Long latency auditory evoked potentials in students with specific learning disorders

Potenciais evocados auditivos de longa latência em escolares com transtornos específicos de aprendizagem

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ABSTRACT

Purpose: To study the components of long latency auditory evoked potentials and to compare data from these measures in students with and without learning disabilities. **Methods:** Thirty students, 15 with learning disorder (study group) and 15 typical without learning problems (control group), of both genders, aged 7-14 years, mean age 10 years. They underwent clinical assessment in a clinic belonging to a public university in the state of São Paulo. Following, audiological assessment was performed to determine normal peripheral auditory system and electrophysiological assessment by examining the long latency auditory evoked response. **Results:** The results showed that there are functional differences between the groups. Increased latency components of long latency auditory evoked potential was observed in the study group compared to the control group. Longer latency values of these components were observed in the left ear when stimulated in the study group. **Conclusion:** This study contributed to better understanding of the auditory pathway functioning in children with learning disorders and can be a reference for other clinical and experimental studies and thus improve the definition of diagnostic criteria in this population.

Keywords: Auditory Evoked potentials; Auditory perception; Hearing; Electrophysiology; Learning

RESUMO

Objetivo: Estudar os componentes dos potenciais evocados auditivos de longa latência e comparar os dados dos achados dessas medidas em escolares com e sem transtornos específicos de aprendizagem. **Métodos:** Trinta escolares, 15 com transtorno de aprendizagem (grupo pesquisa) e 15 típicos, sem problemas de aprendizagem (grupo controle), de ambos os gêneros, com idades variando de 7 a 14 anos e média de idade de 10 anos, foram submetidos à avaliação fonoaudiológica. Foi realizada avaliação audiológica para determinar a normalidade do sistema auditivo periférico, além de avaliação eletrofisiológica, por meio do exame de potencial evocado auditivo de longa latência. **Resultados:** Houve diferenças funcionais entre a população estudada. Foi observado aumento da latência dos componentes dos potenciais evocados auditivos de longa latência, no grupo pesquisa, quando comparado ao grupo controle. Os maiores valores de latência desses componentes foram verificados na orelha esquerda, quando estimulada, no grupo pesquisa. **Conclusão:** O estudo contribui para melhor compreensão do funcionamento da via auditiva em crianças com transtorno de aprendizagem e pode ser referência para outros estudos clínicos e experimentais, além de ampliar a definição de critérios diagnósticos nessa população.

Descritores: Potenciais evocados auditivos; Percepção auditiva; Audição; Eletrofisiologia; Aprendizagem

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INTRODUCTION

The Long Latency Auditory Evoked Potential (LLAEP) refers to a series of electrical changes that occur in the central and peripheral nervous system, usually related to sensory pathways resulting from acoustic stimulations that measure the neuro-electrical activity of the auditory pathway, and cortical activities involved in the brain's abilities of discrimination, integration and attention[1,2].

These responses correspond to a series of peaks with negative (N) and positive (P) polarities generated along the auditory pathway, by one or more brain events. These peaks are the result of acoustic events and form the N1, P2, N2 complex and the P3 component or P300, cognitive potential related to events. It is possible to analyze these components as for their latency and amplitude[1].

The most important parameter in the analysis of LLAEP records is wave latency, measured in milliseconds (ms)[2]. Another parameter in the analysis of the results, is the amplitude, for it corresponds to the size of the electrical activity measured in microvolts (μV)[1] relating to the event or task involved in the response, preferably from the baseline of the record to the peak of the wave.

P300 provides objective response on a cognitive task that requires attention, discrimination, recognition, perception and auditory memory, because the individual must recognize the characteristics and notice the variations of the presented stimuli, so it is possible to make a full assessment of the functioning of the auditory cortical system[1-3].

The learning of spoken and written language also depends on the incorporation of acoustic elements and the representation of the phonetic characteristics of a language, which makes LLAEP an important tool for assessing patients with language impairments and, thus, of great use in speech language pathology clinical practice.

Detection and early intervention in children with learning disabilities are essential to mitigate the negative impact on academic and social life in this population[4].

The auditory processing, phonological awareness and sound discrimination are factors that interfere with the learning of reading and writing because they are directly related to receptive hearing[5,6]. Data from the literature demonstrate auditory deficits in children with learning disabilities[7].

To confirm the diagnosis framework, the following is needed: multidisciplinary assessment, family history, educational observation, presenting lower academic achievement in academic skills, and analysis of the response to intervention. The diagnosis of specific learning disability requires persistent difficulty in reading, writing and arithmetic or in tasks that include mathematical reasoning during formal education learning[8].

Students with learning disabilities have lower performance on tests that comprise phonological, lexical, syntactic and semantic processes (than the students without disabilities) due to different factors that interfere, along with other altered abilities in the process of learning to read, write and arithmetics[9].

The performance of students with learning complaints on LLAEP exams and/or behavioral tests was studied by several researchers[10-14]. The authors suggested alterations in the central auditory processing in this population, being of great importance in the therapeutic targeting. In a study using LLEAP before and after progressive training, the authors found[15] significant results as to P2 component amplitude, indicating that the perceptual changes arise from the brain's ability to adapt to the cortical representations of sensory stimuli.

In this context, it is essential to investigate the auditory electrophysiological responses in individuals with specific learning disabilities. Studies in this direction will contribute to better a understanding on how the central auditory processing is this population, providing greater clarity for a diagnosis framework and developing therapeutic programs.

Therefore, the purpose of this study was to analyze the LLAEP components in students with specific learning disabilities and to compare the findings with students without specific learning disabilities.

METHODS

After approval by the Ethics Committee in research of Faculdade de Filosofia e Ciências, from Universidade Estadual Paulista "Júlio de Mesquita Filho" (UNESP) (registration number 842/2010), a cross-sectional, with quantitative and qualitative design, analytical study was conducted.

All the people responsible for the study participants signed an informed consent before the beginning of data collection.

Study participants were middle-income-class students, from an elementary public school. The intellectual performance assessment was conducted by a psychologist with the application of Wechsler Intelligence Scale for Children[16]. All participants (G1 and G2) had performance within normal limits.

The study participants were divided into two groups: study group (G1), characterized by 15 students aged 7-14 years (mean 9.47 years) with nine males (mean 10.11 years/standard deviation 3.02 years) and six females (mean 8.5 years; SD 1.05 years). The G1 was assessed during supervised training of Diagnostic Speech Therapy, which diagnosed learning disabilities[8]. The second group was the control group (G2), characterized by 15 students aged 7-14 years (mean 10.47 years), with eight males (mean 11.25 years; standard deviation 2.43 years) and seven females (mean 9.57 years; SD 1.99 years). G2 was composed by students with good performance in reading, writing and mathematics for four consecutive months (selected by the teachers), confirmed by speech language assessment and further evaluation.

The process of speech language pathology diagnosis for both groups was performed by a speech therapist with experience in diagnosis. Specific speech language pathology procedures were applied: clinical history, systematic clinical evaluation, with tests that analyzed performance on phonological, reading, writing and mathematical skills, interview with teachers and educational observation. Varying levels of impairment were found for participants in Group 1 on the assessed skills, with performance within normal limits for Group 2. Clinical evaluation was complemented by the Academic Performance Test (APT)[17]. Group 1 had lower performance in reading, writing and arithmetic in APT, whereas subjects in Group 2 had performance expected for their level.

Students with and without a diagnosis of specific learning disorder were included. For both groups the following preliminary selection procedures were performed: (1) inspection of the external auditory canal; (2) pure tone audiometry, (3) speech audiometry, (4) acoustic immittance (tympanometry and acoustic reflex); (5) investigation of the Distortion Product Otoacoustic Emissions (DPOAE); (6) investigation of Brainstem Auditory Evoked Potentials (BAEP). In order to carry out this step, we used Heine® otoscope, 2-channel audiometer GSI 61, middle ear analyzer GSI-7 and Eclipse EP25 - Interacoustics®.

In pure tone audiometry, frequencies 250-8000 Hz were evaluated through airway, thus excluding bone pathway, as none of the investigated frequencies showed thresholds higher than 20 dB HL in the airway[18]. Speech audiometry was performed using the Speech Reception Threshold (SRT) to confirm the audiometric thresholds.

For Tympanometry we used 226 Hz catheter and the acoustic stapedial reflex (ipsilateral and contralateral) was investigated at 500, 1000, 2000 and 4000 Hz frequencies. We included in the sample those patients whose tympanogram results were type A (Jerger Classification[19]) and ipsilateral and contralateral acoustic reflexes were present.

To conclude the investigation of the peripheral auditory system integrity, we investigated the Distortion Product Otoacoustic Emissions (DPOAE). DPOAEs were considered present when there was a signal/ noise ratio (SNR) of at least 6 dB SPL[20].

In investigating the integrity of the central auditory pathways, we used Brainstem Auditory Evoked Potentials (BAEP), and the students should present latencies of waves I, III, V and interlatencies I-III, III-V, I-V within normal limits, bilaterally, according to chronological age[21].

For LLAEP record, subjects were accommodated in an acoustically treated room with controlled temperature of 24°C, placed in a reclining chair and instructed to remain relaxed, eyes open and alert. The electrodes were placed with micropore tape, after cleaning the skin with abrasive paste, using electrolytic paste to improve the electrical conductivity. Impedance of each electrode did not exceed 5 Kohms and did not exceed 2 Kohms, between the electrodes impedance[2].

The equipment used in the research of Long Latency Auditory Evoked Potential (LLAEP) was the Eclipse EP25-Interacoustics®.

Responses were captured with active electrode at the median frontal region - Fz, with reference to the electrodes placed at the right lobe - A2 and left - A1 and the ground electrode on the forehead - Fpz. For LLAEP investigation we used 3A earphone, and for the acoustic stimulus we used tone burst at 70 dB HL for frequencies of 1000 Hz (standard stimulus) and 2000 Hz (nonstandard stimulus), randomly presented by a computer at a ratio of 20% for nonstandard stimuli, from a total of 200 stimuli, recorded at a 500 ms window, alternating polarity, pass band filtering of 0.5-30 Hz and stimulation rate of 1.1 stimuli/sec. For LLAEP, the task involved paying attention and identifying nonstandard random stimuli - within a series of frequent stimuli - and raising the index finger to demonstrate identification.

Testing took approximately 50 minutes. As a standard to maintain quality examination, changes in the position were suggested for those subjects who showed myogenic interference, in addition to asking them to keep their eyes closed to eliminate ocular artifacts. Where necessary, the test was repeated.

The identification of AEP waves followed the criteria established in the literature[22,23], including visualization of four "negative-positive-negative-positive" wave sequence peaks, considering the replication of the waveforms in both ears. In LLAEP investigation, the absolute latencies and amplitudes of N1, P2, N2 and P300 waves were identified and analyzed. The identification of the waveforms was performed in record formed by nonstandard stimuli.

For statistical analysis, initially we determined data normality through Shapiro-Wilk test. For comparison of results between group and intra-group, Student's t test was applied. The differences in the tests were considered significant when p-value ≤0.10 (10%) - marked with an asterisk (*) - due to small sample size. The statistical software used was STATISTICA 7.0.

RESULTS

Latencies and amplitudes of N1, P2, N2 and P3, Fz measures, referring to LLAEP were studied. To define the results, latencies and amplitudes were tabulated and treated statistically. The mean and standard deviation of the variables were calculated in the study group (G1) and control (G2).

The results obtained by comparing the studied groups showed that there were differences between the groups in relation to the mean latencies of N1, P2, N2 and P300 in the left ear, and N1 and P2 when measured in the right ear, with higher values in G1 record. However, the intra-group analysis not significant ($p \geq 0.10$) in relation to the ears' measurements neither for G1 nor G2 (Table 1).

With respect to the amplitudes of LLAEP components, we observed a decrease in the amplitude of these measures on N2 wave in the left ear, and N1 and N2 waves in the right ear, when we compared the control and study groups (Table 2).

Table 1. Comparison between research group (G1) and control group (G2) for the studied variables

Variables	RG (G1) n=15		CG (G2) n=15		p-value
	Mean	SD	Mean	SD	
Lat N1 RE	148.4	29.70	127.33	28.68	0.058*
Lat P2 RE	212.4	32.87	186.27	43.86	0.075*
Lat N2 RE	274.0	57.76	243.33	37.03	0.094
Lat P300 RE	345.5	67.01	342.93	29.63	0.894
Lat N1 LE	168.0	32.25	127.47	35.09	0.002*
Lat P2 LE	226.1	53.35	182.80	53.54	0.034*
Lat N2 LE	282.8	57.89	232.93	42.41	0.011*
Lat P300 LE	382.1	60.72	347.87	36.19	0.070*

* Significant values (p≤0,10) – t Test

Note: RG = research group; CG = control group; SD = standard deviation; Lat = latency; RE = right ear; LE = left ear

Tabela 2. Comparison between research group (G1) e control group (G2) for the studied variables

Variables	RG (G1) n=15		CG (G2) n=15		p-value
	Mean	SD	Mean	SD	
Ampl N1RE	0.51	6.57	-3.23	4.58	0.081*
Ampl P2 RE	0.66	3.03	-0.68	2.91	0.217
Ampl N2 RE	-0.12	4.85	-3,25	3.87	0.051*
Ampl P300 RE	3.36	3.95	4.68	2.65	0.290
Ampl N1LE	0.98	7.19	-2.78	5.34	0.115
Ampl P2 LE	1.21	3.20	-0.53	3.15	0.142
Ampl N2 LE	0.78	4.75	-4.48	3.73	0.002*
Ampl P300 LE	5.06	3.81	5.08	3.13	0.985

*Significant values (p≤0.10) – t Test

Note: RG = research group; CG = control group; SD = standard deviation; Ampl = amplitude; RE = right ear; LE = left ear

DISCUSSION

LLAEP is one of the promising measures used in the research of central auditory processing that reflects cortical activity, ranging from simple to the most complex auditory skills. Among children with learning disabilities, one or more alterations in auditory abilities have been observed.

In comparing the latencies of LLAEP components of the study and control groups, the data obtained in this study demonstrating higher latency values in the study group (G1), corroborates the literature that shows there is a direct relationship between processing time and latency of some LLAEP components. Thus, the longer the individual takes to understand and determine the characteristics of the received stimulus, the longer the wave latency[1,2,10].

Moreover, the decrease in N1 and N2 amplitude in the left ear may be related to the reduced amount of electrical activity involved in processing primary and secondary areas, in supratemporal auditory cortex, understood in more complex auditory abilities associated with auditory-linguistic processing, deficient in G1[24].

The N1 wave, exogenous component, which is generated in the supratemporal auditory cortex, primary site of the auditory pathway during LLAEP record is associated with attention and initial decoding of the stimulus. In the present study, as in another one[25], higher values for N1 latencies in students with learning complaints were observed, demonstrating basic alterations in auditory processing in this population.

Another exogenous component, the P2 wave, related to acoustic and temporal characteristics of the stimulus, had late onset in children with learning disabilities and showed deficits in encoding and characterization of the received information by the central auditory pathway[2].

The N2 wave, a mixed component, elicited by both exogenous and endogenous factors[2], contributes to physical discrimination of the acoustic characteristics of the stimuli and also relates to endogenous factors related to sensory auditory processing, responsible for attention, perception, discrimination and recognition of sounds. The passive and pre-attentional automatic response, elicited by the discrimination of a nonstandard stimulus amid the standard stimuli, during LLAEP record, was deficient on students with learning disabilities in this study, indicating that discrimination and attention were altered[26,27].

Electrophysiological studies in patients with learning difficulties signaled that the mean values of P300 latency, are generally longer, confirming auditory perceptual deficits in this population from the difference observed between the studied groups[28,29].

From the anatomical point of view, the literature states that children with learning disabilities show differences in the blood flow quantification in the right hemisphere (inferior and anterior temporal, inferior frontal, midline and anterior)[30]. The brain areas generating LLAEP components - the thalamus, the primary and secondary auditory cortex and the hippocampus - cover most areas of the brain, cited above. Therefore, the changes observed in this study can be considered markers of neuro-functional deficits in children with learning disabilities.

Finally, the electrophysiological findings of this study may suggest anatomical and/or functional changes described in the literature, in students with learning disabilities. Thus, LLAEP investigation in students with specific learning disabilities is crucial to assist in the assessment and diagnosis of this condition.

CONCLUSION

From the results obtained in this study, we can conclude that students with specific learning disabilities have altered LLAEP components when compared with children without specific learning disabilities. This study may contribute to the development of therapeutic programs targeted to specific difficulties of each student, in search of a better prognosis and therapeutic effectiveness. However, we emphasize the need for more studies with this population, varying the parameters for the electrophysiological assessment, for example, and using speech stimuli to clarify the complexity of the factors involved in the different contexts covering specific learning disabilities.

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