Is your ABR Chirping?
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How I met the chirp
- June 2011 bought new ABR unit
  - Thank you Idaho EHDI-SoundBeginnings, Dr. Kangas and Dr. Seikel
- July 2011 Manufacture rep came to set it up/train
- As demonstrating machines function chirp listed as feature

Investigation of Chirp
- Fellow pediatric audiologist
- PubMed search via internet

Investigation Conclusion
- Manufacturers encouraging use of new stimulus with limited or no evidence based research.
- Present research positive, but all on adults with normal hearing
- Researchers still tweaking stimulus
- I have the stimulus – I work with pediatrics

What is ABR?
Auditory Brainstem Response (ABR)
- Objective testing of hearing function
- Response is simultaneously neural firings in the auditory pathway at onset of stimulus
  - Response occurs within a 5-6 msec period following presentation of high-intensity transient acoustic signal
- Click = Gold standard stimulus* for newborn hearing screening
- Common diagnostic protocol
  - Click threshold plus 500 Hz tone burst thresholds
  - Neural integrity check at high intensity
Click – Threshold Estimation

• Response threshold measurements correlate with normal and abnormal hearing function
• Indirect relationship between latency and stimulus intensity used to estimate threshold
• Threshold within 10-20 dB HL of lowest replicable wave V response

Click Analysis – Latencies

• Age specific: Compare results to age specific normative data when interpreting wave latencies
• Predictable -- neurodiagnosis and define hearing impairment

Frequency-specific – Threshold estimations

• Tone-burst evoked ABRs
  • Frequency specific early-latency AERs
• Widely accepted effective clinical method for estimating frequency-specific hearing thresholds in infants (Gorga et al., 2006; Stapells, 2000)
• Limitation: Frequency-specific correction factors are used to estimate behavioral hearing levels
  • 5 to 30 dB higher than their behavioral thresholds (Stapells, 2000; Bagatto et al., 2005)

Current stimulus limitations...

• If synchronous firings increased the more robust the ABR waveform
  • ABR is limited by cochlea’s traveling wave
• Click stimulates basal region of cochlea ~ 2 kHz
• Frequency specific tone bursts use correction factor

What is a “chirp”?

• First publication using chirp 1980
• More recently 2004-2014
  • Multiple reports describing variations of chirp stimulus used to elicit auditory response
  • Researcher: Cebulla, Dau, Don, Elberling, Fobel, Neely, Uppenkamp
• Many different types therefore many different names
  • de Boer Chirp; A-Chirp; O-Chirp; CE-Chirp; LS-Chirp; LSY-Chirp
• CE-Chirp – derived-band ABR latencies developed by Elberling and Don

Chirp Logic

• Mathematically designed “to produce simultaneous displacement maxima along the cochlear partition by compensating for frequency dependent traveling-time difference” (Fobel & Don, 2004)
• Optimize synchronization yielding a more robust ABR
• Low frequencies are presented first to offset the traveling wave delay
• Result = more synchronous firings = larger ABR Wave V response
Adult Research

- Improved synchrony of CE-chirp shown to be more repeatable with:
  - larger amplitudes in mid to high frequencies
  - better morphology

- Interpretation of ABR tracings is easier thereby making chirp stimuli more efficient than click stimuli for evaluating cochlear function

Is the chirp stimulus more efficient then the click stimulus when measuring the ABR in the pediatric population?

My research:

ABRs Evoked by Chirp and Click Stimuli in Children

1. Compare CE-Chirp stimulus to click stimuli in children with normal hearing
   - Latency and amplitude data

2. Establish normative latency data for CE-Chirp ABR responses in normal hearing children in several age ranges

3. Compare CE-Chirp stimulus to click stimuli in children with hearing impairment

Equipment & Stimuli

- ABRs were obtained with click stimuli and broad-band CE-Chirp stimuli
  - Air conduction stimuli were presented at 80, 60, 40, 20, and 10 dB nHL with alternating polarity through ER-2 earphones at a rate of 27/s
  - ABRs were analyzed for wave V latencies and amplitudes
    - Wave-V peak-to-peak amplitude was measured from the peak to the largest following negativity

Objective 1 -- Analysis

- ANOVA compared Wave V differences between age groups and intensity to determine presence of an interaction and to determine if main effect was present for age group and intensity

- Wilcoxon matched-pair signed-rank test (α=0.05) then used to analysis variables with significant difference
  - Investigate difference between chirp and click latencies and amplitudes for wave V
  - Difference determined by chirp - click

- Wave V latency measurements of chirp and click responses were compared within each age group and across all age groups

Objective 1 – Amplitude Results

- No significant interaction between age group and intensity (P = 0.45) when comparing Wave V amplitude difference

- No significant difference between age groups when comparing Wave V amplitude difference

- Significant different (P < .0001) for intensity when comparing Wave V amplitude difference
Objective 1 – Amplitude Results (con’t)

• General amplitude indicate CE-chirp at 10, 20, and 40 dBnHL to be larger than click amplitudes (P < .0001) across all age groups

• No differences in amplitudes between stimuli were detected (P>0.05) at 60 dBnHL stimuli

• At 80 dBnHL, the click stimuli produced larger amplitudes than the CE-chirp (P < .0001)

Objective 1 – Latency Results

• General latencies trends indicate CE-chirp to be longer at 10 and 20 dBnHL as compared to click; however, ≥ 40 dBnHL the click has longer latencies than CE-chirp

Objective 2: Chirp Latencies

• Given Objective 1 findings of general latency trends when comparing responses at varying intensities; stimulus not appropriate as is to determine normative latency values

Objective 3: Hearing Loss

• 4 subjects with hearing loss
  - 1 female, 3 males
  - 2 years to 6 years
  - 2 fluctuating conductive; 2 SNHL
  - 3 aided
  - 1 ear tested for each
  - Awake and somewhat quiet

• ABRs were obtained with click stimuli and broad-band CE-Chirp stimuli

• Air conduction stimuli were presented with alternating polarity through ER-2 earphones at a rate of 27/s
  - Began at 80 dBnHL then dropped to find threshold

• Behavioral thresholds found via pure-tone audiometry using conditioned play

Summary of My Findings

• Chirp ABR amplitude is larger than click ABR amplitude at or below 60 dBnHL

• Chirp latencies do not follow same pattern as click latencies

• Findings are similar to previous studies on adults

• Efficiency revealed below 60 dBnHL would allow for better waveform morphology and shorter test time

• Identify estimated threshold more accurately and confidently

• Estimated threshold closer to behavioral threshold in children with hearing loss
Most recent publications - 2014


Chirp Benefits – summary of recent publications

- Larger amplitude with fewer averages
- Increased clinical confidence
- Shorter test time
- Frequency-specific testing
- More responses at lower frequencies and intensities
- Potentially better correlation to behavioral thresholds

Limitation - latency

- Using the chirp stimulus could potentially improve newborn hearing screenings (NHS) procedures

- However, majority of latencies for chirp stimuli are shorter than click or tone bursts currently used

- Additionally, low frequency stimuli have shorter latencies than high frequency

Addressing inconsistent amplitude at high intensities

- At high intensities CE-Chirp has roll-over characteristic
- Research published since the initiation of this project has addressed this higher intensity issue using the level-specific chirp (LS-Chirp) stimulus

Additional concerns

- Overestimation of hearing function?
- Pediatric research for most part normal hearing

- 1 publication comparing behavioral threshold to ABR Chirp threshold in hearing impaired children (Xu et al., 2014)

Future research

- Determine normative latency values for individual age groups with normal hearing using LS-Chirp
- Further analysis of the LS-Chirp in the hearing impaired population
Clinical implementation?

- Strongly recommend you collect your own normative data before using any Chirp stimuli.
- Click latency information CANNOT be used when comparing Chirp responses.
- Make sure to collect those norms using the specific Chirp stimulus and the exact recording parameters you plan to use in your clinical setting.

References 1 of 2


References 2 of 2