The difference between Chirp & Click stimulation in Diagnostic Auditory Brainstem Response in assessment of hearing among age group between 1-10 years Iraqi children

By

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Abstract:

Background: Aim: To compare the response of human auditory brain stem evoked by clicks stimuli and chirps. **Patients and Methods:** A study of cross-sectional design was chosen to evaluate the objective of the study. Children between 1-10 years were enrolled from the attendants of the Dept. of Surgery and Audiology, Al-Jamhoori Teaching Hospital, Ministry of Health /Nineveh health Directorate, and the outpatient clinics in al-alwiyah teaching hospital for children and done in the privet clinics of the researchers. The data collection extended over the period from 2019 January to 2020 August. A total number of 70 children involved in the study according to the parents' complaints, full history taken and the clinical examination by otoscopy. The probable conductive problem excluded by using the Tympanometry. Moreover, free field test was done before chirp and click. Paired t-test was used for the statistical analysis. **Results:** The males represent (44.3%) and the females (55.7%). The mean age of children included was 49 months ± 27.7 SD. Wave V of the chirp shows lower latency means in all intensities in comparison with that of click stimuli. While waves I and III, show longer latency as the intensity go down, but the differences between chirp and click are insignificant. Wave V amplitudes getting lower values as the intensity decreasing in both chirp and click and become significantly higher than that of click. Wave I and III show decreasing amplitudes with the decreasing intensity in both chirp and click, with higher amplitudes in click in comparing with that of chirp, which are insignificant statistically down to below 70 dBnHL.**Conclusions:** The chirp stimuli are highly significant and more efficient from the click in the detection of hearing loss among the children regarding both latency and amplitude particularly at wave V.

Key words: ABR, Chirp, Click, Latency and amplitude.

Introduction:

Auditory brainstem response (ABR),described first by Jewett with Williston during 1971 for the detection of hearing impairment. It refers to the potential that evoked by short-term click which passed across inserted earphone or headphone to reach the cochlea, generating waves in the brainstem.These waves could be measured by the surface electrodes sited characteristically at the vertex of the scalp and ear lobes. This non-invasive neurological test relies principally on the determination of the weakest stimulus intensity at which the ABR can be elicited [1-3].

In click type ABR, the wave generated at cochlea, transmitted with some delay to the apical fiber end. So, the activation of different unit of neurons located alongside the basilar membrane of cochlear panel from the base to apex will stimulated at different times in such a way that, the apical fibers activated few milliseconds after the activation of basal fibers then the neural activity will be faded out across all nerve fibers. While in chirp stimulus, there is a process of auditory compensation using stimulus, which ensure rearrangement of the higher wave frequency in relation to the lower frequencies, so the arrival of every frequency component is delayed at its site of highest excitation alongside the cochlear apparatus, but arrive approximately at once [4-6].

The composition of click stimulus is broadband; with maximum peak power in the regions from 2000-4000 Hz region. Because of those limitations, researchers have longed for a stimulus that triggers all desired frequencies of the basilar membrane at the same time [7]. The chirp was introduced to solve this problem, although it has a duration up to 10.33 ms, which is much longer than the click, it is a frequency modulated sinusoidal signal with low frequencies at the beginning and high frequencies at the end of the stimulus. Due to the frequency modulation, the place-specific travelling time on the basilar membrane can compensated resulting in an increase of the synchronization of action potentials and with that in higher ABR amplitudes, the advantage of chirp stimulus over the commonly used click stimulus is that it yields a higher synchronization of action potentials on the nerve fibers, which is especially true at stimulus levels close to the threshold. Chirp may contain frequency components covering a major range of basilar membrane [8, 9].

The ABR is an objective measurement, designed primarily to record the behavioral responses to sound in persons who had developmental problems that made them unable to respond and provide precise calculations of threshold [10, 11].

The aim of the current work is to compare the response of human auditory brain

Patients and Methods:

A study of cross-sectional design was chosen to evaluate the objective of the study. Children between 1-10 years were enrolled from the attendants of the Dept. of Surgery and Audiology, Al-Jamhoori Teaching Hospital, Ministry of Health /Nineveh health Directorate, and done in the privet clinics of the researchers. The data collection extended over the period from January 2019 to August 2020.

A total number of 70 children involved in the study according to the parents' complaints, full history taken and the clinical examination by otoscopy. The probable conductive problem excluded by using the Tympanometry. Moreover, free field test was done.

Exclusion criteria: includes absence of suspected neurological alterations or suggested syndromes, absence of agenesis of the external ear, or ear canal.

The formal informed consent was taken from the parents of the children.

Before conducting ABR, a 5% Chloral Hydrate (Hypnoral) syrup given to those children at dose 40 mg/kg, which might repeated if necessary after 20-30 minutes, then the child was placed on a reclining masseuse table with head and neck support by a suitable pillow, furthermore light illumination and low noise environment should be ensure to reduce the accompany noise recorded and the muscle artifact.

The equipment used in the test was PATH-MEDICAL Diagnostic Auditory Brain Stem Response Test (Germany) was used and the stimuli applied in consequences starting by Click type then Chirp types with rarefaction polarity. The electrophysiological signal is picked up differentially between two electrodes; one applied high on the mid-frontal area Fz and the other on the ipsilateral mastoid M1 or M2, while the ground electrode placed at the lower mid-frontal area Fpz. The EEG is band pass filtered from 100 to 3000 Hz using filter slopes of 12 dB/octave.

Statistical analysis was done by using statistical package of social science (SPSS version 20). It measured mean, standard deviation, and the range (whether minimum and maximum limits) for the numerical data, while the categorical data were measured by number, as well as, percentages. The paired *t*-test used for calculation of parametric data. The p-value $\leq$ 0.05 was considered statistically significant.

Results:

A total of 70 children were included in the study. The males represent 31 (44.3%) and the females 39 (55.7%). The mean age of children included in the study was 49 months ± 27.7 SD, distributed as follows: 26 in 0-3 years, 26 in 4-6 years, 16 in 7-9 years & only 2 in 10 years' age groups, as the figure (1) illustrates.

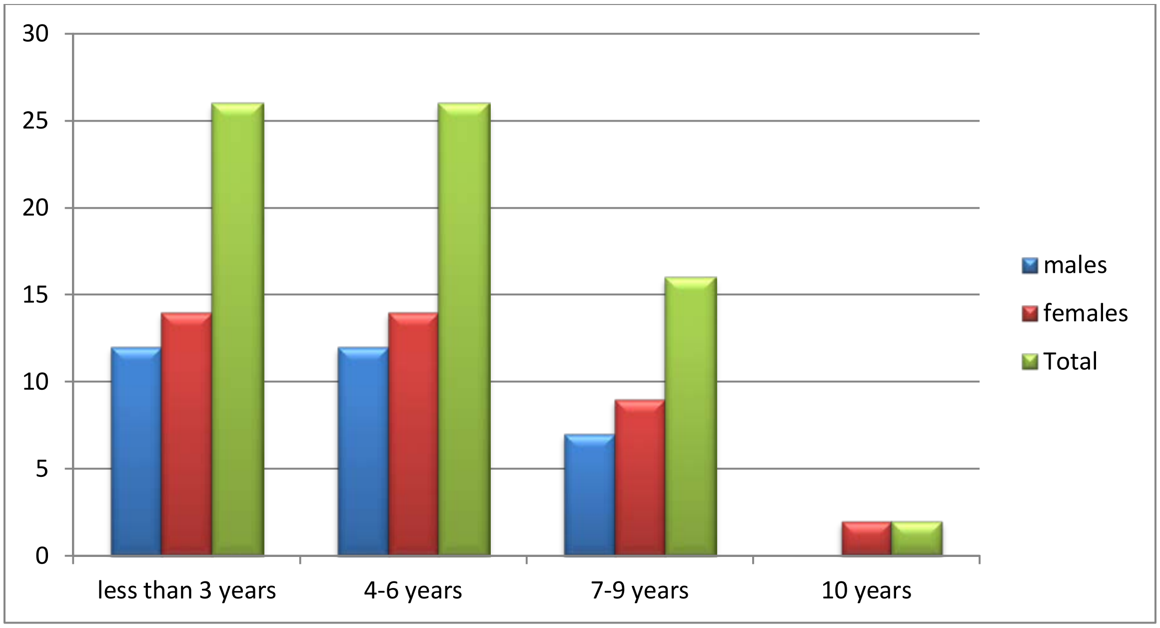

Figure (1): Distribution of study sample according to age groups and gender.

Table (1): The comparison of latency (ms) at different intensity levels, between chirp and click.

Latency of Waves	Chirp	Click	p-value*
	mean± SD	mean± SD	
Wave V 90 dBnHL	5.23±0.47	5.36±0.32	0.000
Wave V 80 dBnHL	5.41±0.13	5.65±0.32	0.001
Wave V 70 dBnHL	5.53±0.47	5.68±0.22	0.017
Wave V 50 dBnHL	6.34±0.52	6.42±0.48	0.000
Wave V 35 dBnHL	7.10±0.20	7.21±0.25	0.005
Wave III 90 dBnHL	3.65±0.76	3.79±1.28	0.127
Wave III 80 dBnHL	3.73±0.62	3.84±0.73	0.338
Wave III 70 dBnHL	3.53±0.36	3.78±1.1	0.073
Wave III 50 dBnHL	4.46±1.58	4.53±1.21	0.769
Wave III 35 dBnHL	5.58±1.32	5.40±2.3	0.571
Wave I 90 dBnHL	1.44±0.51	1.39±0.22	0.415

Wave I 80 dBnHL	1.49±0.72	1.58±0.38	0.357
Wave I 70 dBnHL	1.72±.029	1.61±0.52	0.125
Wave I 50 dBnHL	2.41±0.93	2.59±0.4	0.139
Wave I 35 dBnHL	3.52±0.31	3.48±0.26	0.409

*Paired t-test was used

Table (1) demonstrates the comparisons of latency, in milli seconds between chirp and click at different intensity levels, and reveals that at wave V, the chirp shows the lower latency means in all intensities in comparison with that of click stimuli. The means of latency for both chirp and click rise as the intensity decrease. The waves I and III, similarly show longer latency as the intensity go down, but the differences between chirp and click are insignificant.

Table (2): Comparison of V amplitude (µv) between chirp and click.

Amplitude of Waves	**Chirp**	**Click**	**p-value***
	mean± sd	mean± sd	
Wave V 90 dBnHL	0.89±0.26	0.61±0.18	0.000
Wave V 80 dBnHL	0.83±0.29	0.72±0.15	0.006
Wave V 70 dBnHL	0.78±0.26	0.58±0.153	0.000
Wave V 50 dBnHL	0.65±0.202	0.41±0.169	0.000
Wave V 35 dBnHL	0.50±0.179	0.35±0.145	0.000
Wave III 90 dBnHL	0.36±0.26	0.41±0.11	0.142
Wave III 80 dBnHL	0.34±0.09	0.37±0.18	0.215
Wave III 70 dBnHL	0.33±0.1	0.37±0.17	0.093
Wave III 50 dBnHL	0.31±0.13	0.36±0.11	0.015
Wave III 35 dBnHL	0.30±0.2	0.36±0.12	0.034
Wave I 90 dBnHL	0.29±0.16	0.36±0.27	0.065
Wave I 80 dBnHL	0.29±0.15	0.34±0.17	0.067

Wave I 70 dBnHL	0.27±0.12	0.31±0.13	0.061
Wave I 50 dBnHL	0.12±0.05	0.30±0.03	0.001
Wave I 35 dBnHL	0.10±0.03	0.30±0.07	0.001

*Paired t-test was used

Table (2) demonstrates the comparison of wave amplitude between chirp and click, and reveals that wave V amplitudes getting lower values as the intensity decreasing in both chirp and click. Moreover, the wave V amplitudes in chirp are significantly higher than that of click. Wave I and III show decreasing amplitudes with the decreasing intensity in both chirp and click, with higher amplitudes in click in comparing with that of chirp, which are insignificant statistically down to below 70 dBnHL, where become significantly differ.

Discussion:

Significantly short latencies for wave V by chirp stimulation in comparison to that produced by click at the levels of intensity from 90 down to 50, and at 35 dBnHL as shown in table (1). These findings were agreed with the findings of Rodrigues and Lewis (12) down to the intensity of 35 dBnHL; where chirp latency is shorter at 80 and 60 dBnHL and longer than click at 40 down to 20 dBnHL. Similarly, El-Mously (13) reported significantly short latency for waves V by chirp stimulation in comparison with click at intensity level 70 and 50 dBnHL, while at lower intensity levels (30, 20 and 10 dBnHL), the opposite occurred.

On the contrary, Cobb and Stuart [14] reported significant longer CE-chirp latencies than corresponding click for wave V at 60 and 45 dB, the repetition rate was 57.7/s, to which, the difference can be attributed.

In the comparative study done by El-Attar *et al* (15), the latency analysis of wave V between click and chirp stimuli performed at 90, 70, 50, and 30 dBnHL intensity levels and found that the wave V latencies were shorter with highly significance produced by chirp in comparison with that of click stimuli which matched with the current study. Furthermore, studies of Kristensen and Elberling (16), Elberling and Don (17), and Maloff *et al* (18), all documented that the chirps produced shorter time and higher signal-noise ratio in comparison with that of the click, and the chirp is better than a click in recording of responses. These findings occurred because the chirp stimuli activates different sites of the basilar membrane at the same time and thus balance the reaching time of the sound in the cochlea. Accordingly, low-frequency components are presented before the high-frequency components, that is, before the zero latency reference, in such a way that shorter latencies are expected in response to this stimulus.

The latencies of waves I, as well as, III, and V were noticed with LSCE-Chirp and click and show insignificant differences in the cross-sectional study with 30 normal-hearing individuals done by Cargnelutti [19], which were matched with our findings regarding the waves I and III only. In the study of Vida *et al* [20], different view has been seen, they found that at 80 dB nHL, click stimulus evokes waves I and III significantly more frequent than chirp stimulus does with (p=0.012 and p=0.016 respectively). While CE-Chirp produced significant wave V latency at 20 nHL with (p=0.12) and 40 dB nHL (p=0.000), which were longer than wave V latency of click. Oppositely, at 80 dB nHL wave V latency produced by CE-Chirp is shorter than click (p=0.000). The wave V amplitude at levels of 20, 40 and 60 dB nHL for CE-Chirp is significantly larger than for click (p=0.000, p=0.000 and p=0.013 respectively). The threshold of wave V is around 5 dB lesser with CE-chirp compared to click (p=0.014).

The wave V amplitude values which were clarified in the table (2) of the current study are (0.89±0.26), (0.83±0.29), (0.78±0.26), (0.65±0.202), and (0.50±0.179) at 90, 80, 70, 50, and 35 dBnHL respectively by using CE-chirp which were significantly larger than that evoked by click and this might be due to synchronized excitation of the cochlea. The direct relation between the wave V amplitude with the intensity was similar but higher to the finding of El Danasoury *et al* study [21], in which the wave V amplitude was 0.44, 0.55, and 0.69 μV at 30, 50, and 70 dB, respectively, and to Parlak *et al* [22], who reported small mean wave V amplitude that found to be 0.21, 0.25, 0.38, and 0.42 μV at 20, 40, 50, and 70 dBnHL, respectively.

Cebulla *et al.* [5] concluded that the advantage of CE-chirp stimuli is producing larger amplitude than the click at low intensity levels, and considered it faster and more reliable. While in study done by Rodrigues and Lewis [11] the larger amplitude of chirp was found at low intensity levels 60, 40, and 20 dBnHL, and smaller amplitudes were detected for chirp at a high-intensity level in comparison with click, and this could be due to mechanical factors. whereas Maloff *et al* [18], compared the results obtained by using chirp or click stimuli, and they found larger V wave amplitudes than click V amplitudes especially at lower sound intensities. Vida *et al* [20] study documented that the amplitude of wave V for CE-chirp is larger than click at 20, 40 and 60 dB nHL with statistical significance at (p=0.000, p=0.000, and p=0.013 in that order), and the wave V intensity is about 5 dB significantly lower with CE-

chirp in comparing to click (p=0.014).

In a study of Pushpalatha and Konadath,[1] the waves I and III were absent at a high intensity and this might be due to the increasing spread of activation. Waves I and III could not be obtained in several patients which was a significant limitation for diagnosis and seems to be a disadvantage of the CE-chirp stimulus. Therefore when the waves I and III could be detected with CE-chirp stimulus, the application of this at a level of maximum 70 dB nHL would be suitable. The present work found that the amplitudes of wave I and III evoked by the click were significantly larger than that of the chirp at the lower intensities only.

Conclusions:

The chirp stimuli are highly significant and more efficient from the click in the detection of hearing loss among the children regarding both latency and amplitude particularly at wave V.

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Conflict of Interest: None

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