Innovations in the Electrophysiologic Evaluation of Infant Hearing Part II Cost- Benefit Analysis

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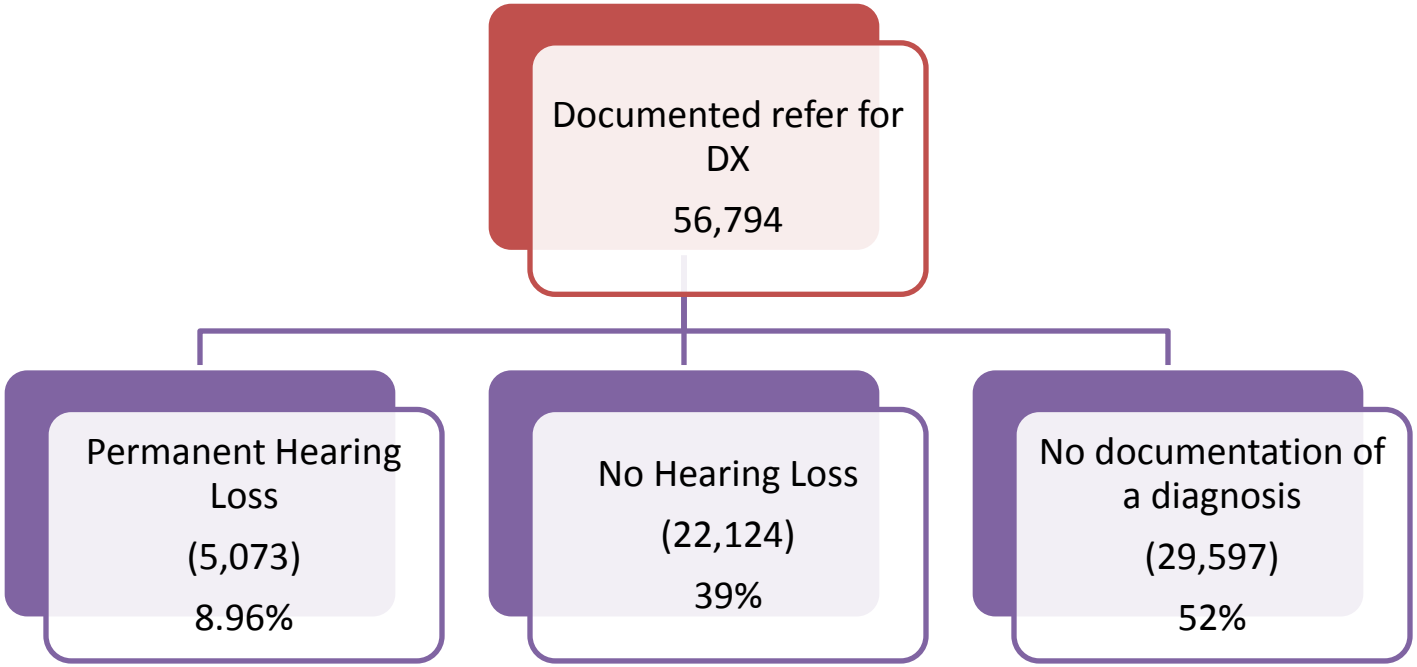
Summary 2009 National CDC EHDI Data, on referrals for diagnostic evaluations



- Additional medical referrals for diagnostic audiologic evaluations will be made for infants and young children with…
  - Children with Special Health Care Needs
    - (NICU grads, chronic health conditions)
  - Non-typical auditory behaviors
    - ASD
  - Trauma
  - Infants & children identified with no pass on inpatient screen and **no OP screen** on routine visits and surveillance
  - Concerns related to risks for late onset hearing loss
    - CMV
  - Developmental delays

Cost modeling example:

- For each noisy infant/child being evaluated the kalman-filtered EEG/ABR improves the chance of obtaining a response at near threshold levels by up to 35%.
    - Induced motor noise raised threshold by 10-20 dB in adults.
    - Kalman-filtering application reduced noise interference by 10-20 dB in 25-35% of subjects
- What does this mean in terms of costs?

What's it worth to you?

- 10 dB closer to true threshold?
  - Hearing aid fitting
  - Other diagnostic procedures
- 35% increased likelihood of obtaining a response?
  - Covert that to audiology time: estimate saving 10 minutes per patient
  - If cost of an eval is $600/hour (all overheads considered) then that is $100/patient.

Other costs

- Cost of general anesthesia ABR = $5,000.00
- Cost of parental anxiety about procedure?
  - No shows, missed appointments
- What percentage of “natural sleep” ABRs are in your caseload?
  - If you start your test at 20 or 30 dB nHL, and get a response, even while the child is awake, how much is that worth to you?

A conservative example

- 3 natural sleep ABRs/day @ $600.00/test
- Advanced signal processing (kalman+*in-situ* amplifier) results in a 40% increased likelihood of being able to obtain a near threshold response during steady or intermittent noise.
- This could translate to 10 minutes of time saving/test.
- $300.00 savings/day.

A less conservative example

- 35% higher likelihood of obtaining a near threshold response translates to 20 minutes of time savings/test
- 1 hour saved per day=$600.00

- What is your time worth?
- 1 more subject/day = shorter wait lists

The Jackpot

- For every patient that can be tested without sedation/anesthesia, the cost savings is up to $5,000.00/test.
  - Given your case-load, how many patients/month would be eligible for natural sleep (or moderately quiet wakefulness) ABRs?

Case Example

- Dr. Norrix will present a case that illustrates how the “experimental” system was used to obtain results in a child who would otherwise not be able to be tested with sedation/anesthesia owing to her medical condition.

Jane

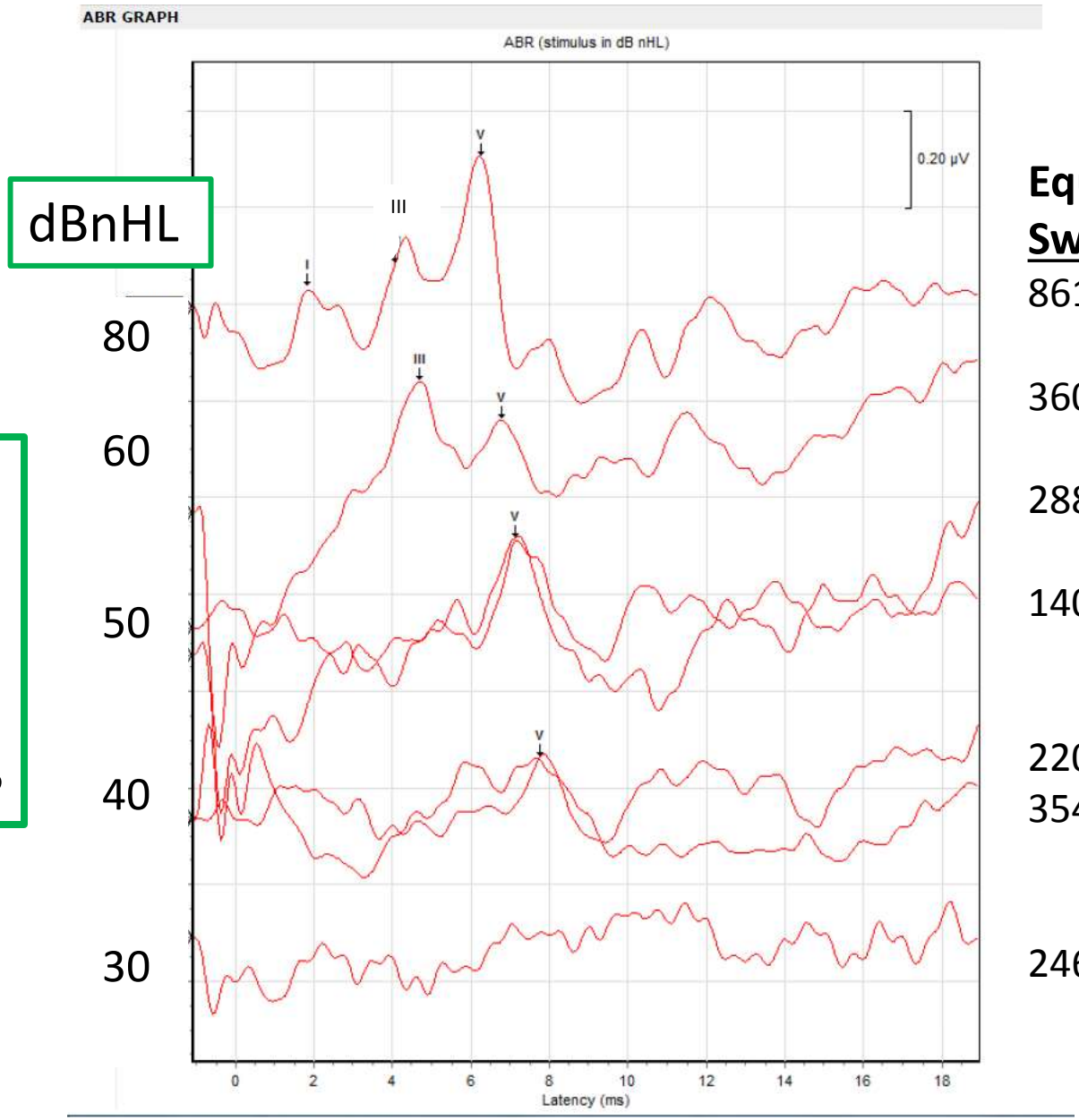
- 9 months of age, full term at birth
- Cardio pulmonary disease and failure to thrive
- 6 month stay in PICU
- Heart surgery
- Currently ventilator dependent via tracheostomy
- GI tube
- Significant developmental delays including motor, cognitive, speech & language

Behavioral Audiologic Evaluation

- Normal acoustic admittance but wide tympanometric widths, AU
- DPOAEs – “refer” but noisy
- BOA – eye widening, smiling, rudimentary heard turn at 75 dB HL in each ear

Better ear

Rarefaction Click Results



Equivalent Sweeps

861

3609

2883

1400

2200

3544

2464

Other scenarios

- Ability to obtain an ABR at 20-30 dB nHL in a moderately wakeful may result in cost savings if combined with:
  - Tympanometry results
  - OAE results
- If a “pass” for these quasi-screening results, then it may be more appropriate to follow the infant using behavioral methods.

Features of the system we did not test

- Wireless connection (blue-tooth)
- 1 vs. 2 channels

Mid-late 1970's: Brainwaves in response to sound are used to test newborn hearing----could these be used for screening all infants?

University of Texas at Dallas, Parkland Hospital ca 1978

How much cost-savings from use of wireless connection of amplifier to computer?

- We did not test this feature in our lab or clinic-based verification studies.
- The comparison data are obvious
  - 100% performance for wireless system
  - 0% performance for conventional hard-wired system.
- How many times did you wish you could test an infant while driving them around in a car to induce sleep??
  - N= 1 (me)
  - About 1,000,000

Other features

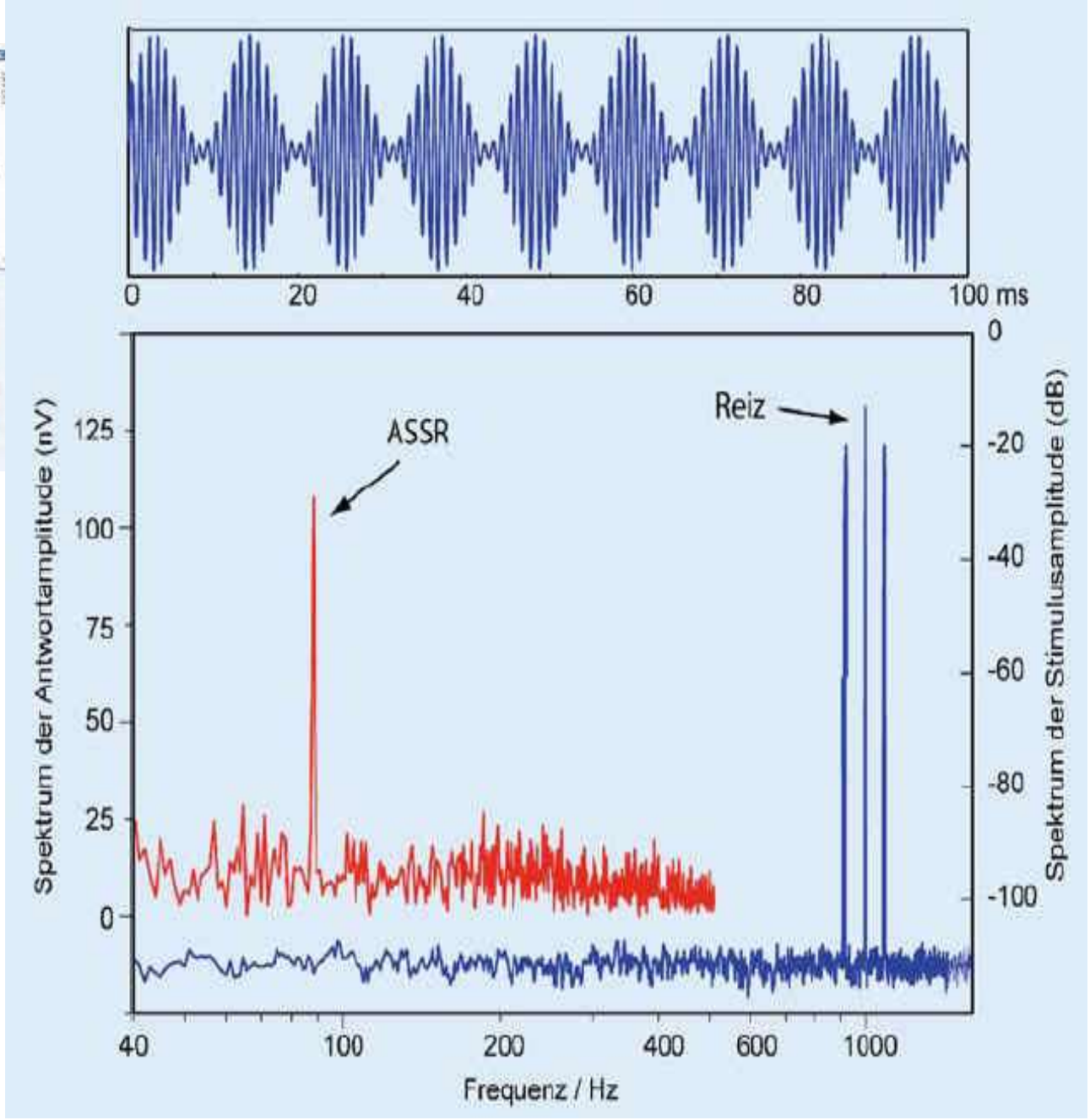
- Currently, the wireless system is limited to 1-channel.
- Does the benefit of wireless out-weigh the cost of having only 1 channel ?
  - How often do you use information from the second channel?
  - Put a $$ value on that and compare it to your estimated value of the wireless connection.
- Positive or negative net effect?

Cost-Modeling Summary

- Costs and benefits must be considered on a “practice-pattern” basis.
- Costs and benefits can be modeled using strict or lax criteria.
  - Strict criteria = conservative estimate of savings
  - Lax criteria = greater estimate of savings
- Empirical data suggests up to a 35% “advantage” for kalman-filtered + in-situ amplifier (2 features of Vivosonic) ABR.
- Other features (e.g. wireless) may result in additional benefits/cost-savings but should be calculated with respect to limitations (e.g., 1-channel).

Innovations

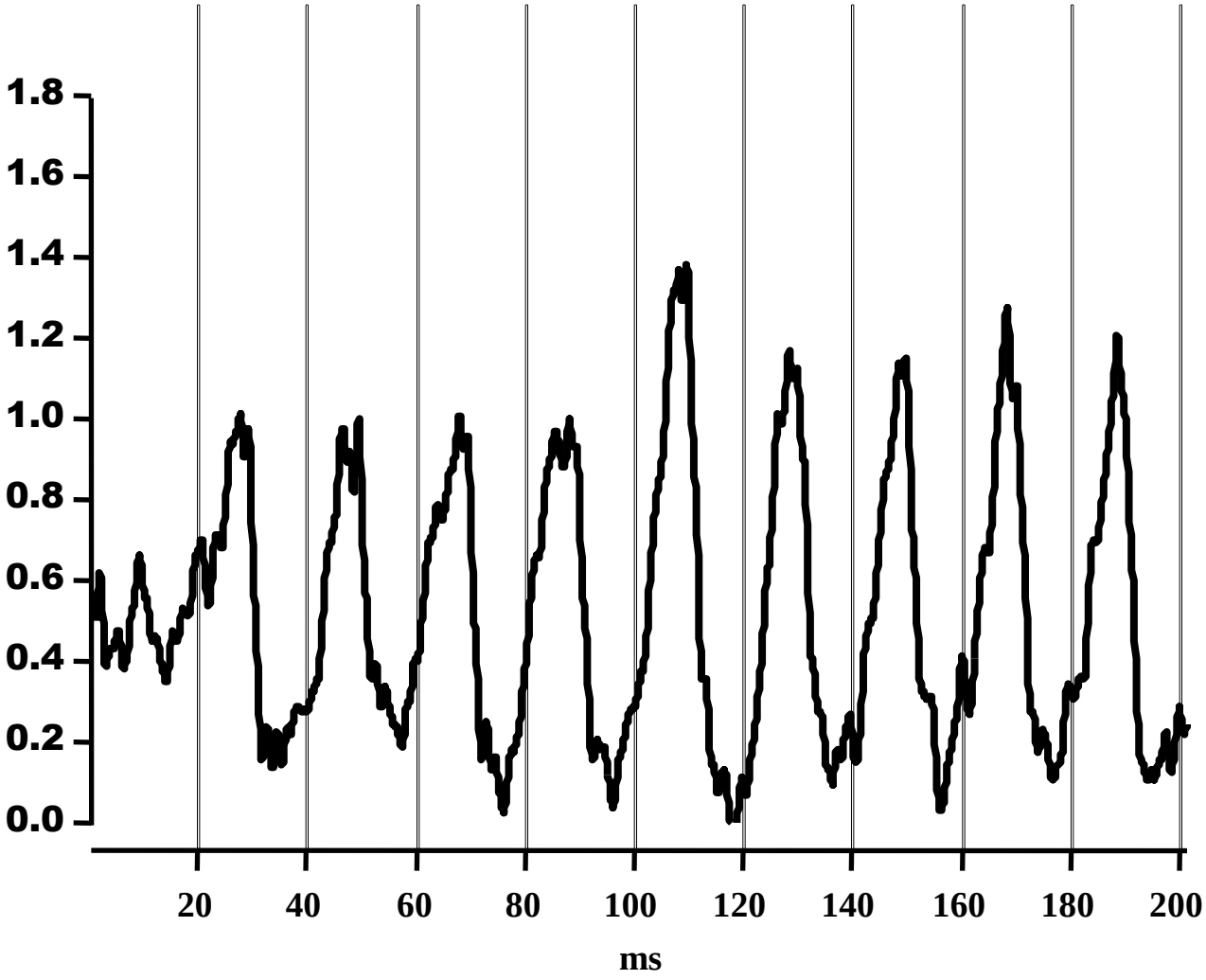
- in the electrophysiologic assessment of infant hearing.
- Funded by AUCD
- Purpose is to investigate 3 innovative methods for estimating threshold using evoked potentials.
  - 40 Hz ASSR
  - Chirps


0
20
40
60
80
100 ms
ASSR
Reiz
Spektrum der Antwortamplitude (nV)
125
100
75
50
25
0
0
-20
-40
-60
-80
-100
Spektrum der Stimulusamplitude (dB)
40
100
200
400
600
1000
Frequenz / Hz

History of ASSR for Infant Hearing Tests

- Based upon fundamental research concerned with the brain's response to complex sounds.
- Brain response "follows" the stimulus modulation.
- Brain response is analysed in the frequency domain.
  - **Spectral analyses**
  - **Analyses of phase coherence.**

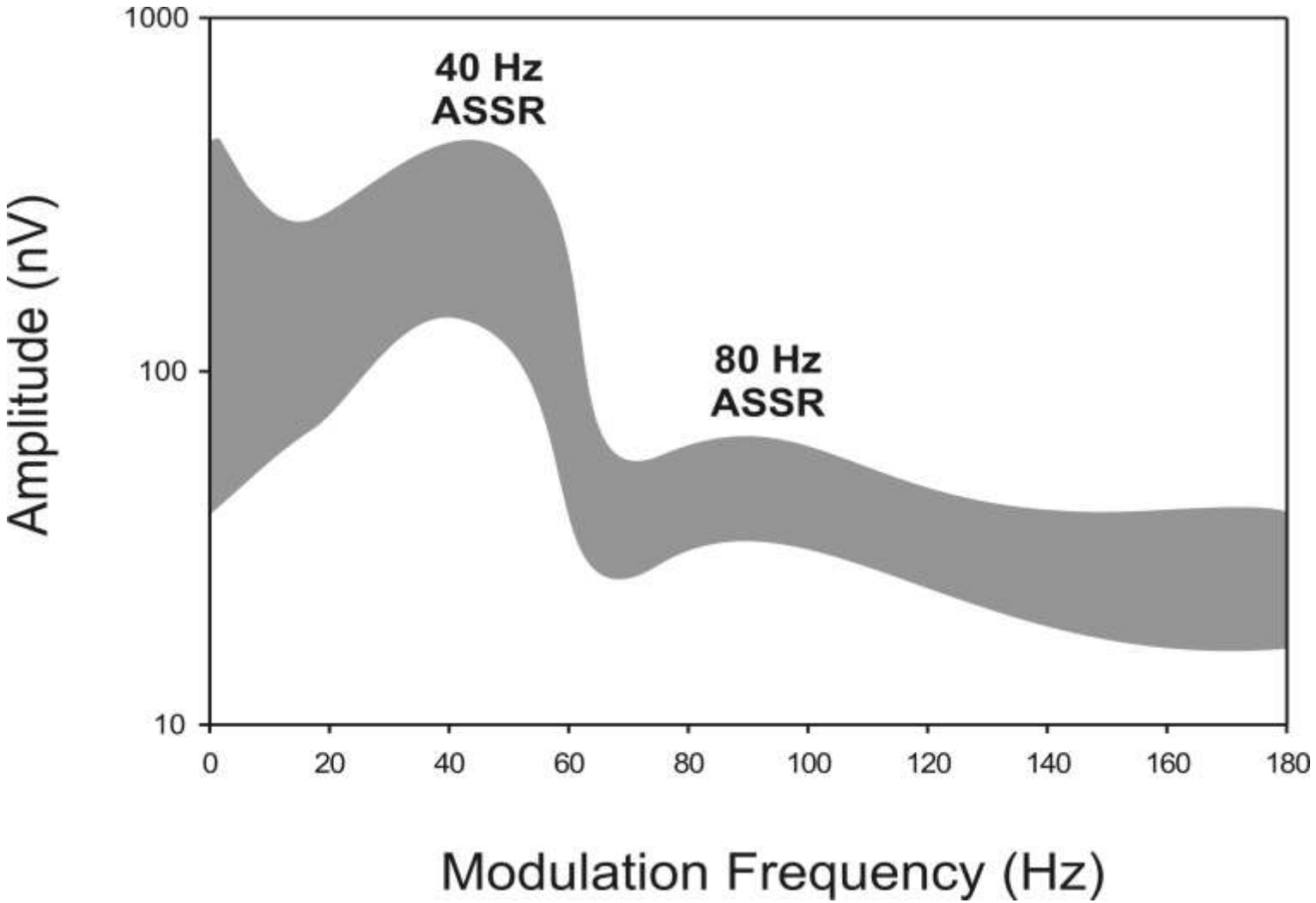
2000 Hz CF, 50 Hz MF



ASSR Characteristics

- Present at near threshold levels.
- Present for a wide range of modulation frequencies, from less than 10 Hz to over 150 Hz.
- Responses for rates $\geq$ 80 Hz have many response characteristics similar to ABR.

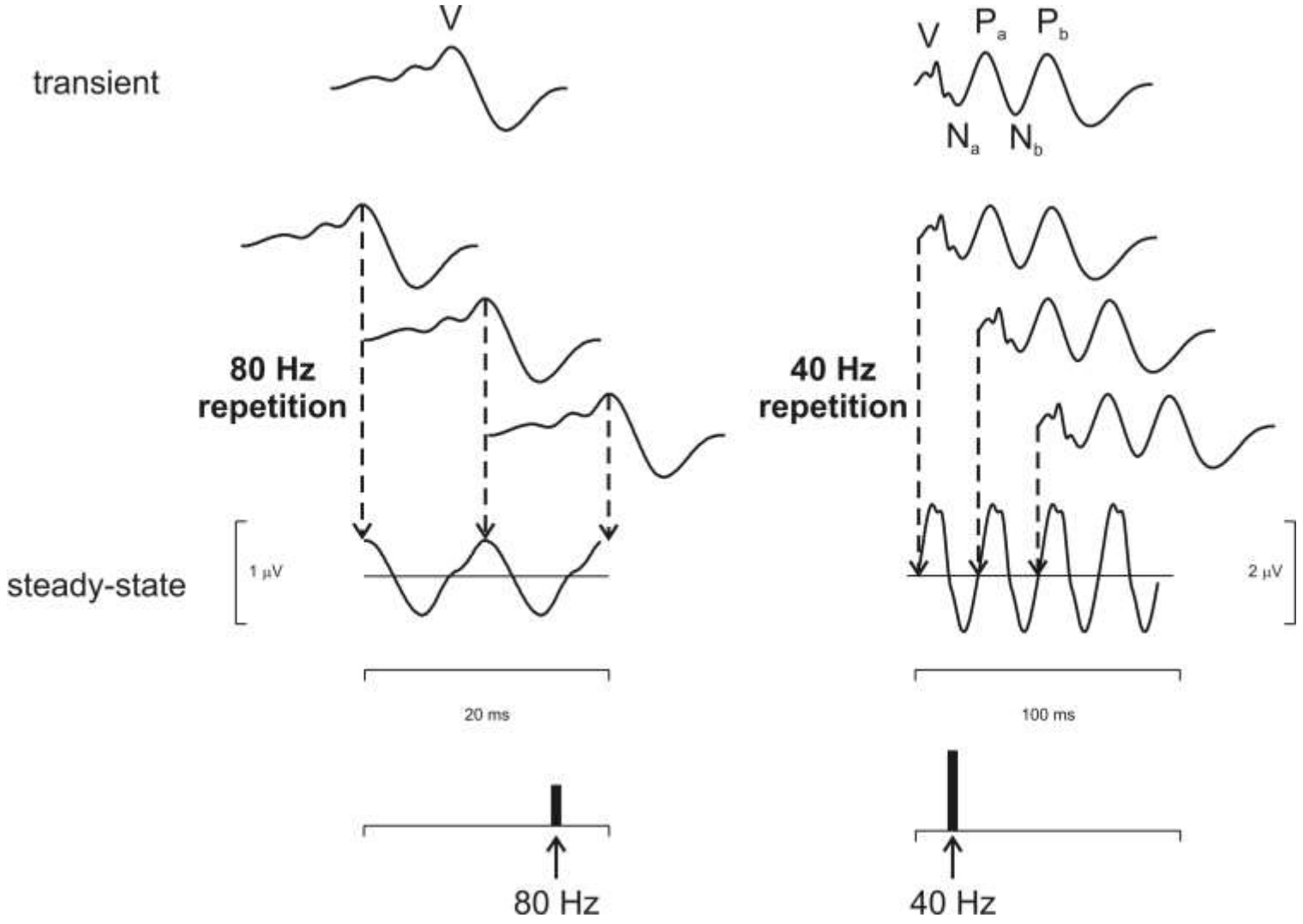
ASSR Amplitude as a function of modulation frequency



Generators

- Dependent upon modulation frequency.
- For MF<20, same as for CAEP:
  - Primary auditory cortex and association areas.
- For MF <40 Hz, same as for MLR:
  - sub-cortical (brainstem, medial geniculate) and primary auditory cortex.
  - For rates>60 Hz, same as for ABR:
  - brainstem auditory system but may also have some contribution from primary auditory cortex.
- For rates>120 Hz, CAP: + brainstem.
    - Need to consider limits of neural rate-following at different levels of auditory system

ASSRs:80 Hz and 40 Hz



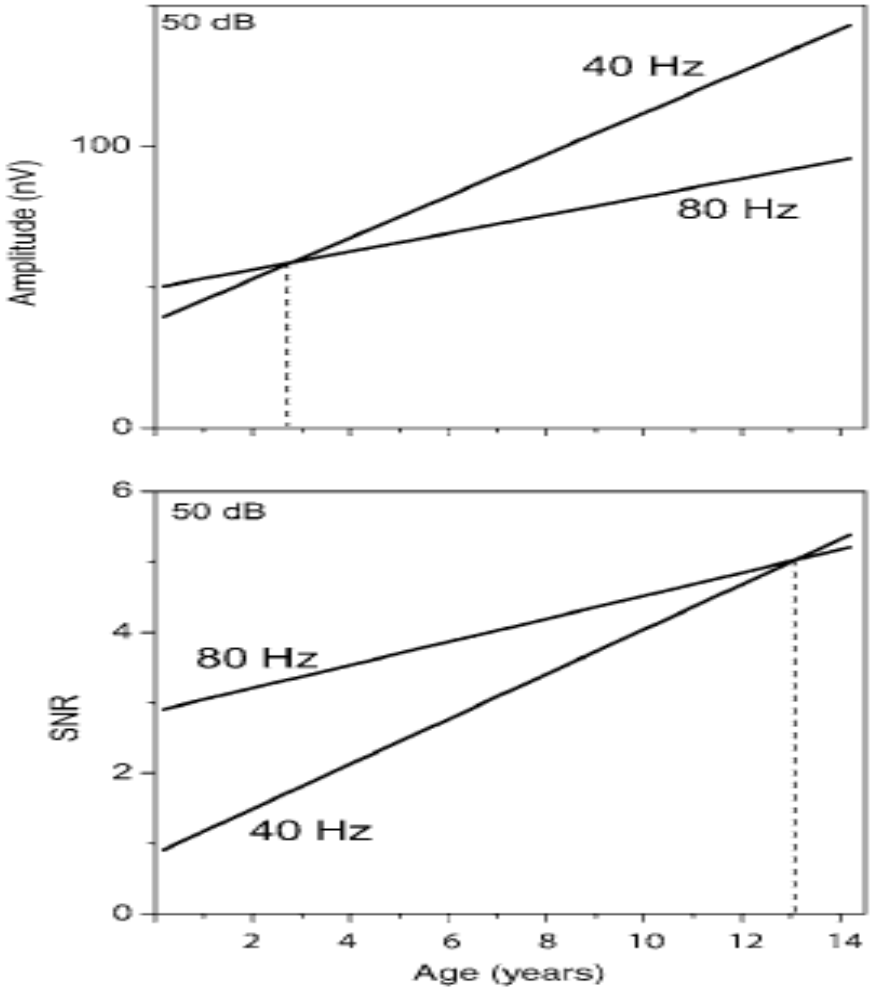


Figure 4. Comparison of AMFR development at 40-Hz and 80-Hz modulation frequencies at 50-dB stimulation level. To characterize the development, the regression lines of the 50-dB representations from Figures 1 and 3 are used. On the SNR graph, the age to the right of the intersection of the more steeply increasing 40-Hz line with the flatter 80-Hz line is interpreted as the age at which the 40-Hz modulation frequency seems more suitable for AMFR recording for audiological purposes. Upper part: development of the AMFR amplitude. Lower part: development of the SNR.

Pethe et al, 2004

1k Hz tone

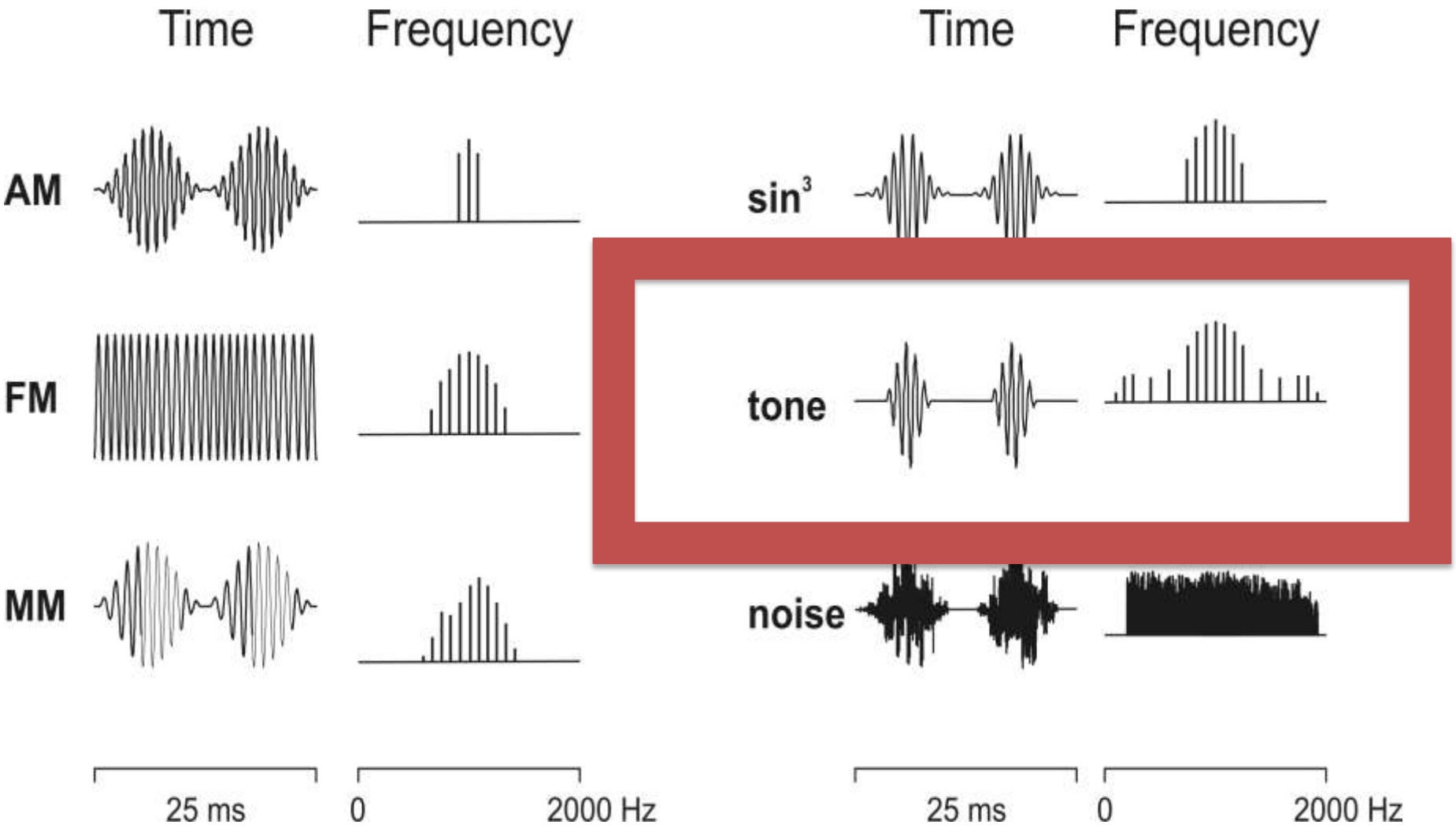
40 Hz ASSR

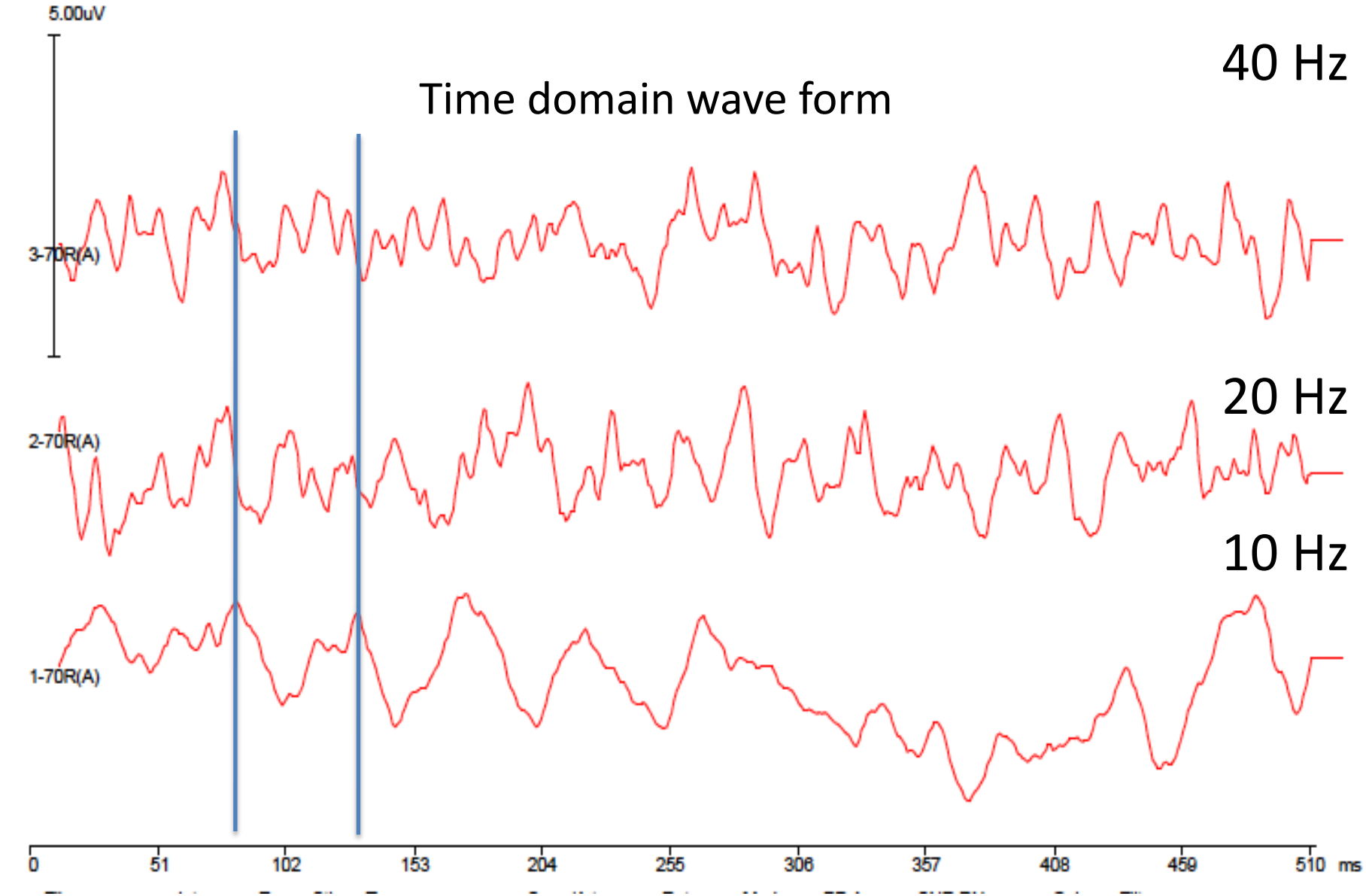
- The 40 Hz ASSR is generated at the level of the auditory cortex.
- It has a larger amplitude than 80 Hz ASSR (generated at the brainstem).
- 40 Hz ASSR can be obtained in quiet wakefulness in older children or adults.

40 Hz ASSR in infants

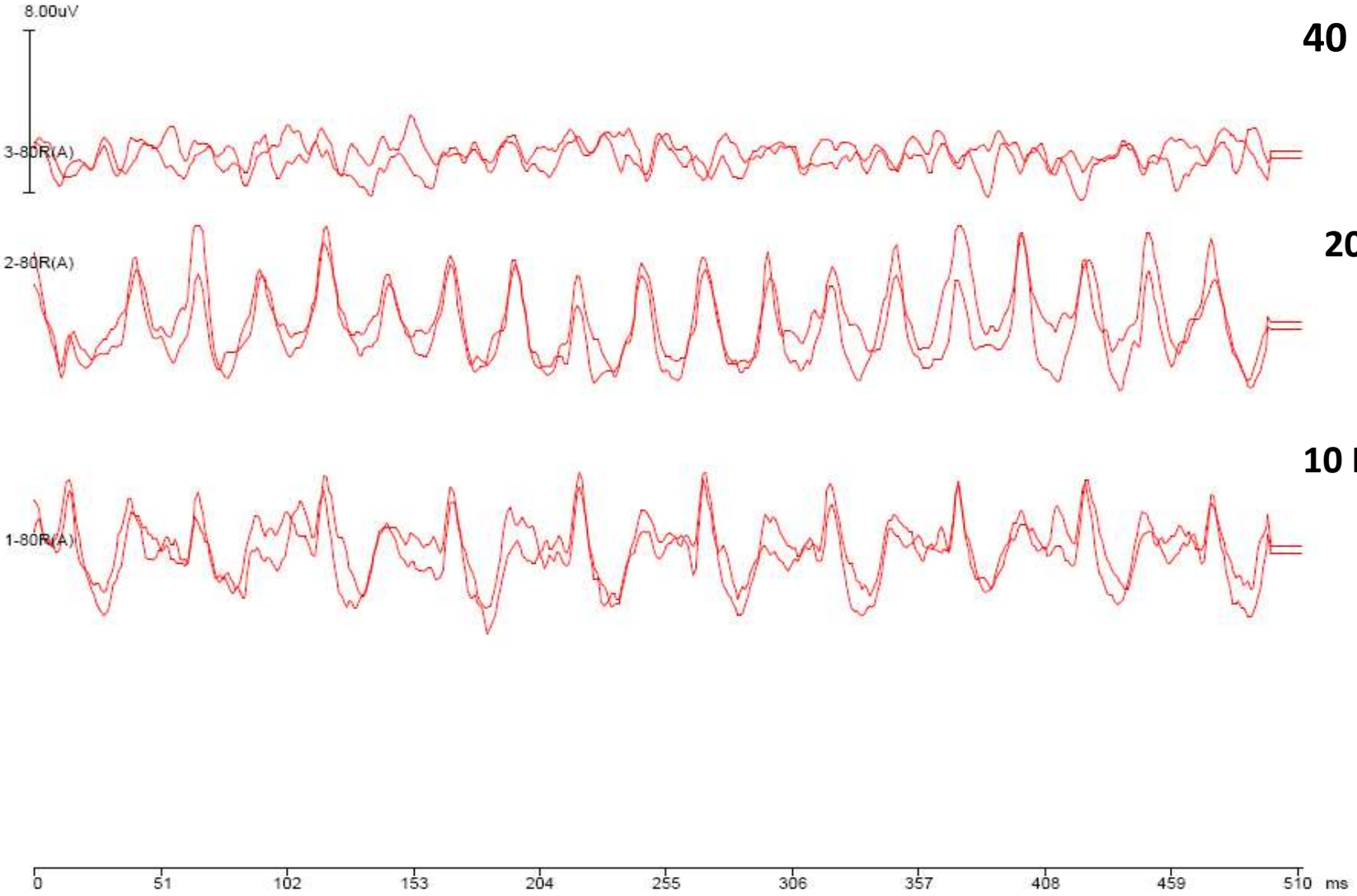
- Are 40 Hz ASSR present in infants tested while awake?
- Are ASSRs present in infants at lower modulation rates?
- How do these differ from those found in adults?

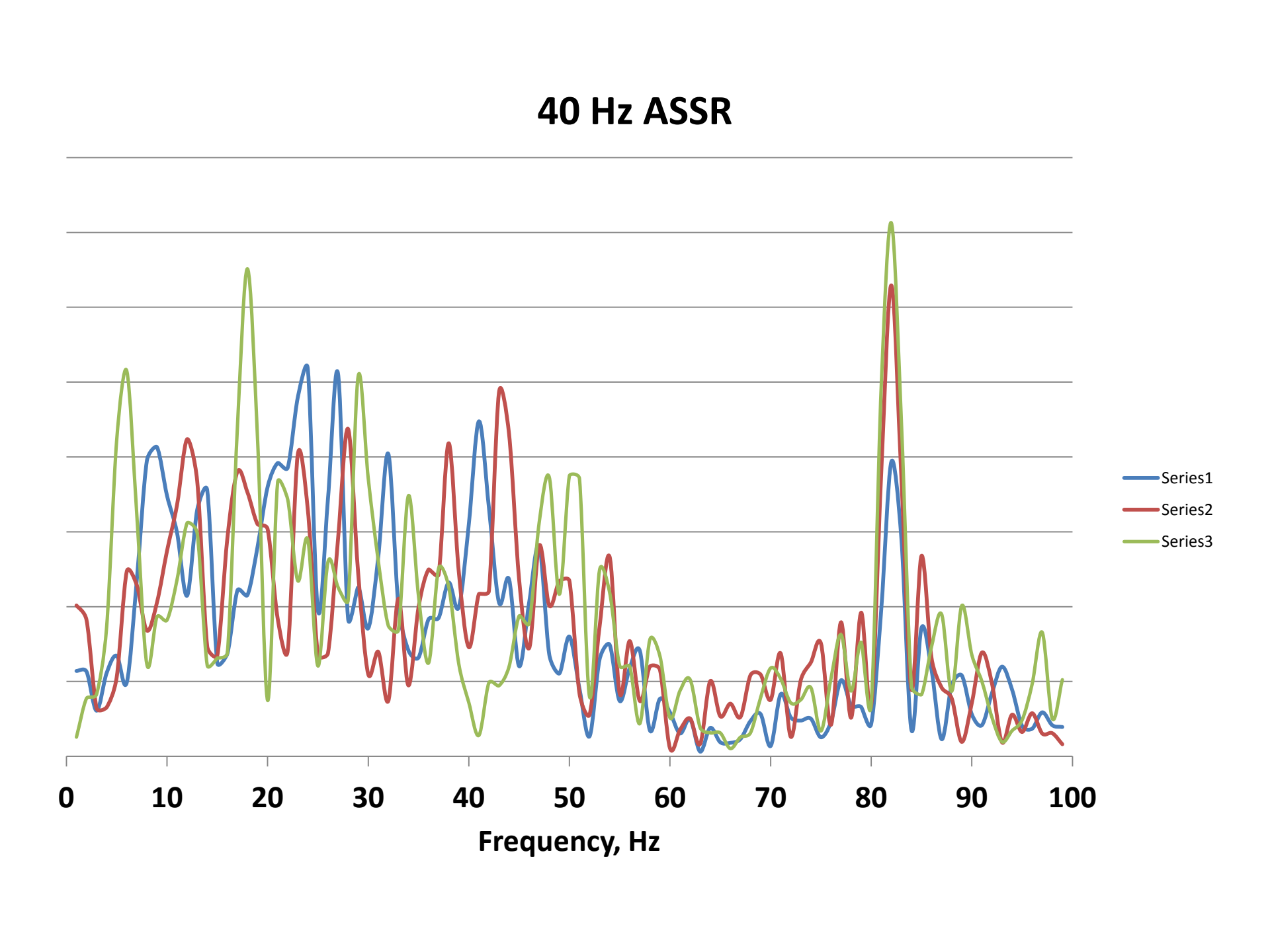
Stimuli for ASSRs

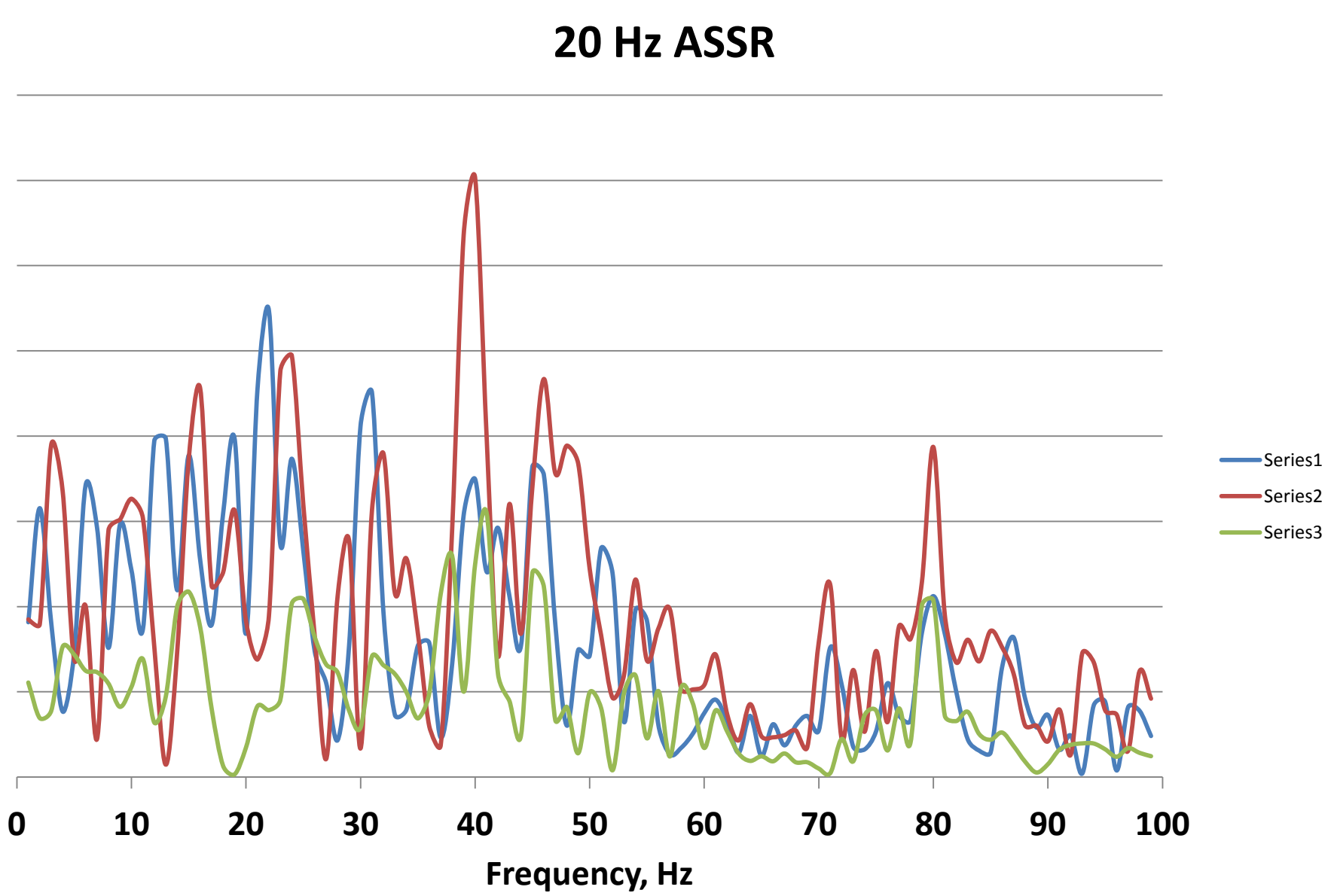


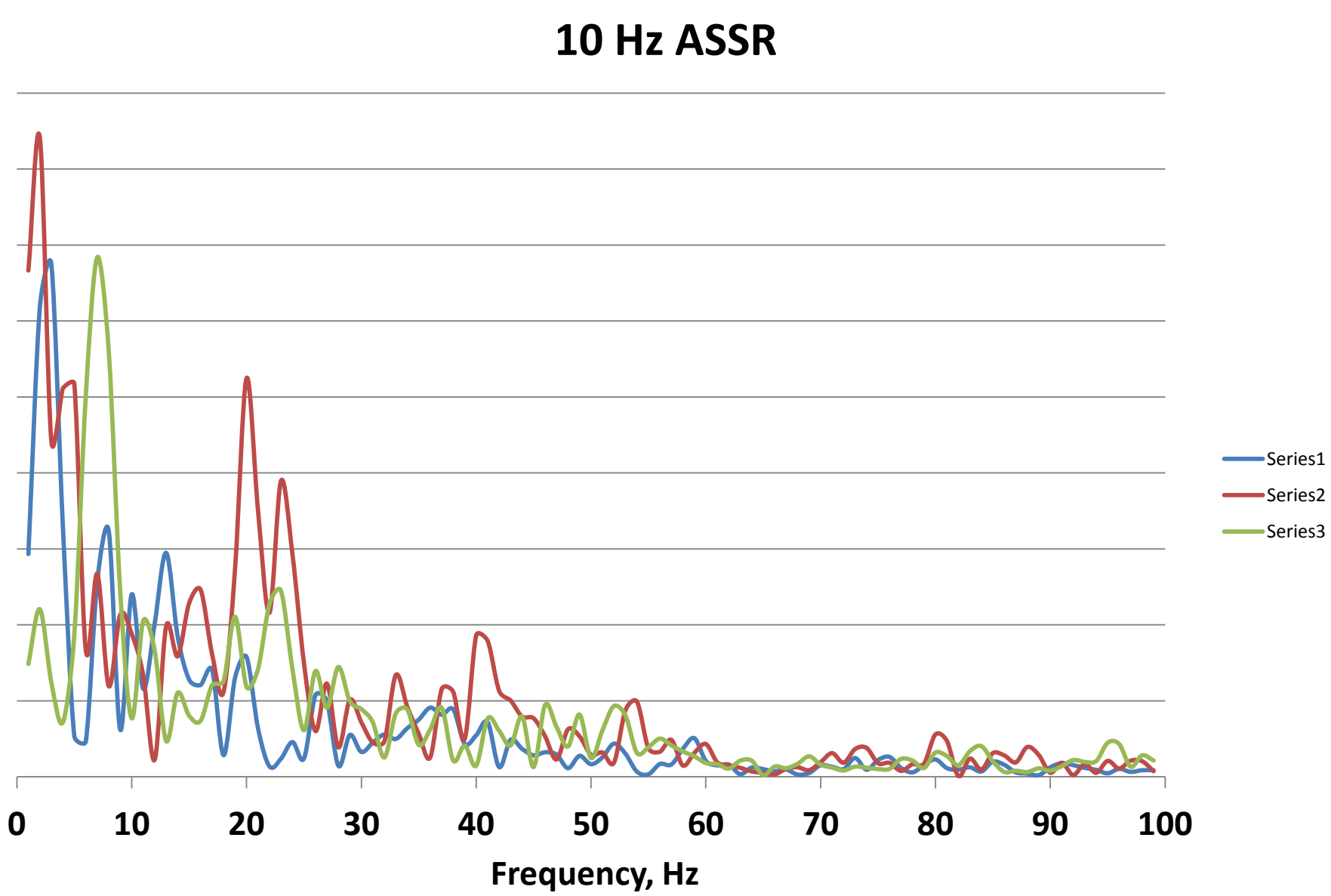

Time domain wave form
5.00uV
40 Hz
3-70R(A)
20 Hz
2-70R(A)
10 Hz
1-70R(A)
0
51
102
153
204
255
306
357
408
459
510
ms

Time domain waveforms



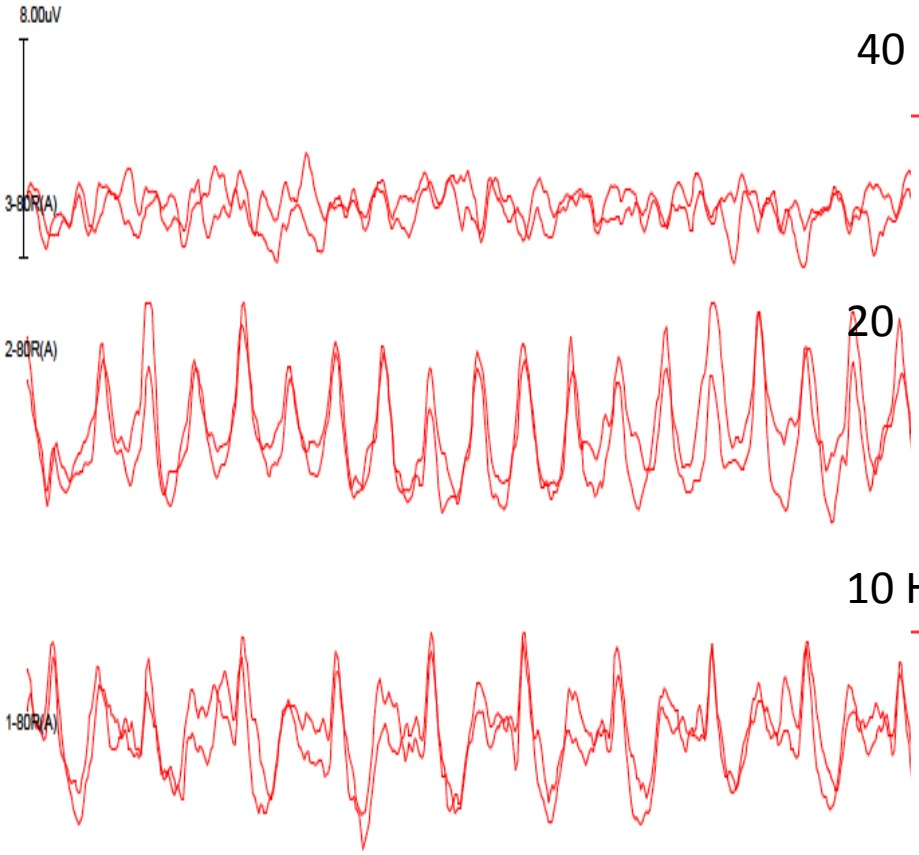

40 Hz ASSR
0
10
20
30
40
50
60
70
80
90
100
Frequency, Hz
Series1
Series2
Series3


20 Hz ASSR
0
10
20
30
40
50
60
70
80
90
100
Frequency, Hz
Series1
Series2
Series3


10 Hz ASSR
Series1
Series2
Series3
0
10
20
30
40
50
60
70
80
90
100
Frequency, Hz

B10 B10
ID: IHS4876-20127U01 Page: Acq Test Date: Mar. 22, 2013 Age: 12.2 months Report: Mar. 23, 2013

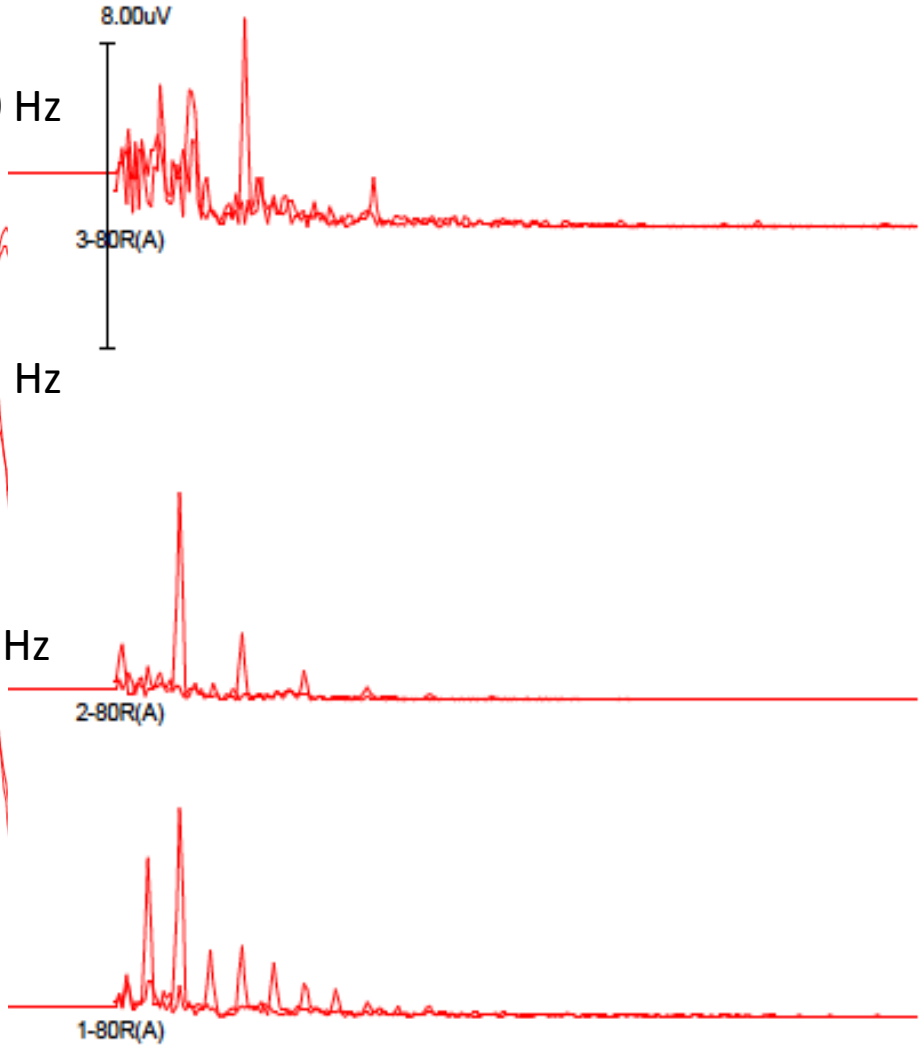
Age = 12 months



40 Hz

20 Hz

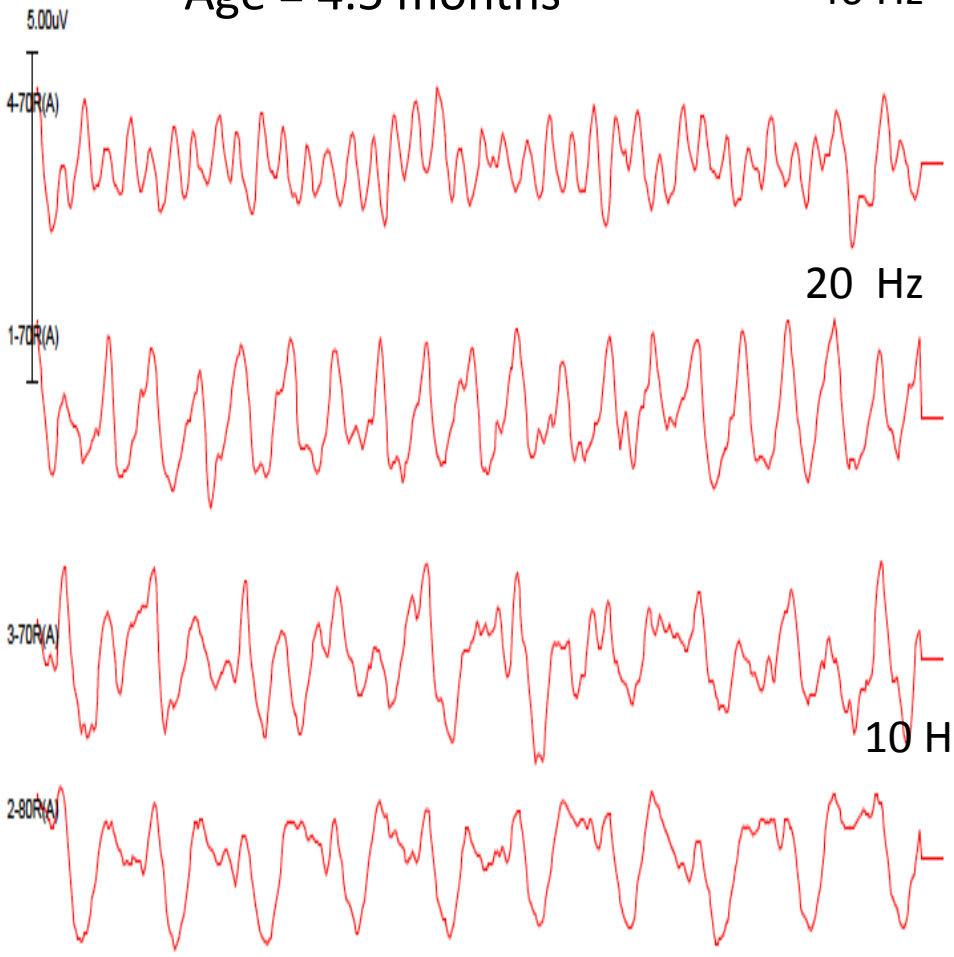
10 Hz

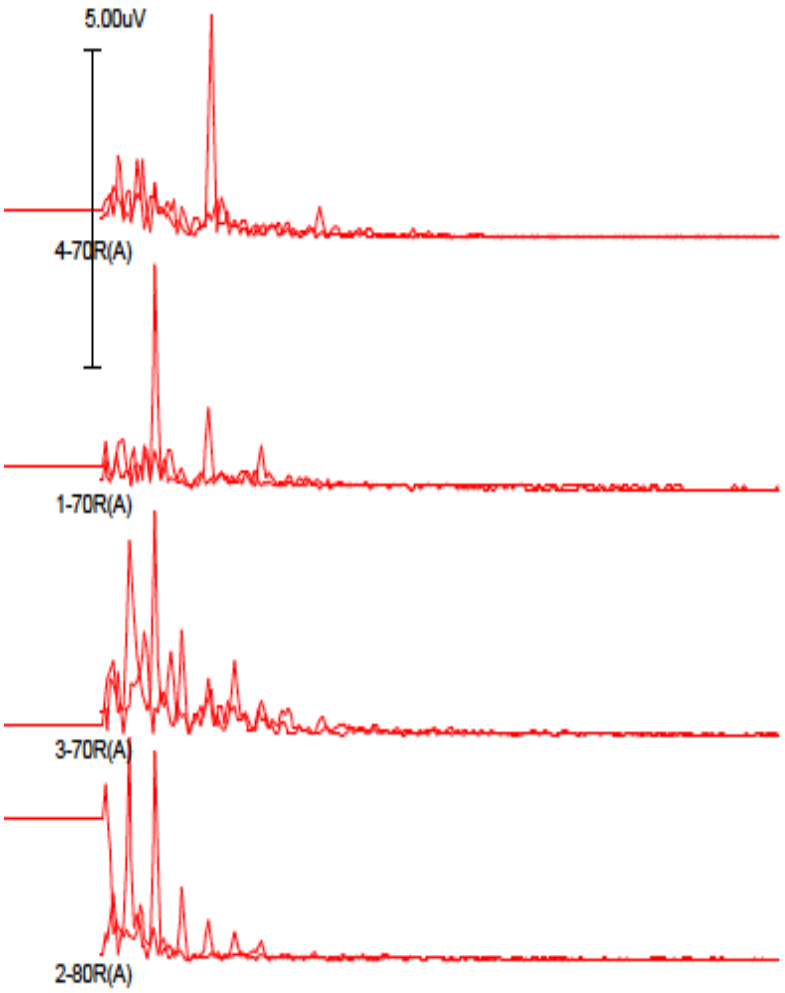


B018 B018

ID: IHS4876-20132F01 Page: Acq Test Date: Mar. 19, 2013 Age: 4.5 months Report: Mar. 23, 2013

Age = 4.5 months





Some thoughts about these data

- The 80 Hz harmonic is present even when response to the fundamental (20 or 40 Hz) is of low amplitude.
- Harmonic at 80 Hz indicates dominance of brainstem generators.
- At this age (<12 months) the transient cortical response demonstrates rapid adaptation even for stimulus rates as low as 1 or 2 Hz.
  - We cannot rule out brainstem generation site at this time.
- Large amplitude responses, detection in the frequency domain may allow more efficient estimates of threshold in awake babies.