AUDITORY TEMPORAL PROCESSING IN CHILDREN WITH ATTENTION DEFICIT HYPERACTIVITY DISORDER (ADHD)

Processamento auditivo temporal em crianças com transtorno do déficit de atenção com hiperatividade (TDAH)

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ABSTRACT

Purpose: to compare the findings of behavioral assessment of temporal auditory processing in children with and without Attention Deficit Disorder with Hyperactivity. **Methods:** study participants were 30 children aged 8-12 years, 15 in the control group and 15 of the study group, with audiometric thresholds within normal limits. As procedures were performed testing temporal frequency pattern and duration. **Results:** in comparing the temporal evaluation of study group and control group in both tests – Standard Frequency and Standard Time, significant differences were found between the groups, with the study group showed abnormal results in most cases, while all control group children were normal. It was also possible to observe that all the children in both groups had lower results for Standard Time when compared to the results of Standard Frequency. **Conclusion:** the behavioral assessment of temporal auditory processing in children with and without Attention Deficit Disorder with Hyperactivity showed that subjects with Attention Deficit Disorder with Hyperactivity had changes, whereas the group without ADHD normal results on both tests. The present study has enabled a greater understanding of the central auditory pathways of children with and without Attention Deficit Disorder with Hyperactivity D, but further studies are needed, especially in the national literature, in order to better understand the functioning of the auditory processing of these populations.

KEYWORDS: Hearing; Child; Auditory Perception; Hearing Tests; Attention Deficit Disorder with Hyperactivity

INTRODUCTION

The American Speech-Language-Hearing Association - ASHA (2005)[1] defines auditory temporal processing as the perception of sound or sound change within a restricted and defined period of time, i.e., it is related to the ability to perceive or distinguish stimuli presented in rapid succession, divided into four categories: ordering or temporal sequencing, resolution, discrimination or temporal acuity and integration or temporal summation.

The temporal perception depends on behavioral responses, but their processing is central and the temporal lobe and the superior olivary complex would be responsible for the perception of sequential patterns of stimuli and the encoding of temporal information[2].

The literature has described comorbidities among the symptoms of children with attention defficit hyperactivity disorder (ADHD) and auditory processing (AP) and such symptoms have been neglected in the evaluation and therefore the rehabilitation of these individuals[3, 4]. Children with ADHD have problems in various aspects of temporal information processing, including the difficulty in discriminating the duration of sounds, which contributes to the low results found in cognitive and behavioral assessments of these children[5, 6].

The literature[6] has related to the processing of temporal information as a multidimensional concept, and have encouraged the development of a wide variety of methods to quantify the abilities that

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comprise it, once claimed to be difficult to integrate the results of temporal information, especially in children with ADHD.

Studies in temporal processing with ADHD children are limited by being conducted with small samples and do not differentiate the various subtypes of ADHD[4,5,7]. In this study we chose to investigate the temporal processing of children with the combined type of ADHD, attention deficit plus hyperactivity, and exclude the isolated types.

In addition, other studies still need to be conducted, since some authors claim that the difficulties in AP, sometimes observed in individuals with ADHD, do not represent a primary deficit, being better understood as a phenomenon secondary to inattention[4].

Due to what was exposed above, this study aims to compare the findings of the behavioral evaluation of auditory temporal processing in children with and without Attention Deficit Hyperactivity Disorder (ADHD).

METHODS

This was a case-control study, and its realization was submitted for analysis and assessment of the Ethics Committee of Universidade Estadual Paulista, and was conducted after approval in accordance with the protocol number: 0094/2011.

The study included 30 children of both genders aged 8 -12 years divided into:

Control Group (CG) - composed by 15 children with good academic performance, selected by their school teachers following the criterion of satisfactory performance for two consecutive marking periods in reading and writing assessments;

Study Group (SG) - composed by 15 children diagnosed with ADHD by an interdisciplinary team, which included speech-language assessment, neurological, neuropsychological and educational assessment, which considered the presence of at least six (or more) symptoms of inattention and six (or more) symptoms of hyperactivity-impulsivity persisting for at least six months, according to the DSM-IV Diagnostic Criteria for Attention Deficit Disorder / Hyperactivity Disorder. Neuropsychological set of instruments were administered: WISC-III[8] as well as the neuropsychological set, in order to discard neuropsychological disorders. The students in Study Group were assessed after a period of 24 hours without the use of medication (methylphenidate), once following recommendations of the specialized literature[4], the auditory processing assessment in situations of medication use improved the performance in behavioral tests in patients with ADHD. However, it is worth noting that the lack of the drug may impair the hearing behavior, making the test falsely harmed. Thus it is necessary that other studies on the use of this medication are also conducted so that the findings are compared.

Children in both groups were assessed after signing an informed consent by the responsible kin, all children were between 8 and 12 years and were previously submitted to audiological, ophthalmological and psychological assessments. Thus, we excluded the subjects who did not present audiometric thresholds within normal[10] and had cognitive and visual acuity changes.

The characterization of the subject is found in Table 1.

Basic audiological assessment was performed in a soundproof booth. As for the tone audiometry thresholds, we used GSI 61 (ANSI 3.6-1989 and S3.43-1992) audiometer with TDH-50 headphones. Hearing thresholds were obtained by airway, in sound pitches of 250-8000Hz. The used normal range was the classification proposed by Lloyd and Kaplan (1978)[11] in which the average frequencies of 500, 1000 and 2000Hz must be equal or lower than 20dB HL.

The assessment of auditory temporal processing was performed in a soundproof booth, using a CD player attached to the GSI 61. The followed protocol was proposed by *Auditec*Ò (1997)[12], the children's version, which uses for the pitch pattern test (PPT) the presentation of 30 sequences of three tones, which can be low pitch (L) (880 Hz) or high pitch (H) (1430 HZ). Each tone has a duration of 500 ms, with an interval between the three tones of 300 ms and

Table 1 – The characterization of the subject the control and study group for age, sex and audibility

Subject CG	Average Age	female	male	Basic audiological assessment
15	10	5	10	Normal*
Subject GP				
15	10	5	10	Normal*

Audiometric assessment: Pure tone audiometry threshold * Lloyd and Kaplan (1978), CG = Control Group, GP = Search Group

the interval between each tone sequence of 10 sec. These range from six possibilities: HHL, HLH, HLL, LLH, LHH and LHL.

Duration patterns tests (DPT) presented 30 sequences of three tones that differ in length: long pure tones (L) (500ms) and short (S) (250ms), with a 300 ms interval between tones, and the frequency is kept constant at 1000 Hz. DPT presents six possible combinations: LLS, LSL, SSL, SLL, SLS and SSL.

In this study, the stimuli were presented binaurally[13,14], in an intensity level of 50 dBSPL above the arithmetic average of the hearing thresholds obtained for the sound frequencies at 500Hz, 1000Hz and 2000Hz. The subject was instructed, by demonstration, to verbalize the exact sequence of sounds heard, using the terms “fine” (1430 HZ) and “thick” (880 Hz) for PPT and “long” (500ms) and “short” (250ms) for DPT. Example: “fine, fine, thick” and “short, long, short.” Finally, we computed the number of correct answers and the result of this test was presented as a percentage of correct answers. The inversions of tones, for example, “fine, fine, thick” with “thick, thick, fine” and inversions of sequential patterns, such as “fine, thick, thick” with “thick, fine, fine,” were considered errors[15], as well as the omission of patterns and tones, and the insertion of tones in the sequences, such as, “fine, fine, thick,” for “fine, fine, thick, thick.”

The results were considered normal or altered according to the values described by Bahlen (2001)[16].

Regarding the time for recording, it took about 20 minutes, an average of 10 minutes for each test, with a rest interval of three minutes between one test and the other.

Descriptive analyzes of the results of the tests were performed, based on the construction of tables with mean and standard deviation for each group and ear. The Shapiro-Wilk test was applied to check the normality of the data. The comparison of mean values between groups was taken from the analysis of variance - F test (ANOVA), and when verified, significance was confirmed by Tukey test (ANOVA), a parametric test that compares mean values using variance in data which necessarily constitute normal distribution.

The result was described as the p value, and the level of significance was always 5% or 0.05 ($p \leq 0.05$).

RESULTS

When the comparison between the temporal evaluation of Control Group and Study Group in both tests - pitch pattern (PPT) and duration pattern (DPT), significant differences between groups were observed, showing that the children in SG had significantly inferior results compared the CG.

Moreover, it was observed that all children in both groups had lower results for DPT when compared to the results of PPT.

Tables 2 and 3 show the mean values, standard deviation and p-value for frequency and duration pattern tests for both groups.

DISCUSSION

The literature has often described that children with ADHD have deficits in the production and reproduction of time[17-19], however, there is still no consensus about these alterations[20-22].

In this study, a comparison between study and control groups was performed in assessing PPT and DPT and we found a statistically significant difference between groups: SG had lower mean values when compared to CG in both tests, in addition, it became evident that the DPT had worse results when compared to PPT.

The findings of this study, in which children with ADHD performed better in discriminating pitches when compared to duration, can be explained by the fact that when the test varies in length, two variables related to temporal processing are present, the duration of the stimulus and its order, tasks described in the literature[23, 24] as of greater degree of difficulty.

This investigation found that individuals with ADHD have alterations when they need to maintain

Table 2 - Descriptive Statistics of Mean, standard deviation and p-value calculated from the Standard Testing Duration

Variable	Group	Average	D.P.	Value of p
TPD	GC	85,3	6,6	*0,0008**
	GP	53,3	32,3	

TPD = standard Testing Duration of SD = Standard Test duration. Tukey Test ** - Minimum Significant Difference = 17.48 respectively

Table 3 - Descriptive Statistics of Mean, standard deviation and p-value calculated from the Pitch pattern test

Variable	Group	Average	D.P.	Value of p
TPF	GC	92,0	8,8	*0,0083**
	GP	74,6	21,9	

TPF=Pitch pattern test SD = Standard Deviation. Tukey Test ** - Minimum Significant Difference = 12.49T

attention and to discriminate different stimuli, especially when tasks related to duration are involved, which corroborates studies[5] that claim growing evidence that children with ADHD have problems in various aspects of processing temporal information, including the difficulty in discriminating the duration of sounds, contributing to the low results found in cognitive and behavioral assessments of these children.

Neuropsychological studies have reported that children with ADHD have alterations in cerebral regions and circuits related to control of both cardinal symptoms (attention, hyperactivity and impulsivity) and appropriate executive functioning, emphasizing structures and pathways associated with prefrontal regions, parietal lobe, basal ganglia and cerebellum[25,26] compromising the proper functioning of planning, problem solving, strategy changes, working memory, inhibition of distraction factors as well as inappropriate behaviors and thoughts[27].

Authors[28] have analyzed the degree of symptom overlap between ADHD and AP disorder from the assessment of 15 subjects with ADHD and 10 normal subjects. The results showed that 12 subjects with ADHD showed alteration of AP, suggesting that ADHD and AP disorders are closely related - data which corroborate the results of this study.

A study[7] proposed two models to explain how temporal processing may be altered in ADHD, and the most common is that the inhibitory control of these children is poor and interfere in the working memory, subsequently affecting the temporal processing.

Authors[29] have claimed that the alteration in processing is often found in children with ADHD, but there are differences in relation to the nature of inattention observed in children with ADHD, which is often persistent and supramodal, and in children with altered AP which is restricted to auditory attention.

Moreover, researchers[30] have argued that memory and attention deficits, which are common in children with ADHD, may lead to deficits in tests involving discrimination between stimuli with different duration, which may also explain the findings of this study.

This study led to a better understanding of the central auditory pathways of children with and without ADHD when assessed from the auditory temporal processing tests (DPT and PPT), but other studies are still needed, especially in the national literature, in order to better understand the functioning of the auditory pathway of these populations.

CONCLUSION

The comparison between the performance of children with and without ADHD in temporal auditory processing tests, resulted in significant differences between the groups: children with ADHD showed alterations in both tests, while children without ADHD were normal.

It was also possible to observe that the results were more altered in DPT than in PPT in both groups.

RESUMO

Objetivo: comparar os achados da avaliação comportamental do processamento auditivo temporal em crianças com e sem Transtorno do Déficit de Atenção com Hiperatividade. **Métodos:** participaram desse estudo 30 crianças na faixa etária de 8 a 12 anos, sendo 15 do grupo controle e 15 do grupo pesquisa, com limiares audiométricos dentro dos padrões de normalidade. Como procedimentos foram realizados os testes temporais de padrão de frequência e de duração. **Resultados:** na comparação entre o grupo controle e grupo pesquisa em ambos os testes – padrão de frequência e padrão de duração foram verificadas diferenças significantes entre os grupos, sendo que o grupo pesquisa apresentou resultados alterados em sua maioria, enquanto que todas as crianças do grupo controle apresentaram resultados normais. Foi possível observar ainda que todas as crianças de ambos os grupos tiveram resultados inferiores para o Padrão de Duração quando comparado aos resultados do Padrão de Frequência e. **Conclusão:** a avaliação comportamental do processamento auditivo temporal de crianças com e sem Transtorno do Déficit de Atenção com Hiperatividade, mostrou que os sujeitos com Transtorno do Déficit de Atenção com Hiperatividade apresentaram alterações, enquanto que o grupo sem Transtorno do Déficit de Atenção com Hiperatividade resultados normais em ambos os testes. O presente estudo possibilitou um maior conhecimento da via auditiva central das crianças com e sem Transtorno do Déficit de Atenção com Hiperatividade, porém, outros estudos ainda se fazem necessários, principalmente na literatura nacional, a fim de se conhecer melhor o funcionamento do processamento auditivo dessas populações.

DESCRITORES: Audição; Criança; Percepção Auditiva; Testes Auditivos; Transtorno do Déficit de Atenção com Hiperatividade

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