Protocol for Fast, Efficient Audiogram Prediction using Electrophysiology

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Interacoustics

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What Improvements Are Needed In Obtaining Audiogram Predictions in Infants??

--TESTING MUST BE FASTER TO COMPLETE AUDIOGRAM IN ONE SESSION--

1. Janssen et al (2010) found that only 80% of infants seen for audiology sleep more than 33.1 minutes. (Average is 48 minutes)
2. When testing cannot be completed, a second appointment is needed:  
   • Clinics get overloaded.  
   • Wait time for appointments goes up.  
   • Infants get older and don’t sleep as well -> sedation.  
   • More infants are lost to follow up.  
   • Hearing aid fittings are delayed.  
3. ASSR could be faster than ABR but is not well accepted.
What Improvements Are Needed In Obtaining Audiogram Predictions in Infants??

--THRESHOLD PREDICTIONS MUST BE RELIABLE--

1. ABR testing protocols are not standardized:
   • Amount of averaging varies. Current study found that the number of sweeps needed at threshold varied from 800 to 8000.
   • Response detection is arbitrary! Varies drastically across clinics.
   • Correction factors are also unclear and arbitrary.
2. ASSR uses automated protocols that are standardize **BUT**:
   • Many ASSR detection algorithms are not finding responses close to actual threshold.
   • Updated ASSR with better response detection is available.
This suggested protocol is based on a recent study of 102 children.

• Start with Tympanometry and OAE

• Get an ABR threshold in each ear using a Wide-Band CE-Chirp

• Use *AUTOMATED DETECTION* for Audiogram Prediction
  – ABR thresholds using NB CE-Chirps with reliance on Fmp  OR
  – ASSR thresholds using NB CE-Chirps and “Next Generation” detection protocol.

• Bone Conduction by if necessary
Why Start with Tympanometry and OAE?

1. Gives good advance information: Recent study, children with all points pass on DPOAE and normal Wide-Band Tympanometry had average hearing levels of 14 dB or less.
2. Easy to perform and infant does not need to be asleep
3. Knowledge of middle ear status can help guide testing decisions.
4. Advance information can help to focus the Electro-physiology and reduce test time.
SUGGESTION: Wide Band Tympanometry

![Graph showing Wide Band Tympanometry](image-url)
Views of individual frequency and wide-band (800-2k Hz) Tymps
Wideband Averaged Tympanogram

For Infants < 6 months—800-2000 Hz
For > 6 months 375-2000 Hz
Wide Band Absorbance

Frequency in kHz

Wide Band Absorbance at peak pressure (-32 daPa)
Suggestion: Wide Band Tympanometry

- Test performed using the InterAcoustics Titan
- Medium Pump Speed
- Pressure range +200 to -400 daPa
- Both ears tested
- Click Stimuli
Same Probe Used for DPs and WB Tympanometry

Time Saver: Insert Probe Ear 1, WB Tymp then DPOAE
Switch to Ear 2, DPOAE then WB Tymp.
SUGGESTION: DPOAEs

• Test Frequencies: 2, 3, 4, 5, 6 & 8kHz (descending order)
• f2/f1 ratio = 1.22
• L1/L2 65/55 dB SPL
• Response criteria:
  – Minimum DP Level = -10 dB SPL
  – SNR = 6 dB
  – Residual Noise = -20 dB SPL
  – DP reliability= 98%
• Not a screening protocol- Number of frequencies with DP recorded.
Starting with Wide-Band Tympanometry and DPOAE

Testing time for both is under 10 minutes and often less than 5 minutes for both ears.

Testing after electrophysiology can wake baby who then will be fussy.
Broad-Band CE-Chirp® LS Thresholds
More advance information to streamline electrophys

Minimum 10 dB
Broad-Band CE-Chirp® LS Thresholds
ABR Protocol -- Testing

- Use NB CE Chirps (larger amplitudes)
- Use automated detection
- 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 **only 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)
ABR Protocol-- Testing

- If response is slow (>3000 sweeps) descend in a small step size (10 dB).
- If possible use a 5 dB step size to establish threshold.
- Do not attempt to obtain thresholds below 10 dB (20 dB @ 500 Hz)
- If 5 or 6 DPOAEs are present and WB CE-Chirp threshold is 10-15 dB, start testing NB Chirps at 20 or 10 dB.
- Do everything possible to complete the test as quickly as possible:
  - Do not repeat responses that meet criteria unless necessary
  - do not test more levels than necessary
  - start threshold search at or near BB CE-Chirp threshold
  - do not stop to mark responses until after the test is fully completed
ABR Protocol--Setup

• Stimuli: .5, 1, 2, & 4kHz NB CE-Chirps LS (nHL calibration)
  – Alternating Polarity
  – 39.7/ second
  – ER-3 Insert Earphones

• Filters: 100-1500 Hz

• Window: 0-20 ms

• Stopping Rule: Which ever happens first-
  – Fmp = 2.25 (95%)
  – Residual Noise = 15 nV
  – Sweeps = 6000

• Bayesian Weighting employed – no need to pause with noise.
WB CE-Chirp Threshold = 60

WB CE-Chirp Threshold = 50
Stopped on low noise

1k Hz
Special Circumstances

• If Fmp is growing but may not reach in 6000 sweeps, additional number of sweeps can be added by the user.

• Before using external isolation transformers, noise interfered with Fmp detection in three cases where exceptional noise interference was detected.
ASSR Protocol

• Default is 4 frequencies per ear all running simultaneously.
• Starting Level is determined by tester, start 10-20 dB above WB CE-Chirp threshold.
• 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 <= 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.
WB CE-Chirp Threshold = 60

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Subject 6514  1 Month

1 month old
Natural Sleep
Failed NHS- no other risks
Subject 6514  1 Month

Wide Band Absorbance

**Right Ear**

**Left Ear**
DPOAEs

Right Ear

Left Ear

Subject 6514  1 Month
Subject 6514  1 Month

**Broad Band CE-Chirp ABR Threshold**

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

Subject 6514  1 Month
Subject 6514  1 Month

1k Hz < 10 dB Both Ears
ASSR

Right Ear

Left Ear

Subject 6514  1 Month
• 3-months-old at time of study visit
  – 3rd 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
Broad Band Tympanometry

Left Ear

Right Ear

Subject 2672  3 Months
Subject 2672
3 Months

Right Ear

226 Hz

1k Hz

.8 to 2k Hz

Left Ear
Wide Band Absorbance

**Right Ear**

**Left Ear**

Subject 2672  3 Months
DPOAEs

Right Ear

Subject 2672  3 Months

Left Ear
Broad Band CE-Chirp ABR Threshold
50 dB Right Ear and 45 dB Left Ear

Subject 2672  3 Months
1k Hz 60 dB Right Ear and 55 dB Left Ear
Subject 2672  3 Months

4k Hz  55 dB Right and 45 dB Left

Reproducibility

80 %

92%

0%
BB Chirp Bone Threshold = 30 & 35 dB

Subject 2672  3 Months
2672 3 Months - Natural Sleep - Failed Screening

**RIGHT EAR**

- **bone**-

**LEFT EAR**

- **bone**-

**TIME**

- 32.51
- 43.98

**ASSR ABR**
TEST TIME

**Projected Test Time**

*Eight Thresholds*

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<th>ASSR</th>
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**Number of Thresholds Actually Completed**

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**Test Time in Minutes**

- ABR: 32.14 minutes
- ASSR: 19.63 minutes
QUESTIONS??