians may be capable of this....*

Problem

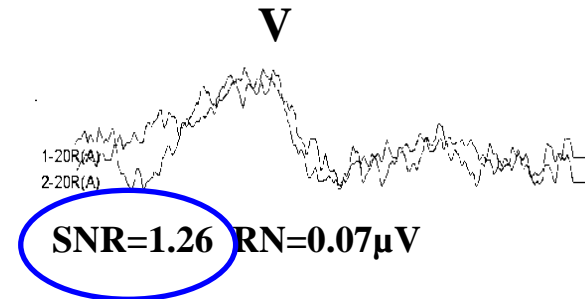
Misinterpretation of ABR waveforms

(When is it a “response”, “no response” or “could not evaluate”?)

- Requires both **experience** and **innate skill**
- **Online measures**^{*} of **signal-to-noise** and, especially, waveform “**residual noise**” must be used (*required for all new equipment to be purchased!*)

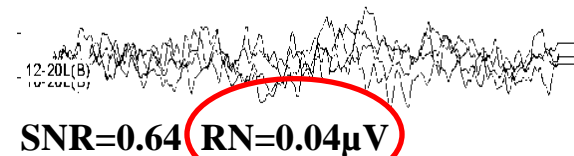
*SNR usually ≥ 1 BUT not always:
Visual replicability overrides*

**RESPONSE
PRESENT**



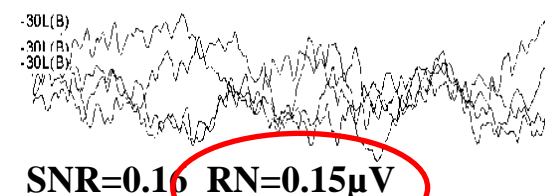
***RN must be $\leq 0.08\mu$ V** ($\leq 0.08\mu$ V not
always quiet enough for NR);
SNR almost always < 1 .*

NO RESPONSE



***RN $> 0.08\mu$ V**, no visually replicable
wave seen; SNR almost always < 1*

**COULD NOT
INTERPRET**



* SNR & RN measures using IHS SmartEP

A service of BC Children's Hospital
and the Provincial Health Services Authority

In general, testing for most infants seen for ABR assessment aims to answer the following three questions, *in order of priority*:

1. Is an ear's AC threshold normal or elevated? Is the other ear's AC threshold normal or elevated? **Start at low ("normal") intensity; Switch ears**
2. If elevated, is the elevation conductive in nature or is there a sensorineural component? **Go to bone conduction *early* in testing**
3. If elevated, what are the specific thresholds (AC and/or BC)? **Determine actual thresholds *after* the above**



Conclusions: ASSR vs Tone-evoked ABR?

- *November 2010:* Only the tone-evoked ABR has the necessary clinical database to be recommended for general clinical implementation as a "stand alone" AEP procedure
- However, the multiple ASSR to AC stimuli may currently be used at beginning of diagnostic test to quickly check if “normal” or “elevated” (i.e., both ears, 4 frequencies simultaneously). *If ASSR absent at normal level, elevation must then be assessed using AC & BC tone-ABR*
- When thresholds elevated, only the tone-evoked ABR can be recorded to both air- and bone-conduction stimuli
- AC-ASSR good as a “cross check” *after* AC & BC tone-ABR results completed
- REMINDER: If auditory neuropathy spectrum disorder (or other neurophysiologic problem) suspected/present, *ABR recordings to high-intensity clicks required*

An aerial photograph of the University of British Columbia campus in Vancouver, BC, Canada. The image shows a large green campus with numerous buildings, surrounded by a dense forest. In the background, the city of Vancouver is visible, along with the Burrard Inlet and the mountains of the Pacific Northwest. The sky is clear and blue.

GOOGLE:

"BCEHP DIAGNOSTIC AUDIOLOGY PROTOCOLS"

THANK YOU FOR LISTENING!

**University of British Columbia
Vancouver, BC Canada**