Potencial evocado auditivo de tronco encefálico com estímulo de fala*****

Brainstem auditory evoked potential with speech stimulus

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Abstract
Background: although clinical use of the click stimulus for the evaluation of brainstem auditory function is widespread, and despite the fact that several researchers use such stimulus in studies involving human hearing, little is known about the auditory processing of complex stimuli such as speech. Aim: to characterize the findings of the Auditory Brainstem Response (ABR) performed with speech stimuli in adults with typical development. Method: fifty subjects, 22 males and 28 females, with typical development, were assessed for ABR using both click and speech stimuli. Results: the latencies and amplitudes of the response components onset (V, A and complex VA), the area and slope that occur before 10 ms were identified and analyzed. These measurements were identified in all of the studied subjects and presented wave latency values (ms) of: V = 7.18 (SD = 1.08), A = 8.66 (SD = 1.13); Complex VA = 1.49 (SD= 0.43). For the wave amplitudes (μV), the values were: V = 0.29 (SD = 0.15), A = -0.3 (SD = 0.18); Complex VA = 0.58 (SD = 0. 25). The area measurements (μV X ms) and slope (μV / ms) were 0.27 (SD = 0.17) and 0.4 (SD = 0.17) respectively. Conclusion: based on the gathered data it can be observed that this potential works as a new tool for understanding the encoding of sound at the brainstem level.
Key Words: Electrophysiology; Evoked Potentials, Auditory, Brain Stem; Speech Perception.

Resumo
Tema: embora o uso clínico do estímulo clique na avaliação da função auditiva no Tronco Encefálico (TE) já esteja bastante difundido, e uma grande variedade de pesquisadores usarem tal estímulo nos estudos da audição humana, pouco se sabe a respeito do processamento auditivo de estímulos complexos como a fala. Objetivo: o presente estudo tem como objetivo caracterizar os achados dos Potenciais Evocados Auditivos de Tronco Encefálico (PEATE) realizados com estímulos de fala, em indivíduos adultos com desenvolvimento típico. Método: 50 indivíduos, sendo 22 do gênero masculino e 28 do feminino, com desenvolvimento típico, foram avaliados quanto aos PEATE, tanto para estímulo clique quanto para estímulo de fala. Resultados: foram identificadas e analisadas as latências e amplitudes das componentes da resposta *onset* (V, A e complexo VA), a área e s*lope*, que ocorrem antes dos 10ms; essas medidas foram identificadas em todos os indivíduos avaliados, e mostrou valores de latências (ms) para as ondas V, A e Complexo VA: V= 7.18 (DP= 1.08); A = 8.66 (DP=1.13); Complexo VA = 1.49 (DP=0.43). Para as amplitudes (μV) das ondas, os valores foram: V = 0.29 (DP=0.15); A = -0.3 (DP=0.18); Complexo VA = 0.58 (DP=0.25). As medidas de área (μV X ms) e *slope* (μV/ms) foram 0.27 (DP=0.17) e 0.4 (DP=0.17) respectivamente. Conclusão: a partir dos dados coletados, pode-se constatar que este potencial surge como uma nova ferramenta para o conhecimento da codificação dos sons em nível de TE.
Palavras-Chave: Eletrofisiologia; Potenciais Evocados Auditivos do Tronco Encefálico; Percepção da Fala.

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Introduction

The Auditory Brainstem Response (ABR) is generated by the synchronism of auditory pathway structures. The ABR initiates in the auditory nerve and continues through the cochlear nucleus, superior olivary complex, lateral lemniscus up to the inferior colliculus. In clinical practice, the most frequently used acoustic stimulus is the click because it triggers synchronous response of several neurons and exhibits a broad spectrum of frequencies1. However, other types of stimuli, such as pure tones and speech stimuli 2-3 can also be used to trigger electrical responses.

The speech signal - complex spectral-temporal structure - requires a synchronized neural response for accurate encoding. The evoked responses exactly depend on this type of synchronous activation and are ideal for studying the neural basis of speech perception4.

The speech perception involves several processes - such as peripheral auditory analysis and extraction of automated characteristics in the brainstem nuclei (SCT) - that lead to the classification of words and phonemes 4.

Thus, the brainstem responses generate direct information on how the speech syllable sound structure is encoded in the auditory system. The ABR with speech stimuli can be divided into: transient and sustained portions, onset response components (stimulus onset), and frequency-following response (FFR). The onset responses are transient processes, similar to the click, with tenths of milliseconds precision. They primarily represent the response to discrete stimulus events, as during the initiation, and the successive modulations caused by the vibration of the vocal folds. The components of sustained response continue during the reproduction of a periodic stimulus and reflect the overall integrity of the response in relation to the stimulus3.

Recent studies have reported alterations in brainstem responses to speech stimulus in children with learning disabilities and auditory processing disorders3,5-8, as well as the relation to cortical processing9-11 and the efficiency of auditory training in the rehabilitation of individuals with speech perception deficits 5, 12.

Abrams and colleagues7 suggest that delays in latencies of brainstem responses for speech stimuli have a negative impact on the rapid processing of acoustic signals by specialized cortical structures. Similarly, Wible and colleagues (2005) concluded that the impairment of speech processing at the brainstem and cortical level may be an indicator of physiological mechanisms alterations, which may be responsible for an abnormal perception of speech and thus compromise language abilities.

Song and colleagues13 explored the relationship between the click stimulus and the speech stimulus in ABR in children with and without learning disabilities. They concluded that the responses obtained by the two stimuli reflect separate neural processes and only the processes involved in encoding complex signals (speech) are altered in children with learning disabilities.

Therefore, it is necessary to study the auditory representation and perception of speech in individuals with typical development establishing reliable procedures and normative values in order to determine the encoding of speech stimuli in brainstem. This would enable the comparison of such normative values to findings in individuals with Auditory Processing Disorder (APD), learning disabilities, and language disorders. This comparison would provide information of great importance both for a differential diagnosis and for rehabilitation.

This study aimed to characterize the findings of ABR performed with speech stimuli in adults with typical development.

Method

Casuistry

Fifty individuals (22 men and 28 women) aged between 19 and 32 years (mean ± SD: 23.56 ± 3.13 years) participated in this study.

Eligibility criteria for the participants were:

. Age between 18 and 35 years;
. Thresholds within normal limits;
. Acoustic impedance measures within normal limits;
. Absolute and interpeak latencies values of ABR waves within the normal limits (click stimulus);
. No Auditory Processing complaints;
. No other associated disorder.

Stimulus

The speech stimuli used in this study (syllable /da/) was produced at the Radio Laboratory of the School of Communication and Arts, University of São Paulo (USP); the equipment used in production were: Newman 189 microphone;

MACKIE/SR32-4 mixer; M-AUDIO/1010LT sound card; Sound Forge 6.0 software(Sony); Vegas 4.0 editing software (Sony).

The syllable /da/ was narrated by a male voice and edited to produce the stimulus according to the parameters described by King9 and Wible14. Only the first five formants were separated from the original syllable, resulting in a 40ms stimulus that contains the transient portion of it; the vowel /a/ was shortened to allow for the increased rate of stimulation and thus better activate the system.

The stimuli were organized into groups of four, separated by 12 ms, and the interval between each group of stimuli was of 30 ms.

Procedures

The research project and the consent form were reviewed and approved by the Ethics Committee on Research of the University Hospital of University of São Paulo, protocol 527/04.

Audiometric assessment, behavioral assessment of auditory processing, and electrophysiological (ABR) assessment were carried out in a quiet environment.

3.1. Audiometric assessment: inspection of the external auditory canal; acoustic immittance measures; pure tone audiometry at frequencies of 0.25, 0.5, 1, 2, 3, 4, 6 and 8 kHz; Speech Detection Threshold, Speech Recognition Threshold and Speech Recognition Index.

3.2. Behavioral Assessment of Auditory Processing: Speech in noise Test15, and Frequency and Duration Pattern Test from AUDITEC16.

3.3. Electrophysiological assessment: ABR with click and speech stimuli with the two channel equipment GSI-Audera. After cleaning the skin with abrasive paste, the electrodes were placed at the vertex, and right and left mastoid positions; electrolytic paste and adhesive tape were used. The impedance values of electrodes were below 5 K s.

The click stimulus was used to confirm the integrity of the auditory pathway. The stimulus was presented to the right ear with insertion earphone at a rate of 19 stimuli per second. A total of 2000 stimuli at 80 decibels hearing level were presented with a write window 10 milliseconds. A second stimulation was performed in order to reproduce and confirm the trace of the waves.

For the assessment with speech stimulus, CD player and headphones (CV320-Coby) were used; the stimulus was presented to the right ear at 75 decibels hearing level, with a rate of 11 stimuli per second. A total of 2000 stimuli were presented - two scans of 1000 stimuli - with recording window of 50 milliseconds.

The tracings obtained from each scan were summed and the components of the response onset that occur before 10 milliseconds (V, A, and VA complex) were identified in the resulting trace.

Results

The ABR waves to clicks were analyzed for values of absolute latencies and interpeaks of waves I, III and V in order to verify the integrity of the auditory pathway according to normal parameters proposed by Hall17.

For ABR with speech stimuli, the components of the onset response (V, A, and VA complex) that occur before 10 ms were identified and latency and amplitude values were analyzed. The VA complex was investigated by measurements of latency, amplitude, area and slope (VA amplitude / VA duration).

The values of both stimuli were statistically analyzed. Mean, standard deviation, minimum and maximum values, and Pearson correlation were calculated.

ABR with speech stimuli

Table 1 shows the latency and amplitude measures obtained at the onset response to the waves V, A and VA complex, with the mean, standard deviation, minimum, and maximum values.

Table 2 displays the values of mean, standard deviation, maximum, minimum and Pearson correlation of the area and slope of the VA complex.

Analyzing the correlation, a possible positive moderate correlation between measures of area and slope is verified in the studied group.

Comparison between different stimuli

In Figure 1, scatter plot A represents the correlation between the latency of wave V for the click stimulus and for the speech stimulus, and scatter plot B displays the comparison of wave V obtained in ABR with click stimuli and ABR with speech stimulus to each individual.

No correlation was observed between wave V of ABR with click stimulus and wave V with speech stimuli ($r = 0.0035$).

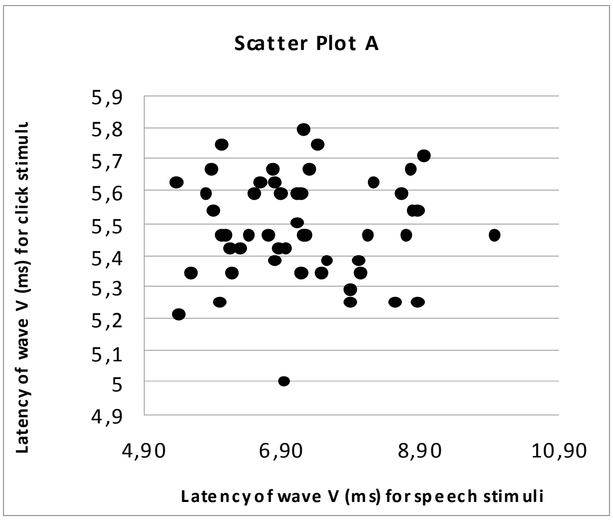
TABLE 1. Mean, standard deviation (SD), maximum and minimum values of latency and amplitudes of waves V, A and VA complex for speech stimuli

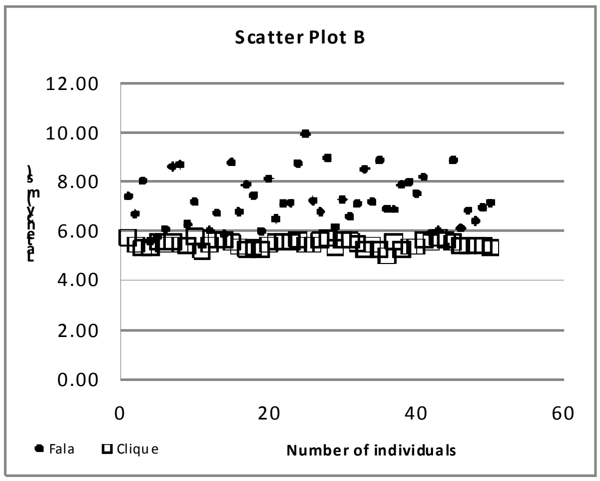
	Latency (ms)				Amplitude (µV)			
	Mean	SD	Maximum	Minimum	Mean	SD	Maximum	Minimum
Wave V	7,18	1,08	9,96	5,38	0,29	0,15	0,68	0,01
Wave A	8,66	1,13	11,09	6,79	-0,3	0,18	-0,01	-1,03
VA Complex	1,49	0,43	2,88	0,88	0,58	0,25	1,57	0,25

TABLE 2. Mean, standard deviation (SD), maximum and minimum values and Pearson correlation of measurements of area and slope of VA complex.

	Mean	SD	Maximum	Minimum	Pearson
VA complex area (µV x ms)	0,27	0,17	0,85	0,08	0,39
VA complex slope (µV/ms)	0,4	0,17	1,05	0,17	

FIGURE 1. Scatter Plot A, scatter plot for the correlation between Latencies of wave V for click and speech (r = 0,0035); Scatter Plot B, comparison of waves V of ABR with "click" and "speech" stimulus".





Discussion

This study aimed to describe and characterize the findings of ABR with speech stimuli in adults with typical development and thus provide a possible normalization of such responses. This data can be used in the assessment of the integrity of speech signal encoding in normal individuals and individuals with alterations.

Measures of latency and amplitude were identified in the onset, slope, area and amplitude of VA complex response components (Tables 1 and 2). Such measures are used to describe the brainstem neural activity for speech, characterized by rapid temporal changes and complex spectral distributions 3.

Latency measures generate information about the precision with which the brainstem nuclei synchronously respond to acoustic stimuli. In contrast, amplitude measures generate information about how robust the response of the brainstem nuclei for the acoustic stimulus is. Alterations in these measures might indicate a difference in conduction speed along the dendrites and axon projections, or a difference in kinetic channels of neurons, or even differences in the synchronization of the response generators.

These measures were identified in all individuals evaluated in the current study. However, unlike the results found in other studies which demonstrated highly reproducible results with the waves and stability at test-retest situations 3,9,12, the measures of the current study presented committed wave reproducibility.

This instability probably occurred in the current study due to the use of an edited natural speech signal, rather than a synthesized speech signal, which is commonly found in ABR research in other countries. The use of synthesized speech, instead of natural speech, allows the precise manipulation and modification of these dimensions that are difficult to control in natural speech4.

The VA complex measures inform about the timing of neuronal discharges18. Values of slope and area of the VA complex were calculated by measuring the latency and amplitude of VA complex (Table 2) according Russo3. The authors interpret area measurements as the amount of activity that contributes to the wave generation and slope as the temporal synchronization of the response generators.

In the same study, results showed lower responses of slope in children with learning disabilities when compared to normal children. This finding corroborates with other studies6, 13.

There was no correlation between wave V to click and wave V to speech stimuli (Figure 1 - scatter plots A and B) probably because the responses obtained by the two different stimuli reflect neural processes. The speech signal contains different acoustic information than the click stimulus, which adds information about the neural coding at the brainstem level13. The processing that occurs in this region, for both types of stimuli (click and speech), will reflect different pathways on cortical processing11. Song and colleagues13 showed that a delay in measures of ABR with speech stimuli does not necessarily cause a delay in measures with click, and that only the processes involved in encoding complex signals are altered in children with learning disabilities.

Thus, the responses obtained in the brainstem for both stimuli provide additional and objective information on the encoding of sound in the auditory system.

The data provided here serve as a measure to determine the normal function of brainstem in response to speech stimuli.

Deficits in the latency and amplitude of the brainstem response to speech stimuli have been found in some children with learning disabilities 3, 5-7, 9, 13.

Another possible application of this potential refers to its use in monitoring the auditory training; it demonstrates the existence of brainstem plasticity and the efficiency of such training, and in the rehabilitation of individuals with speech perception deficits5, 12.

Measures of latency and amplitude of the brainstem responses to speech stimuli can provide information about the neural encoding for speech sounds. The analysis of the responses obtained for individuals with typical development allowed an objective estimation of normative values for the studied potential.

Conclusion

Analysis of ABR responses obtained with speech stimuli in the sample of individuals with typical development showed latency (ms) results for waves V, A and complex VA with the following values: V = 7.18 (SD = 1.08), A = 8.66 (SD = 1.13); VA Complex = 1.49 (SD = 0.43). For the amplitudes (µV) of the waves, the values were: V = 0.29 (SD = 0.15), A =- 0.3 (SD = 0.18); VA Complex = 0.58 (SD = 0 25). The area measurements (µV x ms) and slope (µV/ms) were 0.27 (SD = 0.17) and 0.4 (SD = 0.17) respectively. It is confirmed from the literature and from data presented that this potential is a new tool for understanding the encoding of sounds at the brainstem level. Furthermore, this potential can provide important information about the mechanisms and neural bases of normal and altered auditory function as it shows quantifiable measures of neural encoding of speech sound, regardless of the attention of the individual.

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