Investigation of Speed, Accuracy and Utility of Auditory Assessment Technologies

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Overall goal: To evaluate/demonstrate clinical utility of these valuable techniques.

Specific Goals:
1) to determine if estimated behavioral thresholds (in dB HL) obtained by Next Generation ASSR (multiple frequency-binaural) are equivalent to those obtained with ABR (individual ear and test frequency). Hypothesis: thresholds determined by both methods will be equivalent.

2) to compare the time needed to complete an assessment with both techniques. Hypothesis: ASSR will reduce test time over ABR by ½ or more.

Study Specifics

Equipment:
Eclipse and Titan systems were provided by the Study, installed and calibrated at each site.

Training and Monitoring:
Two or more training session at each site.
Conference calls at regular intervals.

Data Management/Analysis:
Anonymized, encrypted data files emailed to Santa Fe.
Analyzed data point entered into REDCap at University of Colorado Medical Center.
Data analyzed with SPSS.

The CE-Chirp

- Stimulus that reorganizes timing of spectral components to synchronize cochlear response.
- CE-Chirps are of the same energy and frequency composition as traditional stimuli- clicks and tone bursts.
- Produces neural response (ABR, ASSR,…) with up to 2X amplitude of traditional stimuli.
- Greater amplitude enhances response detection.
- Reduces time to automated detection.
- Lowers threshold of response detection and reduces correction factors.

See handouts.
Average ABR = Neural Potential + Noise.

It is not possible to accurately determine how much of each is present, merely by looking.

Noise can obscure a response so it is important to know how much noise is present.

**Bayesian Weighting**

*What is it and why would I use it?*

First proposed by Elberling & Wahlgren in 1985 as a method of noise reduction during averaging.

Rather than rejecting all sweeps with high amplitude (traditional noise rejection) Bayesian weighting assigns a “weight” to each block of sweeps based on estimated noise in the block.

When a block is quiet, it is given greater “weight” in the average than when a block is noisy. Almost nothing is discarded.
How are ASSR and ABR Alike, Different?

- ABR and ASSR both look at the same brainstem neural activity.
- ASSR modulates the stimulus at a known frequency.
- Response detection then searches for evidence of that frequency in the ongoing EEG.
- If the neurons are activated by the stimulus, there will be a spike in the frequency response of the EEG at the modulation frequency and the phase of the EEG will be synchronized with the stimulus onset.

Traditional ASSR Detection Searches for Significant Amplitude and/or Phase Coherence of the Modulation Frequency

How is the “Next Generation” ASSR Different than the First Generation??

- Next Generation uses BOTH amplitude and phase information for detection.
- Next Generation uses the fundamental and 20+ harmonics for response detection.
- Next Generation ASSR uses Narrow Band CE-Chirps.

Next Gen ASSR uses Response Detection (Phase and Amplitude) at Fundamental and 20+ Harmonics Compared to Fundamental Alone

Protocol Summary

- Start with Wide-Band Tympanometry and DPOAE
- Get an ABR threshold in each ear using a Wide-Band CE Chirp
- Determine the order of electrophysiologic tests- randomized by subject number.
- ABR thresholds using NB CE-Chirps with reliance on Fmp.
- ASSR thresholds using Eclipse protocol.
- Bone Conduction by ABR if necessary
**ABR Protocol-- Testing**

- Establish Threshold for BB CE-Chirp® LS in each ear before Frequency-Specific testing (ASSR or ABR).
- Order of frequency presentation or ear is at the discretion of the tester.
- Begin the threshold search just above the BB Chirp threshold.
- Test each level once unless special circumstances.
- If a response to level X is fast (800-1200 sweeps) and response large (>100 nV) use a large descending step size (20 or greater)

**ASSR Protocol**

- Default is 4 frequencies per ear all running simultaneously.
- Starting Level is determined by tester, can be individually chosen.
- Each frequency has a unique modulation frequency that is close to 90 Hz.
- Background noise and response detection criteria are automatically updated for each frequency/ear.
- New stimulus level can be implemented for any of the eight conditions at any time. The others continue to run.
ASSR Protocol

- Noise rejection level is set to 40 nV.
- Insert ER3-A Earphones used.
- Test will stop at 95% confidence of response or 6 minutes.
- Test time can be extended for any particular condition if needed.
- YS stopping rule. If detection is at or below 50% and noise is \( \leq 15 \) nV, the test can be stopped by the user as a no response.
- Test levels are determined as with ABR with concentration on test speed. A response met quickly warrants a large decrease in level and vice versa.

102 Subjects Enrolled

Mean Age = 12.55 months

Middle Ear / DPOAE

# DP POINTS PASSED
Mean Difference  9.54 dB  
\( p < 0.001 \)  
Regression:  
Slope: 0.86  
\( R^2: 0.863 \)  
Difference: 5.77  

Mean Difference  6.39 dB  
\( p < 0.001 \)  
Regression:  
Slope: 0.87  
\( R^2: 0.852 \)  
Difference: 3.49  

Mean Difference  1.74 dB  
\( p = 0.001 \)  
Regression:  
Slope: 0.93  
\( R^2: 0.954 \)  
Difference: 0.21  

Mean Difference  0.81 dB  
\( p = 0.09 \) (non significant)  
Regression:  
Slope: 0.94  
\( R^2: 0.956 \)  
Difference: 0.40
RESULTS SUMMARY

Next Gen ASSR far more sensitive re ABR

- Most recent similar study: "Next generation ASSR v standard ABR
- Amplitude F-test at modulation frequency
- ASSR used cos(3t) windowed tones, modulation rates of 81-100 Hz.
- ABR used Blackman windowed tones, 39 sec.

Note: Reversed Axes

<table>
<thead>
<tr>
<th>Frequency (kHz)</th>
<th>Mean ASSR Threshold (dBHL)</th>
<th>Mean ABR Threshold (dBHL)</th>
<th>Difference (dBHL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>500</td>
<td>-9.54</td>
<td>6.30</td>
<td>15.86</td>
</tr>
<tr>
<td>1000</td>
<td>-20.67</td>
<td>-9.47</td>
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<tr>
<td>2000</td>
<td>-20.21</td>
<td>-10.86</td>
<td>10.99</td>
</tr>
<tr>
<td>4000</td>
<td>-20.21</td>
<td>-10.50</td>
<td>10.50</td>
</tr>
</tbody>
</table>

This improved sensitivity is due to the improved detection technology.

We also expect overall a reduction of 5 dB in thresholds by both techniques, due to the CE-Chirp Stimuli.

RESULTS SUMMARY

- Next Gen ASSR Thresholds are NOT equivalent to ABR except at 4 kHz. They are lower. This is due to advances in detection technology.
- Average test time difference shows ASSR is faster by 12.5 minutes (for 4 frequencies in each ear).
- Using our protocol, both ABR @ 32.14 and ASSR @ 19.63 minutes are quite fast and feasible for non-sedated infants. The CE-Chirp stimuli is responsible for some of the increased test speed.

QUESTIONS??

CASE PRESENTATIONS

6514

1 month old
Natural Sleep
Failed NHS- no other risks

Broad Band Tympanometry

Subject 6514 1 Month
Subject 6514  1 Month

**DPOAEs**

- **Right Ear**
- **Left Ear**

**Wide Band Absorbance**

- **Right Ear**
- **Left Ear**

Subject 6514  1 Month

**Broad Band CE-Chirp ABR Threshold**

- **<10 dB Both Ears**

Subject 6514  1 Month

**4k Hz <10 dB Both Ears**

Subject 6514  1 Month

**1k Hz < 10 dB Both Ears**

Subject 6514  1 Month
2672

- 3-months-old at time of study visit
  - 3\textsuperscript{rd} ABR evaluation at CCHMC
- Failed NBHS in both ears
- Full-term birth via emergency c-section due to failure of labor progression
- No known risk factors for hearing loss
- At 3 weeks: Mild SNHL, normal tymps, absent DPs, ? Air bone gap?
- At 7 weeks: Mild Conductive Loss, ? Bone, Neg Pressure tymps
Subject 2672  3 Months

**DPOAEs**

- Right Ear
- Left Ear

**Broad Band CE-Chirp ABR Threshold**

50 dB Right Ear and 45 dB Left Ear

**1k Hz 60 dB Right Ear and 55 dB Left Ear**

**4k Hz 55 dB Right and 45 dB Left**

**BB Chirp Bone Threshold = 30 & 35 dB**

**ASSR**
2672: 4-months-old

- HA Fitting
  - Phonak Sky V50 P BTEs
  - Verified using DSL targets and measured RECD
  - Dad very skeptical of hearing loss

2672: 5-months-old

- MRI Completed
  - Bilateral mild bulbous appearance of the vestibules and mild enlargement of the endolymphatic ducts/sacs
  - Probably incomplete partitioning of the middle/apical turns of the cochlea
  - Mild left modiolus deficiency
- ENT Ordered OtoSeq Genetics Testing
  - 2 mutations in SLC26A4 gene → Pendred syndrome

3513

9 months old
Anesthesia/MRI
Failed NHS
**Wide Band Absorbance**

- **Right Ear**
- **Left Ear**

**DPOAEs**

- **Right Ear**
- **Left Ear**

**Broad Band CE-Chirp ABR Threshold**

- **20 dB Right Ear and 60 dB Left Ear**

**500 Hz 55 dB Both Ears**

- **2k Hz 15 dB Right and 70 dB Left Ear**

**1k Hz 45 dB Right and 60 dB Left**

- **4k Hz 20 dB Right and 60 dB Left**

**ASSR**

- **Right Ear**
- **Left Ear**

Subject 3513 9 Months
Masked BB Chirp Bone > 50 dB Left Ear

Subject 3513  9 Months

ABR, ASSR and Behavioral Thresholds

SUMMARY

QUESTIONS??