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Comparative Analysis of Click and Level-Specific CE-Chirp Stimuli in Auditory Brainstem Response Testing in Children

Mayank Mehra[1], Omprakash Preyadarshi[2], Sandeep Kumar[3], Pawan Kumar[4]

[1]Mayank Mehra, Research Scholar, Department of Audiology and Speech-Language Pathology, Faculty of Allied Health Sciences, SGT University, Gurgaon, Haryana, India.
[2]Omprakash Preyadarshi, Senior Audiologist, Meenakshi Speech and Hearing Clinic, Agra, India.
[3]Sandeep Kumar,Audiologist, Gentle Speech and Hearing Clinic, Nawada, India.
[4]Pawan Kumar, Audiologist, Mediniroy Medical College and Hospital, Palamu, Jharkhand, India.

Abstract

Background: Auditory Brainstem Response (ABR) testing is a widely used objective method for evaluating auditory pathway integrity, especially in populations where behavioural audiometry is unreliable. Traditional *click* stimuli, while broadly used, are limited in synchronizing cochlear responses due to travel-time dispersion along the basilar membrane. Level-specific CE-chirp stimuli were developed to counteract these delays and improve neural synchrony. The present study aimed to establish normative CE-chirp ABR data in children aged 6–12 years and compare latency and threshold outcomes with click-evoked responses.

Methods: Thirty children with normal hearing (6–12 years) underwent ABR testing with both click and level-specific CE-chirp stimuli. Latencies of waves I, III, and V were recorded at 75 dBnHL. Standard audiological evaluations (PTA, immittance, DPOAEs) ensured normal peripheral hearing. Statistical comparisons were made using paired t-tests (SPSS v20).

Results: CE-chirp stimuli yielded significantly shorter latencies for waves III and V compared to click stimuli in both ears, whereas wave I latency differences were not significant. Estimated hearing thresholds were significantly lower with CE-chirp stimuli. The differential wave V latency at threshold further suggested improved neural synchrony with CE-chirp compared to click stimulation.

Conclusions: Level-specific CE-chirp stimuli produce more synchronized neural responses, leading to earlier wave III and V latencies and better threshold estimation than click stimuli. Their clinical use is recommended for pediatric ABR protocols to enhance test efficiency and reliability.

Introduction

The Auditory Brainstem Response (ABR) is a fundamental electrophysiological technique used to assess the integrity of the auditory pathway from the cochlea to the brainstem. It is particularly valuable in pediatric assessments where behavioural responses are unreliable due to developmental limitations. Traditional click stimuli activate a broad frequency spectrum, but their effectiveness is constrained by cochlear travel-time dispersion, leading to less synchronized neural firing.

CE-chirp stimuli were designed to compensate for this dispersion by temporally staggering frequency components, thereby maximizing concurrent activation of cochlear nerve fibers. Previous research demonstrates that chirp-evoked ABRs can produce larger wave amplitudes and shorter latencies relative to clicks, reflecting enhanced neural synchrony. This study compares click and level-specific CE-chirp ABRs in normal-hearing children to examine differences in latency measures and threshold estimates, thereby contributing to normative pediatric data and supporting clinical application.

Methods

Participants

Thirty pediatric subjects aged 6–12 years with normal auditory function were included. **Inclusion criteria** were:

- Normal otoscopic examination
- Type A tympanogram
- Present Distortion Product Otoacoustic Emissions (DPOAEs)
- No history of middle ear pathology or neurological disorders
- Typical cognitive and developmental status

Instrumentation

- Pure Tone Audiometer (AudioLab – Labat)
- Maico MI-26 Immittance Audiometer
- DPOAE Analyzer
- Neurosoft ABR System with ER-3A insert earphones

ABR Recording Parameters

- **Stimuli:** Click and level-specific CE-chirp
- **Intensity:** 75 dBnHL, descending to threshold
- **Rate:** 31.1/s
- **Filter Bandwidth:** 100–3000 Hz
- **Sweeps:** 2000
- **Electrode Montage:** High forehead (non-inverting), mastoid (inverting), low forehead (ground)

Procedure

Participants underwent standard audiological assessment, including PTA and immittance, to confirm normal hearing status. ABR recordings were acquired in a sound-treated environment with minimal subject movement. Absolute latencies of waves I, III, and V were documented for each stimulus type. Threshold estimation was determined by descending intensity until the lowest observable V wave was identified. Statistical significance was evaluated using paired t-tests ($p<0.05$).

Results

Table 1: Wave Latency Comparison at 75 dBnHL

Wave	Click (ms)	CE-Chirp (ms)	Significance (p)
I	1.79	1.78	>0.05 (NS)
III	3.95	3.85	<0.05
V	5.77	5.60	<0.05

Table 2: Hearing Threshold Comparison

Ear	Click (dBnHL)	CE-Chirp (dBnHL)	Significance (p)
Right	21.00	14.83	<0.05
Left	21.16	15.66	<0.05

Key Findings:

- CE-chirp stimuli significantly reduced latencies for waves III and V compared to click stimuli.
- CE-chirp yielded significantly better (lower) threshold estimates.
- The latency advantage for wave V at threshold suggests enhanced neural synchrony with CE-chirp stimuli.

Discussion

The present results demonstrate that level-specific CE-chirp stimuli produce more synchronized auditory neural firing compared to traditional clicks, evidenced by significantly shorter latencies for waves III and V and lower threshold estimates. These findings align with studies showing enhanced waveform morphology and reduced latencies with CE-chirp, particularly in infants and children.

Recent pediatric investigations further highlight clinical benefits of chirp-based ABR, including higher wave V amplitudes and consistent detection across intensities. Moreover, comparisons of auditory steady-state responses and ABR suggest that chirp-based evaluations contribute complementary threshold information in comprehensive audiological assessments.

Overall, CE-chirp stimuli enhance the reliability and efficiency of pediatric ABR testing, facilitating earlier identification of neural response thresholds and improving clinical workflow.

Conclusion

Level-specific CE-chirp stimuli provide significant advantages in pediatric ABR testing by improving neural synchrony, shortening key peak latencies, and enabling more accurate threshold estimation compared with traditional click stimuli. Their clinical adoption in routine pediatric electrophysiological assessment is recommended.

Limitations

- Gender-specific and age subgroup comparisons were not performed.
- Amplitude measures were not analyzed.
- Only normal-hearing children were included.

Future Directions

- Evaluate CE-chirp ABR in children with hearing impairment or auditory neuropathy spectrum disorder.
- Compare responses across age brackets and stimulation rates.
- Incorporate tone burst and narrow-band chirp comparisons in normative pediatric data.
- Extend studies to include adults and geriatric populations.

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