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Auditory Evoked Brain Stem Potential with click stimuli and *Ichirp*

Potencial Evocado Auditivo de Tronco Encefálico com estímulos clique e *Ichirp*

Potencial Evocado Auditivo de Tronco Encefálico con estímulos clic y *Ichirp*

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Abstract

Purpose: To compare the traces of Brainstem Auditory Evoked Potential with the use of click stimuli and *Ichirp* in adults with normal hearing. **Methods:** This is a cross-sectional, analytical, quantitative study. Eleven hearing adults with ages between 20 and 25 years, with normal audiometric thresholds, totaling 22 ears were analyzed. These subjects performed the recording of the Auditory Evoked Potential of Click Brain Trunk and *Ichirp*. The latency and amplitude of the V wave was recorded through a computer using the Intelligent Hearing System (IHS) equipment at intensities: 80, 60, 40 and 20 dB. **Results:** No statistically significant differences were observed in V-wave amplitudes when compared to the *Ichirp* stimulus with the click, in the intensities of 80 dB (p = 0.11), 60 dB (p = 0.14), 40 dB (p = 0.96) and 20 dB P = 0.21). Regarding the latency of the V wave, significant statistical differences between the *Ichirp* and click stimuli were found in the following intensities: 60 dB (p = 0.003) and 40 dB (p = 0.016). **Conclusion:** Larger latencies were observed with the *Ichirp* stimulus.

Keywords: Electrophysiology; Auditory Evoked Potential; Deafness; Hearing; Hearing Loss.

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Authors' contributions:
BCSR – data collection, orientation in all phases of the research, revision and authorization of the final version of the article.
RFSS - data collection, literature review, preparation and authorization of the final version.
MS – literature review, preparation and authorization of the final version.
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Resumo

Objetivo: Analisar os traçados do Potencial Evocado Auditivo de Tronco Encefálico com o uso dos estímulos clique e o *Ichirp* em adultos com audição normal. **Método:** Trata-se de um estudo transversal, de caráter analítico, quantitativo. Foram analisados exames de Potencial Evocado Auditivo de Tronco Encefálico de 11 adultos ouvintes (2 orelhas), na faixa etária entre 20 e 25 anos, sem alterações auditivas. Esses sujeitos realizaram o registro do Potencial Evocado Auditivo de Tronco Encefálico com estímulo clique e *Ichirp*. O registro das latências e amplitudes da onda V foi realizado por meio do equipamento *Intelligent HearingSystem* – IHS, nas intensidades: 80, 60, 40 e 20 dB. **Resultados:** Não foram observadas diferenças estatisticamente significativas quanto às amplitudes da onda V, quando comparado os registros do Potencial Evocado Auditivo de Tronco Encefálico estímulo clique e do *Ichirp*, nas intensidades de 80 dB (p= 0.11), 60 dB (p=0.14), 40 dB (p=0.96) e 20 dB (p=0.21). Em relação às latências da onda V, foram encontradas diferenças estatísticas significantes entre os estímulos *Ichirp* e clique, nas seguintes intensidades: 60 dB (p=0,003) e 40 dB (p=0,016). **Conclusão:** Foram observadas latências maiores para o Potencial Evocado Auditivo de Tronco Encefálico com o estímulo *Ichirp*; contudo ausência de diferença entre as amplitudes. Houve maior facilidade na marcação da onda V com o estímulo *Ichirp*.

Palavras-chave: Eletrofisiologia; Potencial Evocado Auditivo; Surdez; Audição; Perda Auditiva.

Resumen

Objetivo: Analizar los trazados del Potencial Evocado Auditivo de Tronco Encefálico con el uso de los estímulos clic y el *Ichirp* en adultos con audición normal. **Método**: Se trata de un estudio transversal, de carácter analítico, cuantitativo. Se analizaron exámenes de Potencial Evocado Auditivo de Tronco Encefálico en 11 adultos oyentes (2 orejas), en el grupo de edad entre 20 y 25 años, sin alteraciones auditivas. Estos sujetos realizaron el registro del Potencial Evocado Auditivo de Tronco Encefálico con estímulo clic y *Ichirp*. El registro de las latencias y amplitudes de la onda V fue realizado por medio del equipo *Intelligent Hearing System* - IHS, en las intensidades: 80, 60, 40 y 20 dB. **Resultados:** No se observaron diferencias estadísticamente significativas en cuanto a las amplitudes de la onda V, cuando comparados a los registros del Potencial Evocado Auditivo de Tronco Encefálico estímulo clic y *Ichirp*, en las intensidades de 80 dB (p = 0.11), 60 dB (p = 0.14) , 40 dB (p = 0.96) y 20 dB (p = 0.21). En cuanto a las latencias de la onda V, se encontraron diferencias estadísticas significativas entre los estímulos *Ichirp* y el clic, en las siguientes intensidades: 60 dB (p = 0,003) y 40dB (p = 0,016). **Conclusión**: Fueron observadas latencias mayores para el Potencial Evocado Auditivo de Tronco Encefálico con el estímulo *Ichirp*; sin embargo, ausencia de diferencia entre las amplitudes. Hubo mayor facilidad en la marcación de la onda V con el estímulo *Ichirp*.

Palabras claves: Electrofisiología; Potencial Evocado Auditivo; Sordera; Audición; Pérdida Auditiva.

Introduction

Auditory health has been one of the most discussed topics in the scientific environment, due to the importance of hearing in human communication, being essential the early identification of auditory alterations, in order to reduce their biopsychosocial consequences[1].

Among the various objective exams for the diagnosis of auditory alterations, there is the Brainstem Auditory Evoked Potential (BAEP) that is constantly used in audiological assessments of adults who present tinnitus, assymmetric hearing loss or when there is a suspicion of simulation of responses in pure tone audiometry [2].

The BAEP, besides evaluating the electrophysiological activity of the auditory system in response to an acoustic stimulus, also evaluates the function of the central and peripheral auditory pathways. The results obtained are represented by

seven waves generated by the cochlear nerve and the brainstem, which emerge from zero to eight milliseconds (ms) after acoustic stimulation, in which only waves I, III and V are analyzed because they present better morphologies and amplitudes [3,4].

The BAEP trajectory is evaluated by the morphology, latency, amplitude, absolute latency and interpeak wave relationships. Any involvement in the peripheral portion and in the brainstem of the auditory system compromises the tracing of these waves [5].

The click stimulus is the most used in clinical practice for evoking electrophysiological responses in the BAEP, stimulating a larger cochlear region, producing greater neuronal synchrony. However, surveys show that click responses are not fully synchronized [3,6].

When a click hits the basilar membrane, the resulting sound wave takes considerable time to reach the base of the cochlea, especially in the low frequency regions[7]. Thus, the click is a short duration stimulus capable of exciting the inner ear in the range of 2,000 Hz to 4,000 Hz [8].

Since the 1990s, researchers have been studying a new stimulus, called the broadband chirp, which is a stimulus of simultaneous neuronal activation of the cochlea, thus improving the temporal delay that the click stimulus causes and increasing the amplitude of the V-wave, mainly in low and medium intensities. This improvement in responses occurs, because, in the chirp, the high frequencies are delayed in relation to the lower frequencies [9,10].

The chirp differs from the click stimulus, because of the way it excites the cochlea. The click is a broadband stimulus that has been developed, so that, all its frequency components present themselves simultaneously. Thus, when considering cochlear tonotopy, each region of the basilar membrane is stimulated, one after another, from the base to the apex. Thus, low frequency components take longer to reach the apex of the cochlea, causing a temporal delay in the excitation of a part of the basilar membrane. Consequently, the activation of the neural fibers responsible for the basal regions of the cochlea precedes that of the apical fibers in a few milliseconds. The result of the stimulation of the different neural fibers at different times is the reduction of the neural synchrony necessary to evoke an auditory potential [11,12].

There are differences in the market between the names given to the chirp stimulus; however, this difference is due to the different manufacturers of the BAEP equipment. It is worth mentioning that all stimuli of the chirp family maintain the basic principles of the stimulus, however, small changes that may interfere with the stimulation of the cochlea can be observed.

In a Brazilian study, which aimed to compare the BAEP with the CE-chirp stimulus to the click BAEP in 12 subjects with normal hearing, the latencies and amplitudes of the V-wave and the presence or absence of waves I, III and V in strong intensities were compared. The results showed that the V-wave latencies observed with CE-chirp were higher than those observed with the click at low intensities (20 and 40 dB). In the strong intensities (60 and 80 dB), the opposite occurred. Larger amplitudes were observed with CE-chirp in all intensities, except for 80 dB[13].

In another study, it was observed that the BAEP with the chirp stimulus has, on average, 15% greater amplitude when compared to the V-wave of the click stimulus [14].

Researchers studied the BAEP with the chirp stimulus based on BAEP-derived bands latencies in ten adults with normal hearing at two levels of intensity, 50 dB and 60 dB. Were found higher amplitudes of responses for the chirp than for the click and it was observed that the lower the intensity, the greater the amplitude for the chirp and the latency of the responses were shown to be smaller for the chirp than for the click [15].

Research [15] observed the latencies and amplitudes of the Composite Action Potential in 16 normal listeners adult, comparing the responses captured with the click and chirp stimuli. The results showed that the responses evoked by chirp were better than by click, since the amplitude was higher and the latency lower, which suggests that the fibers of the auditory nerve responded more synchronously to the chirp.

Cebulla and Elberling [16] constructed five chirps of different durations based on different versions of delay models, denominating them chirp 1, chirp 2, chirp 3, chirp 4 and chirp 5. Comparing them with the click stimulus in the BAEP evaluation in 50 adults with normal hearing at the intensities of 50 and 30 dB were clearly observed the waves III and the IV-V complex in 50 dB, but in the intensity of 30 dB, these details became less clear, especially for longer chirps. Responses with larger amplitudes and lower latencies were obtained for the chirp

when compared to the click stimulus. The chirp seems to offer greater advantage than the click on the lower intensities.

Elberling and Don [17] suggested that the previously developed chirp stimuli were difficult to apply properly since they depended on the influence of different mechanisms. Therefore, the chirps of specific frequency were developed, elaborated from the BAEP latencies. This new model provided estimates of the delay of each frequency that the chirp should compensate. The BAEP responses were compared with the CE-Chirp stimulus and the chirp stimulus at frequencies of 500, 1000, 2000 and 4000 Hz in 25 adults with normal hearing and at six stimulation levels (10, 20, 30, 40, 60, 80 dB). The authors concluded that this chirp stimulus would be the most efficient for BAEP recording, which later became known as *Level Specific Chirp (LS-Chirp).*

The literature has shown that the chirp stimulus has presented significant results in adults and neonates with normal hearing and hearing loss. However, the lack of research involving the *Ichirp* stimulus is evident, making it necessary to study this new stimulus in clinical practice and in the audiological diagnosis, since some devices only have the *Ichirp* stimulus to evocate responses.

In the literature, only one study concerning the *Ichirp* stimulus, carried out in 2016, [18] was verified, in which thirty full-term neonates with click and *Ichirp* stimuli were evaluated at intensities of 60 dB, 40 dB and 20 dB. It obtained, as results, latencies and amplitudes larger with the *Ichirp* stimulus when compared to the click stimulus, in all frequencies tested. It was concluded that the *Ichirp* is recommended for children's audiological evaluation, because it presents good amplitude of the V-wave, facilitating identification in tracing, besides presenting higher latencies.

Thus, considering the constant evolution of new stimuli of the auditory evoked potential in the audiological equipment used, one must consider and reflect on the normative and the scientific-technical base for the execution of a professional practice in reliable audiology.

Therefore, the objective of this study was to analyze the traces of the Brainstem Auditory Evoked Potentials with the use of click stimuli and *Ichirp* in adults with normal hearing.

Methods

This research has a transversal, analytical and quantitative nature. The research complied with the Resolution No. 466/12 and was approved by the Research in Ethics Committee (CAAE 55350316.0.0000.5546). This research is inserted in the Program of Studies of Graduation in Speech, Language and Hearing Sciences, of the Universidade Federal de Sergipe, Campus Prof. Antônio Garcia Filho, in the audiology outpatient clinic, where the investigation was carried out. All the individuals evaluated in the research signed the Free and Informed Consent Term.

Eleven adults with normal hearing (22 ears), aged between 20 and 25 years old, were evaluated. All participants underwent hearing screening, in which the procedures performed were: interview containing identification, health history, audiological complaints and visual inspection of the external acoustic meatus (EAM), using the otoscope to verify the integrity of the EAM, as well as the tympanic membrane. The imitanciometry was performed to evaluate the integrity of the middle ear and the tympanic membrane, using Interacoustics AT 235 equipment. The audiometry was performed to evaluate the auditory system and the auditory threshold of the subject, with the AC-33 audiometer of Interacoustics, using a supra-aural earphone.

The presence of hearing loss, neurological, visual and psychic alterations, poor head and neck formation, and syndromes of any nature were considered as exclusion criteria.

In the evaluation of the BAEP, performed with the Intelligent Hearing System – HIS - equipment, the subjects were asked to lie on the stretcher at rest. The skin was cleaned with Nuprep® abrasive paste, and the disposable Ag / AgCl electrodes of the brand MeditraceTM 200 were placed and arranged as follows: reference electrodes on the right (A) and left (B) mastoids; active electrodes in the Fz region and ground in FPz. The click or the Ichirp stimuli were averaged by the ER-3rd phone insertion in all subjects evaluated, and for 5 subjects, the BAEP record was performed at first with the click stimulus and then for *Ichirp,* and for the other 6 subjects started with *Ichirp* stimuli. The following stimulation and uptake parameters were used: stimulus frequency: 2000 - 4000 Hz; presentation rate: 27.7 / sec; number of stimuli: 1024 stimuli; alternating polarity; intensity: 80, 60,

40 and 20 dBnNA; filter: 100-3000 Hz; analysis window: from 0 to 24 ms; impedance: 1 to 3kΩ. The waves were replicated twice for each record.

The examinations were analyzed qualitatively and quantitatively by two expert and experienced judges in the area of hearing electrophysiology. The V-waves of the BAEP were demarcated, and latency and amplitude parameters were analyzed for the different stimulus intensities (80, 60, 40 and 20 dB).

The data were tabulated and processed by the Statistical Package for Social Sciences (SPSS), version 21.0 for microcomputer application. Descriptive statistics techniques were applied, and the results were expressed in the form of tables and graphs. The normality of the samples was observed through the Kolmogorov-Smirnov test. In order to detect differences in the latency and amplitude parameters of the BAEPs recorded through the click and *Ichirp* stimuli, Wilcoxon's non-parametric test was applied. Alpha values were considered significant when lower than 0.05. The established beta value was 0.1.

Results

The sample consisted of eleven adult subjects (22 ears), 9 women and 2 men, with ages between 20 and 25 years old, without auditory alterations.

No differences were verified for the parameters of the V-wave amplitude and latency of the click BAEP and *Ichirp* BAEP, between the right and left ears and, between the genders, for values of $p \leq 0.005$.

The average values of latency and amplitude of the V-wave of the click BAEP and the *Ichirp* BAEP were analyzed for different stimulation intensities, as can be seen in Tables 1 and 2.

Lower latency values were observed for the V-wave of the click BAEP; however, waves with higher amplitudes were presented in the *Ichirp* BAEP. When applying the Wilcoxon test, significant differences were observed between the *Ichirp* and click stimuli only for the latency variable in the BAEP records at intensities of 60 and 40 dB (Tables 1 and 2).

Table 1. P values of BAEP V-wave latency analysis for click and Ichirp stimuli at different intensities (N = 22).

Absolute Latencies	80 dB		60 dB		40 dB		20 dB	
	Ichirp	click	Ichirp	click	Ichirp	click	Ichirp	click
Mean ±SD*	8.49 ±0.43	5.61 ±0.20	9.03 ± 0.41	6.11 ± 0. 28	10.04 ±0.50	6.80 ±0.63	11.14 ± 0.73	7.67 ±0.75
Median	8.53	5.63	9.05	6.10	9.95	6.78	11.05	7.63
P Value	0.11		0.003		0.016		0.098	

Subtitle: *SD – Standard Deviation.

Table 2. P values for the analysis of the BAEP V-wave amplitude for click and Ichirp stimuli at different intensities (n = 22).

Amplitude	80 dB		60 dB		40 dB		20 dB	
	Ichirp	click	Ichirp	click	Ichirp	click	Ichirp	click
Mean ±SD	0.998 ±0.548	0.850 ±0.372	0.848 ±0.594	0.647 ±0.253	0.768 ±0.540	0.544 ±0.221	0.523 ±0.260	0.430 ±0.150
Median	0.740	0.710	0.690	0.590	0.600	0.490	0.470	0.380
P Value	0.11		0.14		0.96		0. 21	

Legend: SD – Standard Deviation; p values obtained through the *Wilcoxon test.*

It was observed in the clinic that the *Ichirp* stimulus was easier to visualize than the click stimulus, presenting better morphology, especially in the lower intensities, as can be seen in figures 1 and 2.

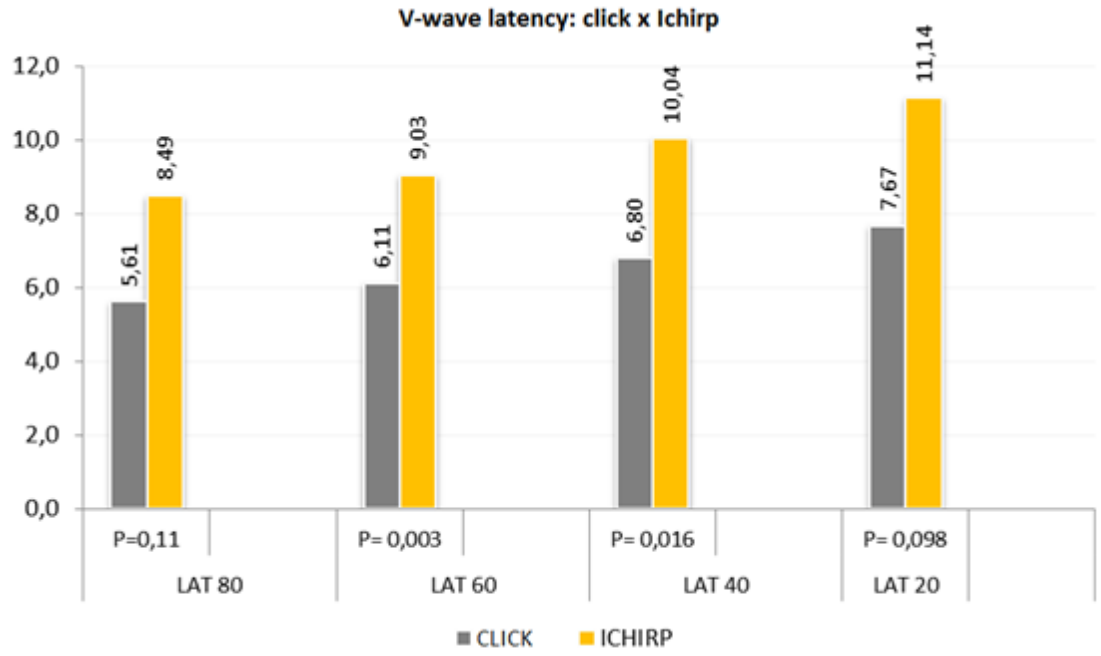

Figure 1. Comparison of the V-wave latencies with the click and Ichirp stimuli.

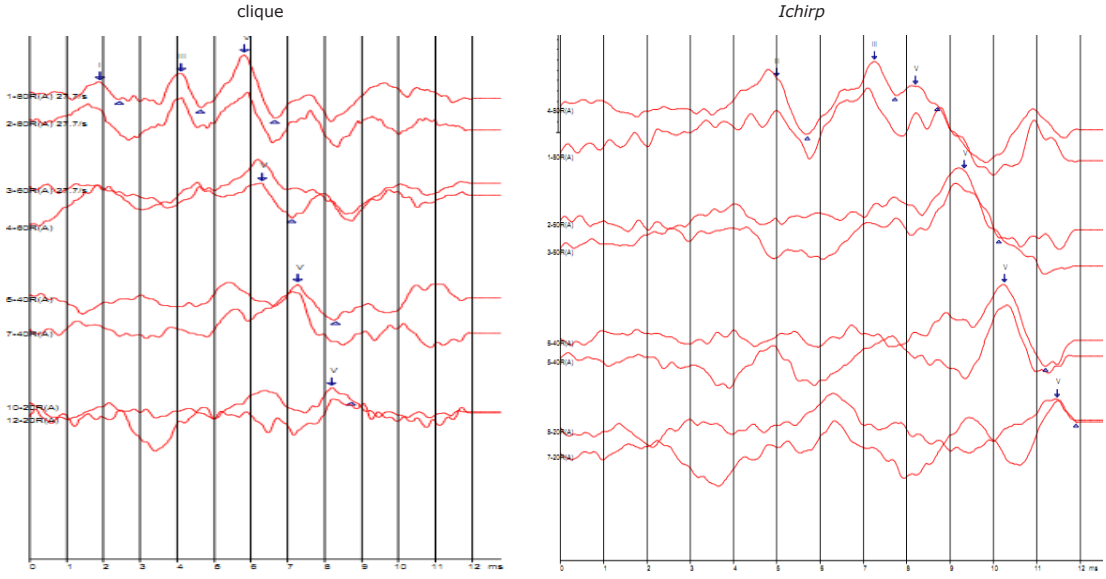

Figure 2. Morphology of the V-wave for different intensities with the Ichirp and click stimuli.

Discussion

The increase in research regarding the stimuli used to evoke responses in the Auditory Evoked Potential demonstrates the concern of researchers in creating a stimulus that evokes electrophysiological responses that are easy to visualize the tracing and, consequently, the decrease in the time of the examination, thus facilitating its use in clinical practice. However, there are a large number of stimuli to be used in the BAEP, in which the majority of these stimuli have been little scientifically tested, which can lead to serious problems in clinical practice, making the examination unreliable [9,10,15,16,18].

In the present investigation, it was evidenced that in all the intensities, were found, with the *Ichirp* stimulus, V-wave latencies longer than those observed with the click stimulus. This can be observed in a study in which the results showed that the observed V-wave latencies with CE-chirp were higher than those observed with clicks at low intensities (20 dB and 40 dB). Similar findings were observed in other studies with neonates, which demonstrated that the *Ichirp* stimulus presented higher latencies in all intensities tested [7,18].

However, a Brazilian research comparing CE-chirp and click stimuli with BAEP in 20 neonates with normal hearing concluded that absolute V-wave latencies were higher for chirp at higher intensities while, at the lower intensities, the opposite occurred [18].

The amplitudes observed with the *Ichirp* stimulus were not significantly higher than those observed with the click stimulus. This result differs from previous studies comparing the chirp to the click stimuli on the BAEP record, observing larger amplitudes at all intensities for the chirp stimulus when compared to the click [10,11,15].

It is noteworthy, in this research, that the *Ichirp* stimulus is promising for its use in clinical practice; however, there is little scientific evidence to prove its efficacy, since a small sample of young adults was used, which makes research indispensable with other populations, such as the elderly, neonates and adolescents.

The results demonstrated in this research contribute, preliminarily, to the improvement of this stimulus, verifying its specificities and clinical applicability.

Conclusion

The *Ichirp* stimulus did not show statistically significant differences compared to the click stimulus for the V-wave amplitudes at frequencies of 80 dB, 60 dB, 40 dB and 20 dB. However, regarding the latencies, statistically significant differences were found, being higher for the *Ichirp* stimulus, especially in the intensity of 60 dB. But better V-wave morphology was observed for the *Ichirp* stimulus, especially at lower intensities, facilitating its identification in the BAEP tracings.

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