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Original articles

Long latency auditory evoked potential: differences in count form of rare stimulus

Potencial evocado auditivo de longa latência: diferenças na forma de contagem do estímulo raro

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ABSTRACT

Purpose: to identify if there are differences in the findings of Long Latency Auditory Evoked Potencial for latency and amplitude in different ways of counting the rare stimulus, being mentally counting or marking on paper (without memorizing).

Methods: this study was prospective and transversal. The sample consisted of convenience and comprised by 49 subjects, including 29 females and 20 males. The following procedures were performed: Visual inspection of the external auditory canal, pure tone audiometry, acoustic emittance measures and long latency auditory evoked potentials, which was performed twice, one after the other, with individuals paying attention to the rare stimulus, always starting counting mentally and after marking on a paper.

Results: there were significant differences between the ears to the P1, P2 latencies and amplitude of N1 for the method of marking on paper and the amplitude of P2 in both methods but with all values within the range normality. In addition, a statistically significant difference was also evident when comparing genders, being found larger latency values of P2 and N2 for males in both counting methods of the rare stimuli. The amplitude of P1, P2 and P3 was lower in males in different ways to count, being in P2 the only difference in the method mentally counting. When comparing the methods, there was a statistically significant difference only to the latency of P2 which was higher values for the method of marking on paper.

Conclusion: there were no differences for the latencies and amplitudes of the long latency potentials in comparison of the rare stimulus score (mentally counting and marking on paper) for almost all potentials except for the potential P2 regarding to amplitude and latency.

Keywords: Evoked Potentials, Auditory; Hearing; Auditory Perception

RESUMO

Objetivo: identificar se existe diferença nos achados do Potencial Evocado Auditivo de Longa Latência em relação à latência e amplitude, em diferentes modos de contagem do estimulo raro, sendo contando mentalmente ou marcando no papel (sem memorizar).

Métodos: esse estudo teve caráter prospectivo e transversal. A amostra foi composta por conveniência sendo constituída por 49 indivíduos, sendo 29 do gênero feminino e 20 do gênero masculino. Foram realizados os seguintes procedimentos: Inspeção Visual do Meato Acústico Externo, Audiometria Tonal Liminar, Medidas de Imitância Acústica e Potencial Evocado Auditivo de Longa Latência, o qual foi realizado duas vezes, uma após a outra, com os indivíduos atentando ao estímulo raro, começando sempre contando mentalmente e após marcando em um papel.

Resultados: houve diferença estatisticamente significante entre as orelhas para as latências de P1, P2 e amplitude de N1 para o método de marcação no papel, da latência de N1 para o método de contagem mental dos estímulos raros, e da amplitude de P2 em ambos os métodos, porém com todos os valores dentro da faixa de normalidade. Além disso, a diferença estatisticamente significante também foi evidente na comparação entre os gêneros, sendo encontrados valores de latência maiores de P2 e N2 para o gênero masculino em ambos os métodos de contagem dos estímulos raros. A amplitude de P1, P2 e P3 foi menor no gênero masculino nas diferentes formas de contagem, sendo no P2 a diferença apenas no método contando mentalmente. Ao compararmos os métodos, houve diferença estatisticamente significante apenas para a latência de P2, a qual foi maior para o método marcando no papel.

Conclusão: não houve diferença para as latências e amplitudes dos potenciais evocados auditivos de longa latência na comparação da contagem do estímulo raro (contando mentalmente e marcando no papel) para quase todos os potenciais, com exceção do potencial P2 em relação à latência e amplitude.

Descritores: Potenciais Evocados Auditivos; Audição; Percepção Auditiva

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INTRODUCTION

The audiological evaluation consists of tests to assess peripheral function and central function. Among the tests available to assess the central function is the Long Latency Auditory Evoked Potential (LLAEP).

LLAEPs refer to the electrical activity from the peripheral auditory system to the central auditory pathways, allowing measuring accurately the auditory information processing function of time in an objective way. The fact that they can be captured in an objective and non-invasively also enables the use of such potentials to evaluate auditory processing disorders[1].

A sequence of waves takes part of LLAEPs, they are: positive 1 (P1), negative 1 (N1), positive 2 (P2), negative 2 (N2) and positive 3 (P3) [2]. The potential (P1, N1, P2, N2) are considered to be exogenous to be influenced by the physical characteristics of the stimulus, such as intensity, duration and frequency[3] and the potential P3 is the delayed wave that appears after the P1-N1-P2-N2 complex with latency of approximately 300ms in individuals with normal integrity and functionality of cortical structures. This potential is considered endogenous; it depends on the individual attention span, different from the potential P1, N1, P2 and N2, which are exogenous and not dependent on the individual's attention to be elicited. N2 Potential is considered a mixed component elicited both by exogenous factors, as by endogenous factors, contributes to the physical breakdown of the acoustic characteristics of the stimuli and also relates to endogenous factors related to the sensorial auditory processing, responsible for the activities of attention, perception, discrimination and recognition of sound[4].

The cortical potentials suffer interference factors such as test parameters (intensity, type of stimulus, task type, interval between stimulus) and conditions of the individual (age, gender, cognitive skills, body temperature) [5]. Therefore, P3 is influenced mainly by events related to cognitive abilities, being used as an investigative tool of information processing - coding, selection, memory and decision-making [1,3].

So that P3 is generated, it is required to occur discrimination of a rare stimulus, among others frequent the same modality and different physical characteristics [6,7].

For the registration of P3 wave occurs, it is necessary for the patient to participate actively in the exam by doing the counting mentally or marking of all rare stimuli presented from the common. In one study, the patient should respond to the rare stimulus count numbering silently or raising the hand when the stimulus is identified [4].

The technique of count mentally a stimulus represents activation of various parts of the nervous system simultaneously and in a defined sequence (involving cortex, thalamus and limbic system). In the execution of a motor act, for example, writing in response to an auditory stimulus is related to the activation and development of neural circuits in specific brain regions. As it is activations in different areas, are expected different answers to the same stimulus[8].

This study is justified by the importance to understand if there is difference in the way of the examination performance, since for many individuals it is necessary support in the rare stimulus count, for failing to carry out the count mentally. This method should be very clear-cut as it may interfere with LLAEP findings, mainly for the P3 wave, which depends directly on the participation and discrimination of rare stimuli among frequent. Still, the technique of counting mentally a stimulus would be checking memory skills, attention and discrimination of sound, but the realization of a motor act by written, does not require auditory memory skills.

Thus, the aim of this study was to identify whether there are differences in LLAEP findings regarding latency and amplitude in different ways of counting the rare stimulus, being counting mentally or marking on paper (without memorizing).

METHODS

This study was conducted in a university hospital in the interior of Rio Grande do Sul, in the electrophysiology outpatient hearing. The research was submitted to the Project Department at the Health Sciences Centre of the Department of research at the University Hospital and it was performed as authorization of the subject with their free and informed consent (IC), after approval of the Ethics Committee of *Hospital Universitário de Santa Maria (HUSM)* under the number: 25933514.1.0000.5346.

The sample had prospective and transversal character, made up of convenience being made up of 49 people, 29 females and 20 males. Individuals were invited to participate in the research within the educational institution.

Those who agreed to participate were informed about the procedures, risks, benefits and confidentiality of research, and when in agreement, signed informed consent. The eligibility criteria for inclusion were:

individuals 18-35 years; normal hearing (average of the sound frequencies of 500, 1000 and 2000 Hz up to 25 dB HL)[9] no complaints of difficulties to understand speech in a noisy environment; Incomplete higher education; no diseases that require use of continuous medication that might interfere with attention and performance on test day, no complaints of difficulty of memory and attention. To exclusion: Over 35 years or under 18 years, middle ear disorders and hearing loss.

The procedures performed were: visual inspection of the external auditory canal, pure tone audiometry by air, Speech Reception Threshold (SRT), Speech Recognition Index (SDI), Acoustic Immittance Testing and Long Latency Auditory Evoked Potential.

1. Visual inspection of the external auditory canal was made with the Clinical Otoscope of *KlinicWelch-Allyn* brand to then be performed pure tone audiometry and other tests. The inspection was to verify the presence of any occurrence that could prevent the achievement of audiological tests.

2. The pure tone audiometry was done in cabin acoustically treated with audiometer *Itera II* and *TDH-39 headset*. The hearing thresholds by air in the frequencies of 250 to 8000Hz monoaurally were surveyed. The technique used was descending-ascending and the criterion of normality was the tritone mean (500, 1000 and 2000 Hz) or less 25dBNA[10].

3. SRT and SDI were surveyed monoaurally being the SRT with lists of disyllabic words, and the SDI with lists of monosyllabic words. The SRT was researched by means of descending-ascending technique and for the SDI was added to 40 dB above the average of frequencies of 500, 1000 and 2000 Hz, in addition to research the level of comfort[11].

4. The acoustic immittance testings were performed by the middle ear analyzer with I*nteracoustics model AT 235 and 226 Hz* and *tom-sonda* brand to search the tympanometric curve and the acoustic reflexes. These were investigated in the frequencies from 500 to 4000 Hz bilaterally, in the contralateral way. They were included in the sample only individuals with type A tympanogram and acoustic reflex present bilateralmente[12].

In cases of excess earwax on visual inspection of the external auditory canal, tympanometric type curves “B”, “C” in tympanometry, hearing loss of any kind or degree in pure tone audiometry, individuals were referred to the ENT specialist and excluded from sample.

5. The record of LLAEP was carried out on the “Smart EP” equipment with *IntelligentHearing Systems (IHS)* brand of two channels. The examination was performed in a quiet room with the individuals awake and sitting in a comfortable armchair.

The surface electrodes were attached with electrolytic paste and microporous tape on the forehead (Fpz = ground electrode), on the cranial vertex (Cz = active electrode), and the mastoid (reference electrodes M1 = left ear and M2 = right ear) according to the pattern of the international system 10-20[13]. Less inter-electrical impedance was guaranteed or equal to 3 Kohm to start the test.

About 300 verbal stimuli were presented in a binaural form (240 frequent and 60 rare) with insertion phones, with the syllable / ba / frequent and / di / rare (80% often and 20% rare), presented in intensity 70-80 dBNA (researching comfort), with application rate of 1 stimulus per second, with pre amplifier channels 1 and 2: input 1 - active electrodes; Input 2 - reference electrode (jumper) with impedance equal to or lower than 3 K ohms, with a maximum number of artifacts accepted 10% of the total stimuli bandpass filter: 1-25 Hz and 520ms window. Speech stimuli are derived from the IHS program and they have the same duration of 170050 usec for the / ba / usec to 209 525 and / di / and they were used with the manufacturer’s specifications.

The amplitude and latency values were obtained by identification of the waves at the peak of highest amplitude, whereas the P3 component was considered only in the route of the rare stimuli. The values of latency and amplitude were obtained by identifying the waves P1, N1, P2, N2 and P3, expected respectively in P1 50 to 80ms, N1 between 80-150 ms, P2 from 145 to 180ms, N2 between 180 and 250ms, P3 between 220-380[14] and the minimum amplitude of P3 3 µV15[15].

The amplitude values considered for the N1, P2 and N2 components are: N1 (5-10 microvolts), P2 (3-6 microvolts) and N2 (8-15 microvolts) [13]. As values for the scale of P1 potential were not finding in the literature, the values found here will serve as a regulation for this study population. Individuals were asked to pay attention to different stimuli (rare stimulus) that appear randomly within a series of equal stimuli (stimulus). The presentation percentage of rare stimuli was 20%, while for frequent stimuli was 80%.

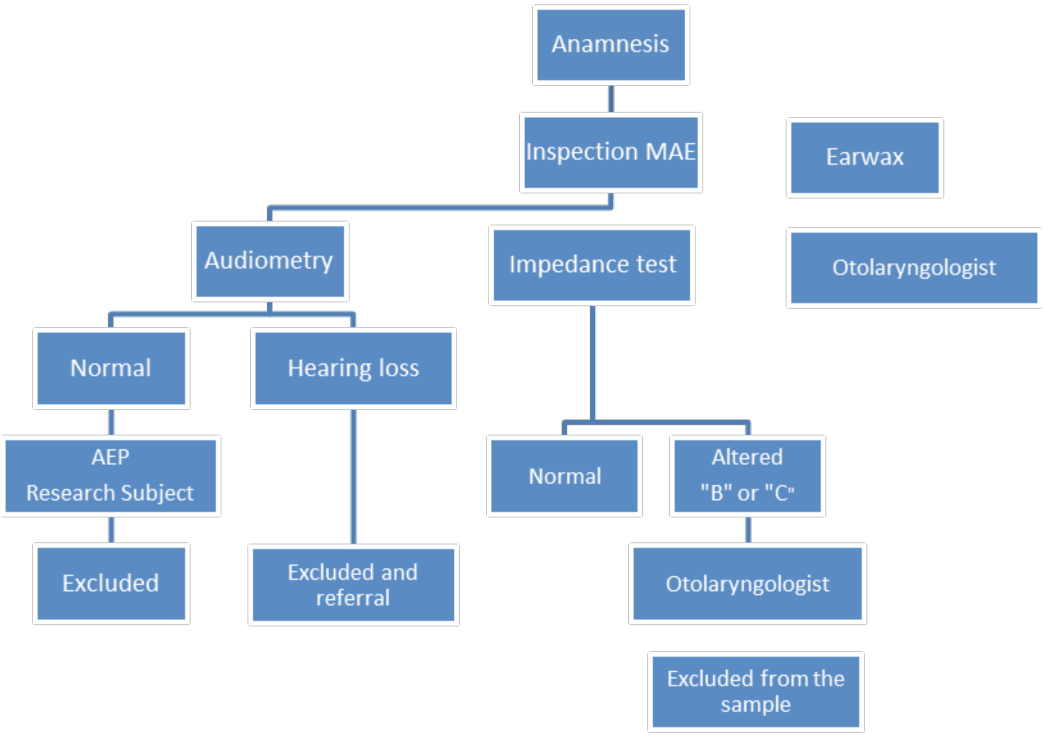
The test was performed twice, one after another, always starting counting mentally and after marking on a paper (with traces in random position). By checking on paper, the individual could not memorize the count and know the quantity of rare stimuli were presented (take the memory ability of this performance way).

After the accomplishment of the research, the data were tabulated in an Excel spreadsheet and performed statistical analysis and, when comparing ears, we used the *Student Paired t-test*. When comparing the genders for all variables, we used *ANOVA* test.

To compare the potential between counting mentally and marking on paper methods we used the *T-Student Paired* test.

The analyses were considered significant with 95% confidence level ($p < 0.05$).

For better understanding of research design follows the chart below:



RESULTS

The method of statistically significant values found are presented in Figures 1 to 6 and Tables 1 and 2, the average of the latencies and amplitudes of each potential studied.

The beginning of the presentation of the results will be comparing the ears for all variables, but separately for each counting mentally method (CM) and marking on paper (MP).

Statistically significant differences were found between the ears to the latencies of P1 (medium latencies of 53,9ms RE and LE 56,7ms), latencies of P2 (medium latencies of 185,3ms RE and LE 190,5ms) and amplitude N1 (medium amplitudes of 7,34µV RE and LE 7,63µV), all the MP method. There was statistically significant difference for the latency of P1 to the method for counting mentally (medium latencies of RE and LE 101,3ms 99,5ms), all of which are presented within the normal range (Figure 1). There was also a statistically significant difference for the amplitude of P2 in both methods (medium amplitudes of RE 4,86µV (CM) and 4,16µV (MP) and LE 5.36 microvolts (CM) and 4,91µV (MP)) (Figures 1 and 2 and Table 1).

There were no statistical differences for the latency of potential N2 and P3 and the amplitude of the potential P3 (Figure 2).

When comparing genders, there were statistically significant differences for latency of P2 (medium latencies for females of 170.4ms (CM) and 180,4ms (MP) and the male 190,5ms (CM) and 198, 8ms (MP)), N2 latency (medium latencies for females of 249,0ms (CM) and 234.9 ms (MP) and for male 270,6ms (CM) and 275.3 ms (MP)). Regarding the amplitude there were significant differences for potential P1 (medium amplitude of 5,18µV for females and 4,33µV for males), amplitude of P3 (medium amplitudes of 6,83µV for females and 4,45µV for the male in the marking on paper method), amplitude of P2 (5,62µV medium amplitude for females and 4,36µV for males in the counting mentally method) (Figure 4).

When comparing the methods with each other, it was observed that there was statistically significant difference in latency and amplitude of P2 being that the average obtained in latency on counting mentally method was 178,6ms and the average obtained in the method of marking on paper was 187 9ms (Figure 5 and Table 2). In relation to the average amplitude obtained in counting mentally method was 5,11µV and 4,52µV for marking on paper method (Figure 6 and Table 2). For other waves there was no significant difference.

The distribution of the results of the variables was presented in Box-Plot charts and tables.

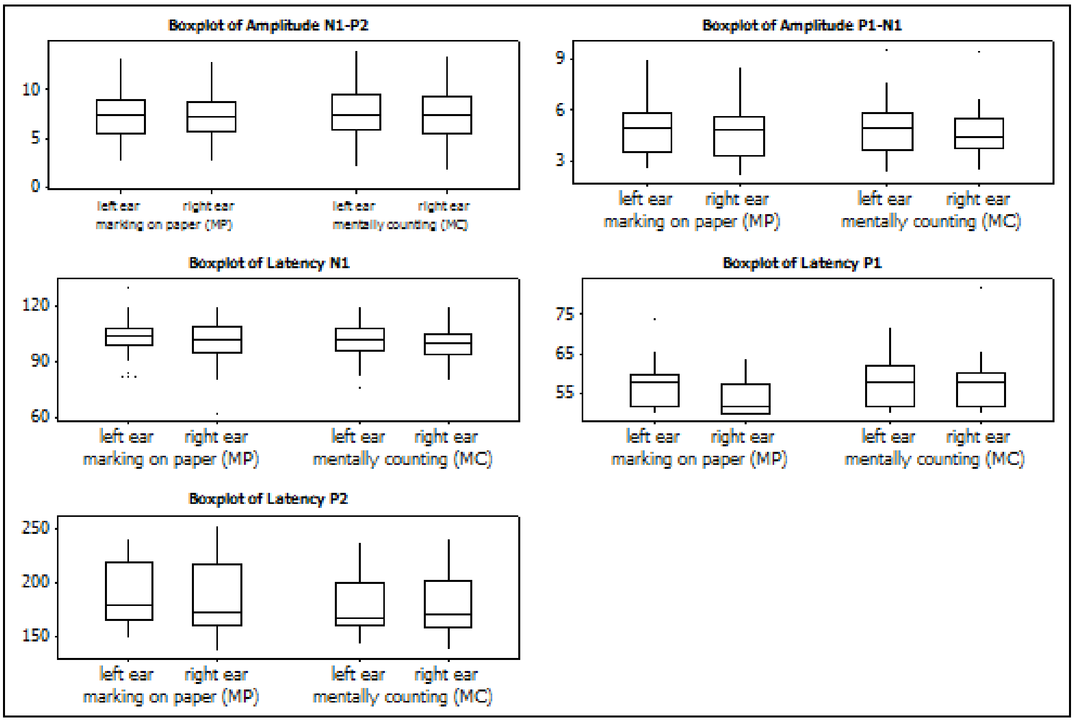


Figure 1. Box-Plot between the ears – Part I

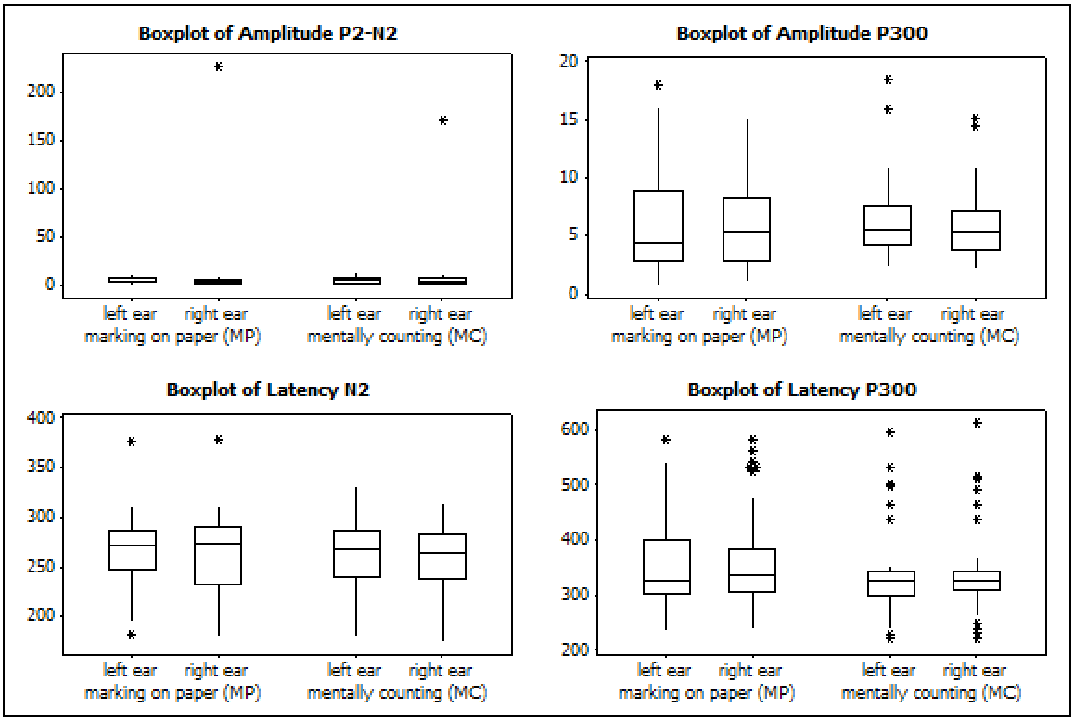


Figure 2. Box-Plot between the ears – Part II

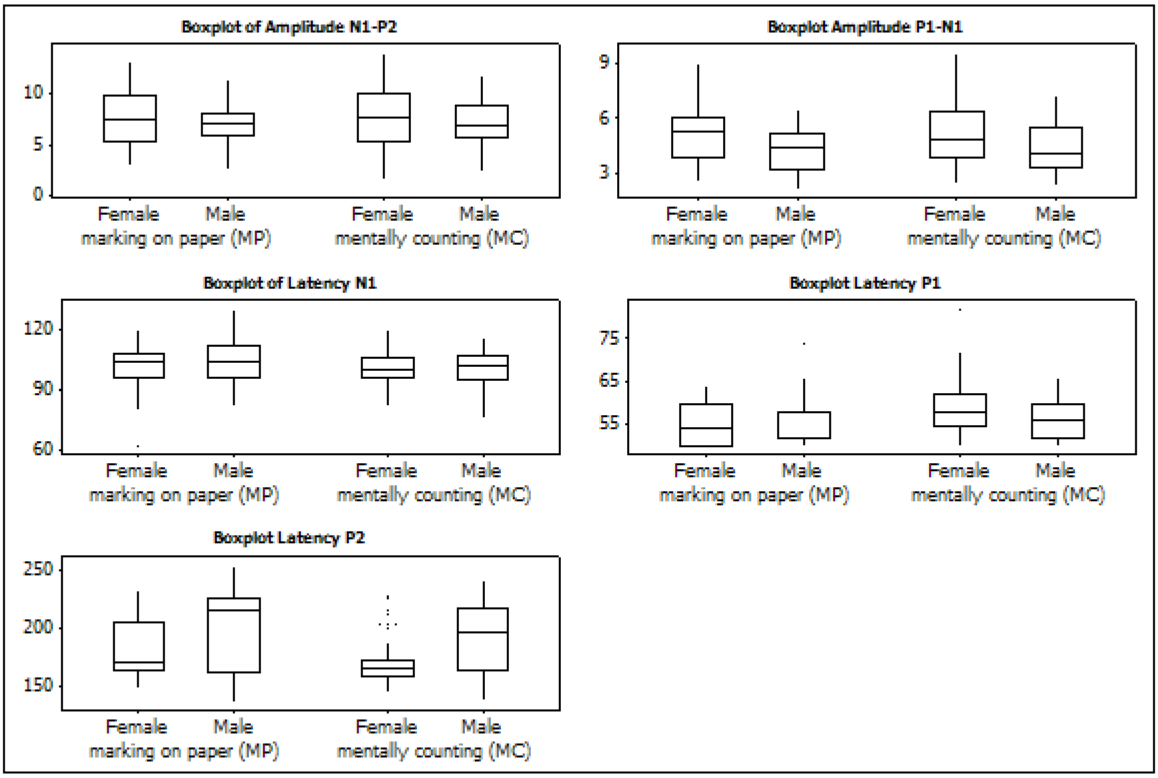


Figure 3. Box-Plot between gender – Part I

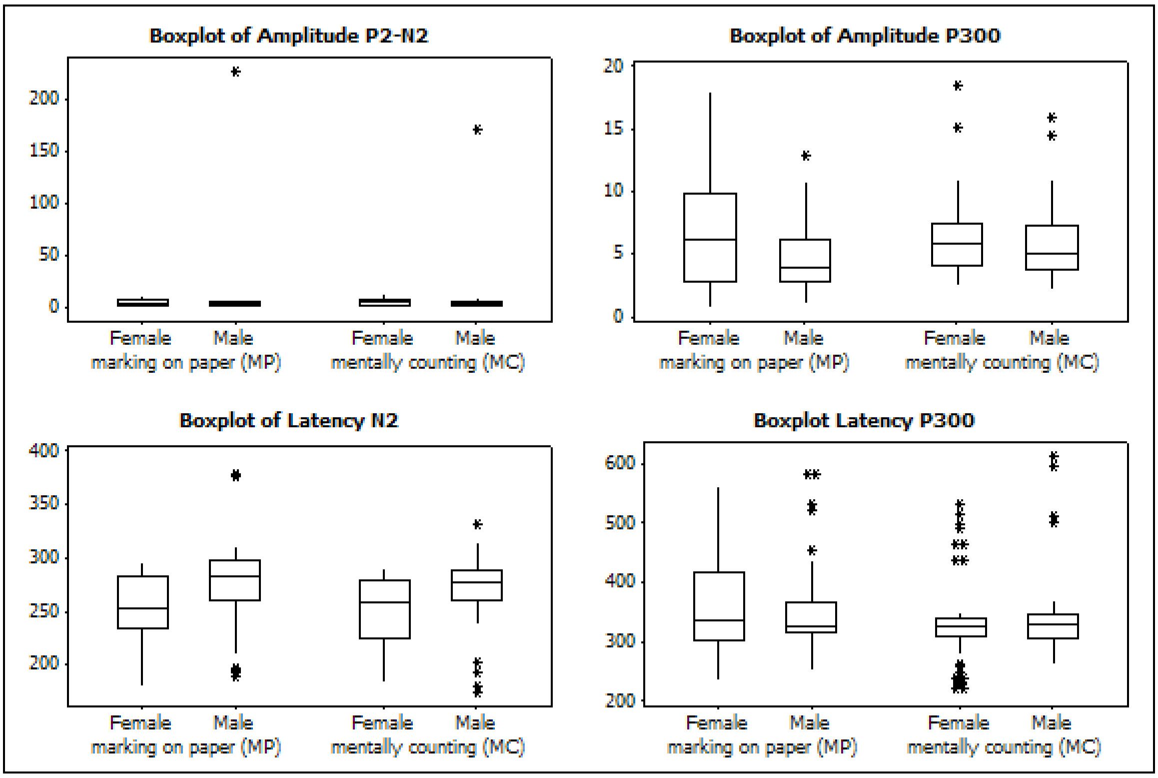


Figure 4. Box-Plot between gender – Part II

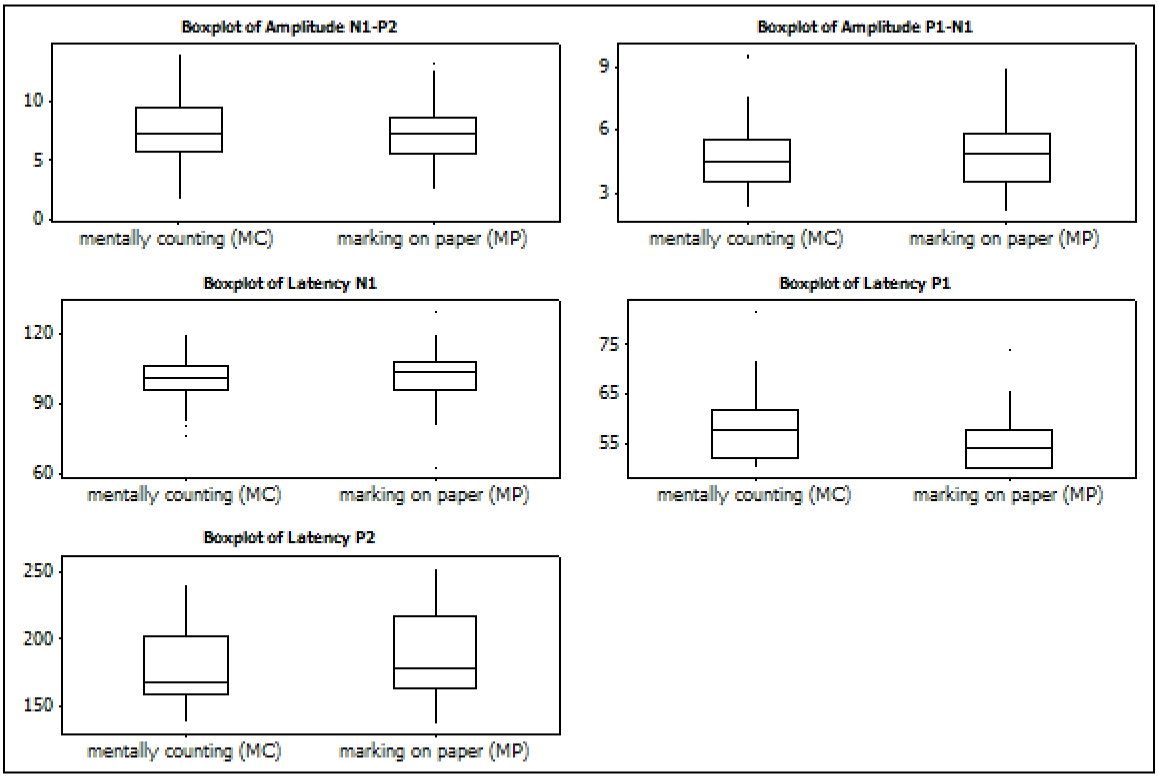


Figure 5. Box-Plot between methods– Part I

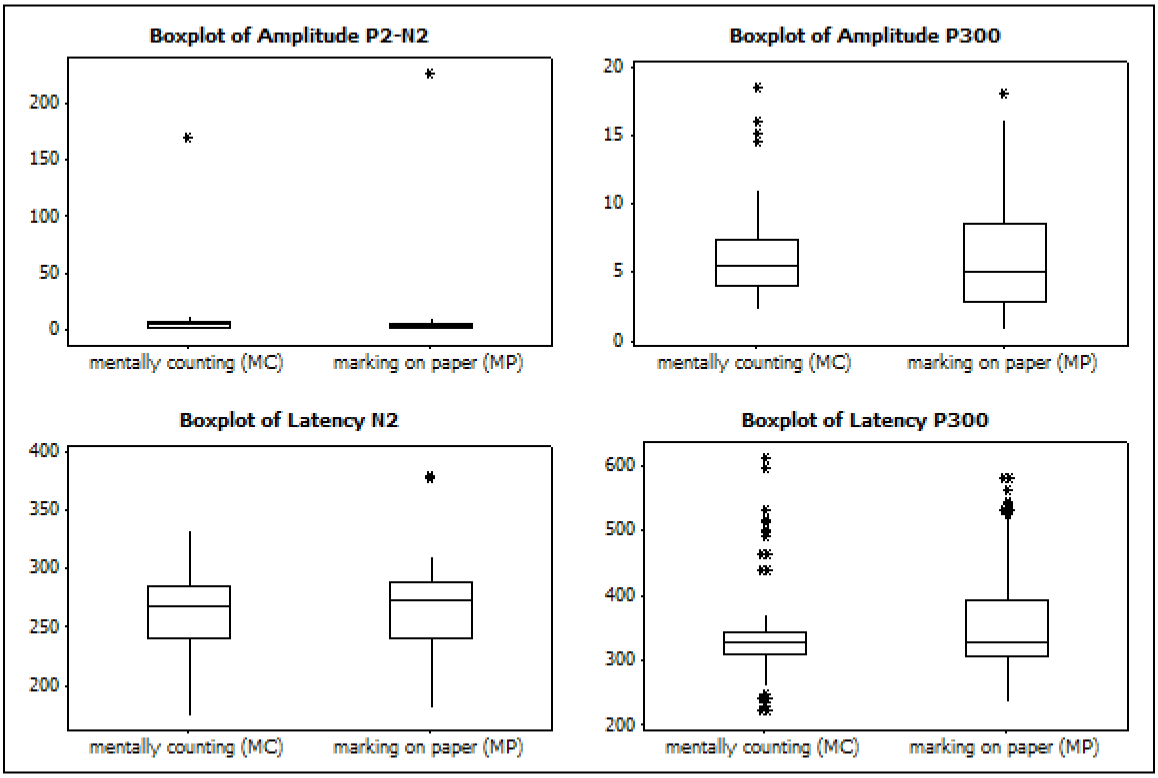


Figure 6. Box-Plot between methods – Part II

Table 1. Mean values and standard deviation between ears for LLAEP components for different methods

	CM								MP							
	Latency (ms)		Amplitude (μV)		Latency (ms)		Amplitude (μV)		Latency (ms)		Amplitude (μV)		Latency (ms)		Amplitude (μV)	
	RE		LE		RE		LE		RE		LE		RE		LE	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
P1	57,8	6,7	58,1	5,9	4,68	1,52	4,98	1,66	53,9	4,6	56,7	5,9	4,74	1,52	4,86	1,55
N1	99,5	8,7	101,3	9,1	7,46	2,86	7,72	2,84	101,3	11,3	103,1	9,9	7,34	2,47	7,63	2,57
P2	178,6	26,4	178,7	25,6	4,86	2,88	5,36	3,15	185,3	31,1	190,5	29	4,16	2,51	4,91	2,69
N2	256,6	35,4	259	36,4					254,9	55,7	247,8	72,8				
P3	337,9	73,5	335,2	73,3	5,97	2,89	6,28	3,17	351,4	102	356,9	88,1	5,71	3,65	5,99	4,15

RE: Right ear
LE: Left ear
CM: Mentally counting
MP: Marking on paper
μV: microvolts
ms: milliseconds
S.D: standard deviation

Table 2. Mean values and standard deviation comparing methods for the components of LLAEP

	CM				MP			
	Latency (ms)		Amplitude (μV)		Latency (ms)		Amplitude (μV)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
P1	58	6,2	4,8	1,6	55,4	5,5	4,8	1,5
N1	100,4	8,9	7,61	2,84	102,2	10,6	7,46	2,51
P2	178,6	25,9	5,11	3,01	187,9	30	4,52	2,61
N2	257,8	35,7			251,4	64,6		
P3	336,6	73	6,13	3,02	354,1	94,8	5,85	3,89

CM: Mentally couting
MP: Marking on paper
μV: microvolts
ms: milliseconds
S.D: standard deviation

DISCUSSION

In figure 1, the values were presented comparing right ear (RE) and left ear (LE) in relation to exogenous potential. It was observed that there was a difference between the ears for potential latencies P1, N1 and P2, and P1 the difference in the MP method, N1 the difference in CM method and P2, the MP method (Figure 1), but both with LE latency higher than that found in the RE.

For the amplitude of P1 (Figure 1) there was no differences between the ears. In N1 amplitude (Figure 1 and Table 1) there was difference between the ears for the MP method, and the LE showed a higher amplitude. There were no values found in the literature referencing the amplitude of P1 potential, but in our study there was an average of 4,98µV in LE and RE 4,68µV in the CM method and 4,86µV in LE and RE in the 4,74µV MP method, so these values can be used as normative for the population studied, taking into account their standard deviations (Table 1). Still, there was a statistically significant difference in the amplitude of P2 and the difference in both methods (Figure 2 and Table 1).

By comparing the ears, there was statistical difference in the latencies of P1 in the method of marking on paper and N1 the counting mentally method, both with highest value for the left ear, however, they are within normal standard [14].

These findings disagree with a study [16] in which the authors found no statistically significant difference in latency between the ears, but such a study was conducted with children. Also, in another research[17], the authors found no differences in latency and amplitude of N1 between the ears, in the research and control groups, the group researches individuals with tinnitus.

For P2 component in the MP method, there were differences between the ears, but both are shown outside the normal standard and higher values for the left ear. The normal values[14] such potential are between 145 to 180 ms, going against the study cited by the authors.

In a study using LLAEP before and after training, the authors found significant results as to the amplitude of P2 component, indicating that the perceptual changes arise from the brain's ability to adapt to the cortical representations of sensory stimuli [18]. Thus both studies should observe the significance of the exogenous components in the study of LLAEP.

For P3 potential there was no difference between the ears (Figure 2), considering latency and amplitude, which corroborates with current study[19] which was carried out with binaural stimulation and analyzed values only one ear, for possible absence of difference between them [20,21]. Other studies also showed no difference between right and left ears in the latency of P3 potential, and amplitude was not considered, corroborating the findings of this, as other authors[22] consider the latency and amplitude of P3 potential it was not found any statistically significant differences. In a study[16] of LLAEP with malnourished children, there was a statistically significant difference between the right and left ears when comparing P3 component amplitude values, and the amplitude of the left ear smaller than the amplitude of the right ear. Our findings do not corroborate the above study, however, it is noteworthy that the study population can bring these differences according to the variables of the study group.

In this study, the highest values for the left ear in the studied components make us think about what might be happening to hemispheric dominance when we use verbal stimuli, regardless of the method used the left ear directs the stimuli directly to the right hemisphere.

The auditory pathway has inter-hemispheric crossroads, the auditory information coming from the right ear crosses into the left hemisphere while the information coming from the left ear crosses into the right hemisphere and across the corpus callosum to again reach the left hemisphere. Thus, we can infer that the results of higher latencies in the left ear may be the result of this longer cross [23].

Addressing the research by gender (Figure 3) there were no differences in checking by ear for P1, N1 components regarding latency. In relation to the P1 component in the case of amplitude (Figure 3), a statistically significant difference was observed, demonstrating a greater amplitude for females in marking on paper method. There were no values found in the literature referencing the amplitude of P1 potential, but in our study there was an average of 5,18µV for females in both methods (MP and CM) and 4,33µV (MP) and 4 37µV (CM) for males, these values found can be used as normative values for this population. (Figure 3).

There was also difference to P2 and N2 being that men had higher latencies (Figures 3 and 4). The same data were evident in the literature[24] on studies showing significant differences between genders in N1, P2 and N2 latencies, being the major latencies in males, treating healthy young adults in a normative study. Our study disagrees with the literature findings of a study[3] with normal subjects that take into account the simultaneous recording value in Fz and Cz, which found no statistically significant difference between genders for latency of N2 components.

Considering the magnitude of P1 and N1 potential (Figure 3) this research did not show statistical differences between genders, only to the amplitude of P2 (Figure 4). But studies[24] found only in the amplitude of N1 data significantly higher in female subjects compared to males, not corroborating with this research.

In our study, the amplitude of N2 potential were not considered due to non-occurrence of a new peak after N2 potential, making it impossible to amplitude writing of it.

The potential for P3 (Figure 4) statistically significant data were not found, which goes against the findings in literatura[25] that when considering the gender variable, observed higher latency values for male subjects. However, in relation to the amplitude (Figure 4) to this potential, the women were higher, and the same findings were found in another study in the literature[26].

When comparing the methods of CM and MP for the average of all the variables there was a statistically significant difference only for latency and amplitude of P2 (Figure 5 and Table 2), demonstrating a higher latency in MP and greater amplitude in CM method. We infer, therefore, that counting mentally a stimulus, also involves the ability to remember and thus, greater stimulation, which may explain the larger amplitude values in CM method and consequently a lower latency in the same method. Our results demonstrate that it is possible to use both methods reliably, however, if the MP method there is a change of P2 potential is needed to confirm this change using the CM method. Because the change was verified by the MP method.

There was no difference in potential (P1, N1 and N2) relative latency (Figures 5 and 6 and Table 2) and

P1 and P2 with respect to amplitude (Figure 6 and Table 2).

In the same study [26] with normal-hearing young individuals , the counting of rare stimuli was carried out in two ways, first counting the stimuli and after counting and raising one hand. The average values found for P3 potential in the method of counting was 337,55ms and the counting method and raising one hand was 341,18ms. Our study corroborates the aforementioned study, as there was no significant difference for the finding as to latency. In the literature there was also the rare stimulus counting in two ways namely: counting mentally [27], counting mentally and raising the hand[21,26,28] to hear it and after, count aloud [21,29].

In another study [30] to identify the rare stimulus, participants were told to take the movement to raise their index finger, and the values of 345,5ms were found for RE and 382,1ms for LE to the research group (school). As for the control group, children diagnosed with the learning disorder, 342,93ms values were found for RE and 347,87ms for LE. Our findings corroborate the values found in the study mentioned above.

Researchers[31] to compare the latencies of P3 before and after auditory training (AT) asked participants to count mentally the rare stimuli. Latency found was 352.47 ms, pre AT and post AT .Our findings agree with the values found in the study mentioned above, however, with the MP method. As in the CM method, our findings have higher latency values, but both normal.

Some authors[32] have chosen to ask the patient to keep eyes closed and count aloud the rare stimulus, different from our study. Studies like this have motivated this research, it is observed in the literature that the stimulus count is performed in different ways. In this case, the counting in loud voice does not make the patient memorize the stimulus as was the case of the MP method in our study, however, is not the method referred to the literature as the most suggested method to be used.

Other studies in the literature performed the rare stimulus count in a different way[33] requesting the hearing impaired individuals who raise the index finger instead of counting mentally and P3 wave was found with latency average of 326,9ms and amplitude average of 3,76µV . In our study, latency of 336,6ms in the CM method and 354,1ms in MP one and amplitude of 6,13µV in CM method and 5,85µV in MP method was found (Figure 6) .Even with different methods the values found between studies approach in latency, but they are far apart when it comes to amplitude.

In literature authors[34] reported that the more frequent stimulation, fewer neurons respond to it, as there is habituation of the auditory system. This way we can justify the smaller amplitude values in the MP method because its realization was after the CM.

Further, it is believed that the MP method that involves less skill in the MC, since the marking does not evoke memory ability thereby, we justify the smaller amplitude values in the MP method.

Our findings showed that there were differences in the different ways of counting the rare stimulus, however, in an exogenous potential (P2) and not the endogenous potential (P3) as our main hypothesis raised. P2 would not have some mixed influences also like N2 potential as referenced in literature[4]. N2 wave is considered a mixed component to be elicited by both exogenous factors and by endogenous factors[4] this potential contributes to the physical discrimination of the acoustic characteristics of the stimuli and also relates to endogenous factors related to sensory hearing process, responsible for the activities attention, perception, discrimination and recognition of sounds[30]. It is suggested, therefore, new studies exploring more exogenous potential, especially P2 component.

CONCLUSION

There was no difference for potential long latency in comparison of the rare stimulus counting (counting mentally and marking on paper) for almost all potential, with the exception of P2 potential, with largest latency and lower amplitude in the marking on paper method.

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