Audiology - Communication Research
ISSN: 2317-6431
Academia Brasileira de Audiologia

Souza, Juliana; Rocha, Vanessa Onzi; Berticelli, Amanda Zanatta; Didoné, Dayane Domeneghini; Sleifer, Pricila

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Audiology - Communication Research, vol. 22, e1690, 2017
Academia Brasileira de Audiologia

DOI: 10.1590/2317-6431-2016-1690

Original Article

http://doi.org/10.1590/2317-6431-2016-1690

Audiology Communication Research
ISSN 2317-6431

Auditory Latency Response – P3 in children with and without learning complaints

Potencial Evocado Auditivo de Longa Latência – P3 em crianças com e sem queixas de dificuldade de aprendizagem

Juliana Souza[1], Vanessa Onzi Rocha[1], Amanda Zanatta Berticelli[2], Dayane Domeneghini Didoné[2], Pricila Sleifer[3]

ABSTRACT

Introduction: Children with learning impairment complaints may show changes in the functioning of the central auditory system. The Long Latency Auditory Evoked Potential - P3 is useful in the functional evaluation of the central auditory structures, and can be used as an auxiliary method in the early identification of learning impairment. **Purpose:** To analyze and compare latencies and amplitudes obtained in P3 of children that complained or not of learning impairment with normal hearing. **Methods:** The sample consisted of 30 children complaining of learning impairment (study group) and 14 children that did not complain (control group), aged 9 years and 12 years and 11 months. All the children underwent peripheral audiologic evaluation and the P3 study. **Results:** It was found that the mean P3 latency of the study group was significantly higher than the control group. When comparing P3 amplitude values, there was no difference, although the mean of the study group was lower when compared to the control group. It was observed that, for age and P3 latency, no significant correlation was detected. A similar situation was observed in the relation of age and amplitude, which, even though negative, it was not significant. **Conclusion:** The group of children with learning impairment complaints presented P3 latency values greater than the children in the group of children that did not complain. No correlation was found in the P3 wave amplitude values between groups.

Keywords: Audiology; Evoked potentials, Auditory; Event-related potentials, P300; Electrophysiology; Child; Learning

RESUMO

Introdução: Crianças com queixas de dificuldades de aprendizagem podem apresentar alterações no funcionamento do sistema auditivo central. O Potencial Evocado Auditivo de Longa Latência - P3 é útil na avaliação funcional das estruturas auditivas centrais, podendo ser utilizado como método auxiliar na identificação precoce das dificuldades de aprendizagem. **Objetivo:** Analisar e comparar latências e amplitudes obtidas no P3 de crianças com e sem queixa de dificuldades de aprendizagem, com limiares auditivos normais. **Métodos:** A amostra foi composta por 30 crianças com queixa de dificuldades de aprendizagem (grupo estudo) e 14 crianças sem queixa (grupo controle), com idades entre 9 anos e 12 anos e 11 meses. Todas as crianças realizaram avaliação audiológica periférica e a pesquisa do P3. **Resultados:** Verificou-se que a média da latência do P3 do grupo estudo mostrou-se significativamente mais elevada que no grupo controle. Quando comparados os valores de amplitude do P3, não houve diferença, embora a média do grupo estudo tenha se mostrado menor, quando comparada ao grupo controle. Observou-se que, entre idade e latência do P3, não foi detectada correlação significativa. Situação semelhante foi evidenciada na relação entre a idade e a amplitude, que, mesmo tendo sido negativa, não foi significante. **Conclusão:** O grupo de crianças com queixas de dificuldades de aprendizagem apresentou valores de latência do P3 maiores que as crianças do grupo sem queixas. Não foi evidenciada correlação nos valores de amplitude das ondas do P3 entre os grupos.

Palavras-chave: Audiologia; Potenciais evocados auditivos; Potencial evocado P300; Eletrofisiologia; Crianças; Aprendizagem

The study was conducted at the Hospital São Lucas, Pontifícia Universidade Católica do Rio Grande do Sul – PUCRS – Porto Alegre (RS), Brazil.
(1) Speech-Language Pathology Course, Universidade Federal do Rio Grande Do Sul – UFRGS – Porto Alegre (RS), Brazil.
(2) Post-graduate Program in Child and Adolescent Health Care, Universidade Federal do Rio Grande do Sul – UFRGS – Porto Alegre (RS), Brazil.
(3) Department of Health and Human Communication, Universidade Federal do Rio Grande do Sul – UFRGS – Porto Alegre (RS), Brazil.
Conflict of interests: No
Authors' contribution: *JS* collection and analysis of data and writing of the article; *VOR* collection and analysis of data and writing of the article; *AZB* data collection and writing of the article; *DDD* review of the article; *PS* guidance and review of the article.
Corresponding author: Pricila Sleifer. E-mail: pricilasleifer@uol.com.br
Received: 2/26/2016; **Accepted:** 12/12/2016

INTRODUCTION

Auditory behavior includes all reactions to sounds, manifested primarily by motor reactions, depending on both the central and peripheral structures, as well as on the biological and psychological integrity of the child. The proper functioning of the auditory pathway to the cortex is essential for the acoustic information transmitted and processed at central level[1,2,3,4].

Often, children with learning impairment complaints are submitted to assessment of hearing function, however, the set of tests performed in most audiology services can only measure the peripheral portion of the auditory system[3,4]. Current studies have related learning impairment with auditory processing disorders[3,4,5,6], demonstrating that these changes occur at central level, requiring the evaluation of these auditory structures.

The auditory processing skills can be assessed by electrophysiological procedures and behavioral tests[7,8,9]. Auditory Evoked Potentials (AEP) are electrophysiological and reflect measures, objectively, the functioning of the central auditory nervous system[10], facilitating the evaluation and monitoring of children.

P3 is the best known endogenous auditory evoked potential. It is classified as endogenous because it is actively generated during the performance of a cognitive task, different from the exogenous P1-N1-P2 complex, which appears passively and reflexively. P3 consists of a positive wave, generated from the discrimination of a rare stimulus, among other frequent stimuli. This potential is generated around 300 ms and reflects the activity of brain areas related to cognition, memory and auditory attention[7,11,12].

In order to check the central auditory functioning in children with a history of school failure, researchers[3] evaluated the P3 children with and without a history of school failure. The authors concluded that the latency of P3 was higher for the group of children who had repeated the school level.

In another study[13], P3 also proved to be a reliable evaluation in identifying alterations of the central auditory system. The authors evaluated the P3 of two groups, the first composed by children without epilepsy, in which 32 had good school performance and 32, poor school performance. The second group consisted of children with epilepsy, in whom 21 had good school performance and 15 had poor school performance. At the end of the study, the authors concluded that no association of epilepsy with P3 was found. However, when compared to school performance, children with good performance had lower P3 latency values than those with poor school performance, demonstrating a better functioning of the central auditory structures.

Other studies[4,6,14] made comparisons between the findings of the evaluation of the P3 and the performance in behavioral tests of central auditory processing in children with some kind of learning disability. Some authors[11,15] emphasized the importance of using the P3 latency values as a therapeutic monitoring tool, comparing the performance of the subjects before and after speech therapy.

Although the assessment of auditory processing skills is suggested in the scientific literature in cases of school difficulties, it is known that the insertion of the battery of behavioral and electrophysiological tests in clinical practice is gradual. Thus, it is believed that the evaluation of P3 can contribute to a better understanding of the functionality of the central structures of children with complaints of school difficulties, reinforcing the importance of this evaluation.

This study aimed to analyze and compare the responses obtained in P3 from children that complained or not of learning impairment, with normal auditory thresholds.

METHODS

This is a contemporary cross-sectional and comparative study, approved by the Ethics Committee on Research with Human Beings (Resolution 466/12) of the *Universidade Federal do Rio Grande do Sul* (UFRGS) under protocol number 25491. Parents or care givers for the children were clarified about the objectives, risks and benefits of the research and those who agreed to participate signed the Informed Consent Term.

In this study, were included children of both genders, aged 9 years and 12 years and 11 months, enrolled in a regular school, with auditory thresholds lower than or equal to 15 dBNA, in all frequencies tested in pure tone audiometry (ATL) tympanometry type A[16], ipsilateral acoustic reflexes and collaterals present in both ears. Children with neurological disorders and/or attention deficit hyperactivity disorder (ADHD), confirmed by a neurologist, were excluded.

The sample consisted of 44 children, divided into two groups: study group, 30 children (68.2%) with complaints of learning impairment and control group, 14 children (31.8%) without complaint of learning impairment.

Before the procedures, all children were submitted to otorhinolaryngological evaluation.

The anamnesis was carried out addressing data on neuropsychomotor development, current health status, acquired diseases, hearing and school performance. Only complaints of learning impairment reported in the application of a questionnaire with parents / guardians, created for this present study, were considered for the analysis, and addressed issues related to disapprovals, teachers' complaints regarding student learning, learning impairment in comparison to other students, difficulties in specific school subjects, among other.

For the P3 survey, children were positioned in a comfortable chair. The skin was cleaned with abrasive paste, alcohol and gauze and silver electrodes were placed with electrolytic paste and adhesive tape in the following positions: close to the scalp, the active electrode (Fz); On the forehead, the ground electrode (Fpz) and the left (M1) and right (M2) mastoids. The eartone 3A insert earphones and equipment Masbe ATC

Plus, Contronic® were used. The evaluation was only initiated when the electrode impedance was less than or equal to 5 kΩ and the impedance difference between the three electrodes was less than 2 kΩ.

Before the P3 study, electroencephalogram (EEG) scanning was performed to capture the spontaneous brain electrical activity, in order to verify artifacts that might interfere with the examination.

For P3 research, subjects were oriented and conditioned with the task of mentally counting, reporting the number of rare stimuli detected in the total stimulus sequence. Before performing P3, the children underwent a training, which aimed to verify the detection and correct discrimination of the acoustic stimuli presented. In addition, the children were monitored during the examination so that they would pay attention to the rare stimuli, allowing reliability and reliability of the results. At the end of the examination, they were asked how many rare stimuli they had listened to and the response was compared to the number of rare stimuli recorded by the equipment.

The stimuli were presented in the form of oddball paradigm, and 2000 Hz the rare stimuli and 1000 Hz frequent stimulation, 80% presentation for frequent stimuli and 20% for the rare stimuli. Presentation was held binaurally with the plateau of 20 ms stimulus, rise-fall of 5 msec, alternate polarity, interstimulus interval of 1 ms, filter 0,5 to 20 Hz, 750 ms window 80 and dBHL, bilaterally.

For the marking of the wave, it was considered the highest peak of positive polarity after N1-P2-N2 complex, displayed in the sum of trace rare stimulus to trace frequent stimulus as literature[17]. The marking of the results was performed by two judges with experience in electrophysiology and the results considered valid only in agreement between the markings.

Data was scanned into Microsoft Excel® spreadsheets. The presentation of the results occurred by descriptive statistics - absolute distribution and relative (n -%) and by measures of central tendency (mean and median) and variability (standard deviation), and the study of old data distribution occurred by Kolmogorov-Smirnov test. For the bivariate analysis of continuous variables compared between two independent groups, the Student's t-test and Mann-Whitney test were applied. Data were analyzed using the Statistical Package for Social Science (SPSS) 18.0 for Windows. For statistical decision criteria, the significance level of 5% was adopted.

RESULTS

The mean age of participants was 10.57 ± 1.34 for the control group and 10.30 ± 1.26 for the study group, and they were similar groups (p>0.05). Gender was predominant in both groups, with 53.3% (n=16) in the study group and 78.6% (n=11) in the control group (Table 1).

Regarding the findings of the P3 assessment between the groups, the P3 wave was absent in 36.6% (n=11) of the children in the study group. In the P3 latency analysis, the mean of the study group (417.24 ms ± 80.91) was significantly higher in relation to the control group (310.58 ms ± 53.71); That is, the difference of 106.65 ms was relevant for this sample. There was no difference between groups in the comparison of P3 amplitude values (Table 2).

Table 1. Characterization of sample

Variables	Group				p-value
	Study (n=30)		Control (n=14)		
	n	%	n	%	
Gender					
Female	14	46.7	3	21.4	0.204*
Male	16	53.3	11	78.6	
Age					
Mean ± standard deviation	10.30 ± 1.26		10.57 ± 1.34		0.519£
Median (Amplitude)	10.00 (9 - 12)		11.00 (9 - 12)		

* = Pearson's chi-square test, with continuity correction; £ = Student's t-test for independent samples; p≤0.05

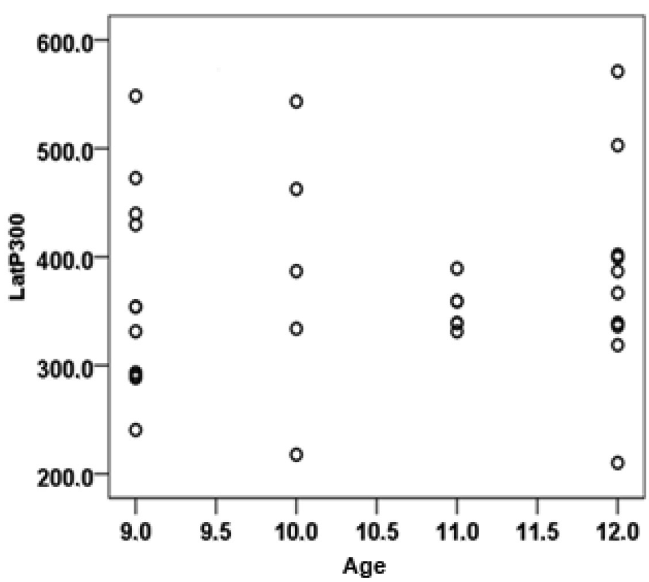
Table 2. Latency and amplitude results found in P3 assessment

Variables	Group						p-value
	Study (n=19)			Control (n=14)			
	Mean	Standard deviation	Median	Mean	Standard deviation	Median	
P3 latency	417.24	80.91	399.45	310.59	53.71	331.33	<0.0001
P3 amplitude	11.16	5.66	9.70	13.52	4.58	12.74	0.210

Student's t-test for independent samples (p≤0.05)

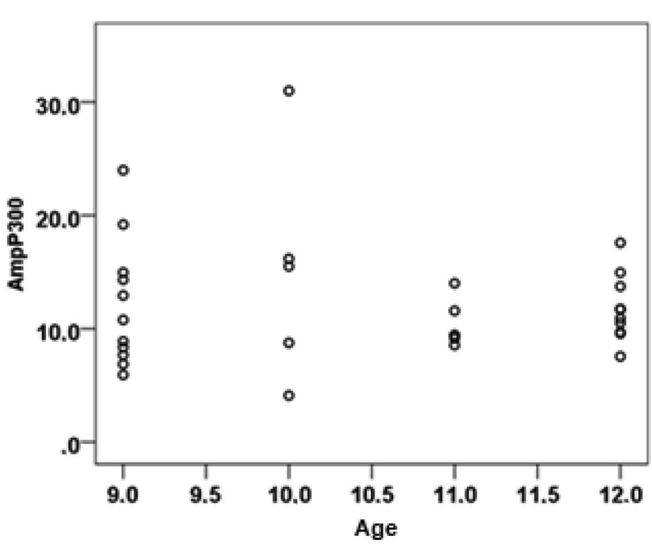
There was no difference between genders when compared to the latencies (p=0.097) and amplitudes (p=0.123) of the P3 waves in the control group. However, in the study group, there was a significant difference in the comparison of gender with P3 latency (p=0.046), with higher latency values for males. When comparing amplitude values, the difference was not significant (p=0.061).

As to the linearity relationship between age and P3 latency and amplitude, no correlation was found between age and latency (r=0.026, p=0.05) (Figure 1) and between age and amplitude (r=0.088, p=0.05) (Figure 2).



Subtitle: LatP300 = P3 latency
r=0.026; p>0.05

Figure 1. Latency and amplitude correlation found in P3 assessment



Subtitle: AmpP300 = P3 amplitude
p=0.-088; p>0.05

Figure 2. Latency and amplitude comparison found in P3 assessment

DISCUSSION

Complaints of learning impairment in school-age children are frequent in clinical speech-language practice. In the present study, it was found that the evaluation of P3 is useful and presents important results in children with complaints of school difficulties, allowing a greater understanding about the functionality of the central auditory structures in this population.

In clinical practice, patients with learning disabilities are, for the most part, male. This finding was also confirmed in this present study, with a predominance of men in both groups. These results agree with the scientific literature[3,5,13], which reports predominantly male occurrences, especially in children with poor school performance. Researchers[18,19] reported differences in the acoustic stimulus processing in the peripheral and central level between genders, being slower in males, which undermines the development language of cognitive skills, reflecting losses in school learning. This fact justifies the greater number of children of the male gender, especially in relation to the group with complaints of school difficulties.

As for the P3 wave latency values in children with complaints of school difficulty, the mean was 417.24 ms ± 80.91. These results agree with the literature consulted, in which studies were found that report changes in morphology and increased P3 latency in children with poor academic performance. A study[3] conducted with 43 children 8-13 years found P3 average of 413.23 ± 82.08 ms. In another study[20], the authors evaluated 18 children from 9 to 11 years and obtained values of 429 ms ± 108.70. Other authors[21] evaluated 10 children aged 9 to 11 years old, finding average latency 438 ms ± 124.90 for the P3 component.

For the control group, mean P3 latency was 310.59 ms ± 53.71, results that confirm other studies in children with good school performance, in which the means of P3 latency were 332.25 ms ± 34.57 msec[3], 336 ms ± 53 ms[13], 315 ms ± 35.7 ms[20], 320 ms ± 32.80 ms[21], 316 ms ± 32.2 ms[22], 305.71 ms ± 4.76 ms[23].

When comparing P3 latency values between the groups, we found that the mean of the study group (417.24 ms) was significantly higher in relation to the control group (310.58 ms). This is in agreement with other studies[3,5,13] with objectives and methodologies similar to those of the present study, demonstrating values of higher latencies in children with poor school performance, compared to children with good academic performance. According to the literature[5], there is a direct relationship between the processing time and latency of some components of cortical potentials, so that the longer perception of the characteristics of the acoustic stimulus by the individual, the higher the latency of the waves, which justifies the higher latencies of the P3 component in the group of children complaining of learning impairment in this study. Other studies also show the association of school difficulties and high values of latency of P3[3,5].

Regarding the amplitude of P3, there was no significant difference in the comparison between the groups. The mean and standard deviation of the amplitude for the study group were 11.15 uV and 5.65 uV, respectively, while for the control group, the values were 13.51 uV and 4.57 uV. This finding agrees with a similar study conducted in a group of patients with language disorders[14]. Although the amplitude representing the magnitude of the responses in the auditory cortex, this variable was not a reliable parameter when comparing the groups of this research, according to scientific literature[24], which reports discrepant values, even in control groups, making it difficult to Analysis of this variable to identify groups with central alterations.

Apart from the differences between the groups being highlighted by P3 latency, the presence and absence of this potential was also an important parameter in the comparison of the groups, since P3 was not evidenced in some children in the group with complaints of school difficulties, Even ensuring the correct detection and discrimination of acoustic stimuli. The absence of the wave P3 infers losses in attention and memory skills[7,11,12] and confirms another study[25], which showed absence of P3 in some children with language disorders.

In the comparison of genders of the control group, there was no difference for P3 latency. However, the male gender presented higher latencies, when compared to the female gender, in the study group. In similar studies[3,9], authors reported higher P3 latency averages in males. The results of this study can be explained by differences in auditory pathway functionality between genders[18] due to morphological and physiological aspects of the auditory pathway, as well as behavioral aspects[26,27], who were pronounced in the group with Complaints of learning impairment, evidencing worse results in the processing of acoustic information at the central level for the male gender.

The literature reports that imperfections in the neural mechanism or neurophysiological changes, in addition to being possibly related to learning impairment, can lead to changes in the latency and amplitude of auditory evoked potentials, such as P3. Delay in latency and decrease in P3 amplitude suggest altered auditory processing. Thus, electrophysiological evaluation is useful in diagnosing cognitive and attentional[3,5,6]. Authors suggest that, during the school period, from 6 years of age, there is a reduction in latency, increase in amplitude and improves the morphology of the P3 register[7,9,11,28], due to the maturation of Auditory pathways, which can be influenced by the overall development of the child. In the present study, no correlation was found between the latency, amplitude and age variables for the studied age group. These results confirm other studies in children[3,9] and are justified by the small age range of children, and the age of 9 years and a maximum of 12 years. These results emphasize that the differences found between the groups are due to the central alterations, which are evidenced by the complaints of school difficulties. In addition, the training of the task performed prior to the evaluation of P3, allowed the correct detection and discrimination of the acoustic stimuli between the groups, guaranteeing reliability of the results for this sample.

Although the variability of P3 values is reported in the scientific literature, it is possible to identify distinct neural mechanisms in children with outdated school performance. In the present study, it was possible to verify the alteration of the central auditory processing abilities, evidenced in P3 in children with complaints of school difficulties. The evaluation of P3 allows to infer about changes in language skills, memory, attention and auditory discrimination, reflecting the lag of the central structures functioning in children with poor school performance, facilitating the identification and early intervention in central auditory processing alterations that affect school performance.

CONCLUSION

The group of children with learning impairment complaints presented P3 latency values higher than the children from the control group. No correlation was found in the P3 wave amplitude values between groups.

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