Habilidades auditivas em crianças com dislexia e transtorno do déficit de atenção e hiperatividade****

Hearing abilities in children with dyslexia and attention deficit hyperactivity disorder

Anila Gabriela Rotger Abdo*
Cristina Ferraz Borges Murphy**
Eliane Schochat***

*Fonoaudióloga. Especializanda em Audiologia Clínica do Curso de Fonoaudiologia da Faculdade de Medicina da Universidade de São Paulo (FMUSP). Endereço para correspondência: R. José Bonifácio Pedroso, 99 - Itapecerica da Serra - SP - CEP 06851-150 (anilagabriela@gmail.com).

**Fonoaudióloga. Doutora em Ciências da Reabilitação pelo Departamento de Fisioterapia, Fonoaudiologia e Terapia Ocupacional da FMUSP.

***Fonoaudióloga. Professora Livre-Docente do Curso de Fonoaudiologia do Departamento de Fisioterapia, Fonoaudiologia e Terapia Ocupacional da FMUSP.

****Trabalho Realizado no Departamento de Fonoaudiologia, Fisioterapia e Terapia Ocupacional da FMUSP.

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Abstract
Background: auditory processing and co-occurrence of pathologies. Aim: to investigate the performance of children with Dyslexia and attention deficit hyperactivity disorder (ADHD) in behavioral and auditory processing tests, comparing the results to a control group. Method: participants of the study were 30 children, with ages between 7 and 12 years, divided into three groups: a control group of 10 children, a study group of 10 children with dyslexia and a study group of 10 children with ADHD. All participants were submitted to the following auditory processing tests: Speech in Noise, Dichotic of Digits and Frequency Pattern. Results: concerning the Speech in Noise Test, there was an interactive effect between the control group and the ADHD group ($p < 0.001$), with the ADHD group presenting a significantly lower performance; for the Dichotic of Digits test, there was an interactive effect between the three groups ($p < 0.001$), with the ADHD group presenting a lower performance, followed by the dyslexic and control groups; for the Frequency Pattern, there was a marginal effect ($p = 0.056$) with the ADHA group presenting a lower performance, followed by the dyslexic and control groups. Conclusion: the ADHD group presented a poorer performance in all tests when compared to the dyslexic and control groups. This result suggests a relationship between attention and hearing abilities.
Key Words: Attention Deficit Disorder with Hyperactivity; Children; Dyslexia; Hearing.

Resumo
Tema: processamento auditivo e comorbidades. Objetivos: investigar o desempenho de crianças com dislexia e transtorno do déficit de atenção e hiperatividade (TDAH) em testes comportamentais de processamento auditivo, comparando-os com grupo controle. Método: foram avaliadas 30 crianças com idades entre 7 a 12 anos, sendo 10 pertencentes ao grupo controle, 10 pertencentes ao grupo com dislexia e 10 pertencentes ao grupo com TDAH. Os testes de processamento auditivo aplicados foram: fala com ruído, dicótico de dígitos e padrão de frequência. Resultados: em relação ao teste fala com ruído, houve efeito de grupo entre TDAH e grupo controle ($p < 0,001$), sendo que o grupo com TDAH apresentou pior resultado; em relação ao teste dicótico de dígitos, houve efeito de grupo entre os três grupos avaliados ($p < 0,001$), com pior desempenho do grupo com TDAH, seguido do grupo com dislexia e grupo controle. Em relação ao Teste Padrão de Frequência, houve efeito de grupo considerado "marginal" ($p = 0,056$), com pior desempenho do grupo com TDAH, seguido do grupo com dislexia e grupo controle. Conclusão: grupo com TDAH apresentou pior desempenho em todos os testes aplicados, se comparado com os outros dois grupos, sugerindo uma estreita relação entre as habilidades de atenção e as habilidades de processamento auditivo avaliadas.
Palavras-Chave: Audição; Dislexia; Transtorno da Falta de Atenção com Hiperatividade; Criança.

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Introduction

Studies have shown that learning disability and attention deficit hyperactivity disorder (ADHD) are the most frequently observed comorbidities to auditory processing disorder (APD) (1-4). However, it is not known which hearing abilities are more related to each of these disorders and how they relate to each other.

There currently exists a wide number of studies that associate dyslexia to temporal auditory processing alteration (5-7). Nevertheless, there is still controversy about this relationship given two factors: the difficulty in establishing a causal association between the two disorders (7); and the great individual variability in performance of these children (8,5).

In relation to ADHD, many studies have already associated it to alterations in Auditory Processing (AP) (9-13,4). According to Chermak et al. (14), many ADHD symptoms overlap with symptoms of auditory processing disorders. Among these we can highlight: difficulties in attention and listening; maladaptive behavior; ease of distraction; difficulties in following instructions; and necessity of more time than usual to complete tasks (14). It is also believed that this possible comorbidity and its consequent impact on daily activities have often been neglected when determining the rehabilitation/habilitation plans (15).

Electrophysiological measures such as ABR and P300 are often used to analyze the relationship between auditory processing disorder and ADHD (12, 16-18). Such studies generally show alterations that are related to the magnitude of responses.

Despite the similar symptomatology of ADHD and auditory processing disorder, some authors have reported that auditory processing disorder is more associated with learning disabilities than with ADHD (4,19). In a study carried out by Cavadas et al. (4) for example, the authors observed poorer performance of the group with learning disabilities in auditory processing tasks when compared to the group with ADHD and the control group. Such findings support the hypothesis that "the difficulties in auditory processing possibly observed in patients with ADHD do not represent a primary deficit and are best comprehended as a phenomenon that is secondary to inattention".

Considering the still remaining questions concerning the relationship between hearing abilities and the most frequent comorbidities, this study aimed to investigate the hearing abilities in children with ADHD and dyslexia - compared to control group - by means of behavioral tests of auditory processing. Such results could provide important information for more precise diagnosis and treatment for both disorders.

Method

The study was approved by the Ethics Committee for Research Project Analysis - CAPPesq, Hospital das Clinicas of Faculdade de Medicina da Universidade de São Paulo (FMUSP) - under Research Protocols 0033/07 and 551/06.

Data collection was performed at the Laboratory in Auditory Processing Investigation, Department of Physical Therapy, Speech, Language and Hearing Sciences and Occupational Therapy (Departamento de Fisioterapia, Fonoaudiologia e Terapia Ocupacional) of FMUSP.

The study included 30 children aged between 7 and 12 years. Ten children (7 girls and 3 boys, mean age = 9;9) with no complaint of auditory processing disorder or delayed oral and written language development composed the control group. Ten children (6 girls and 4 boys, mean age = 10;3) with dyslexia - referred and diagnosed by the Brazilian Dyslexia Association (ABD) - composed the dyslexia group. Ten children (2 girls and 8 boys, mean age = 9;1) with ADHD - referred and diagnosed by the Psychiatry Department of FMUSP - composed the ADHD group. All participants were native speakers of Brazilian Portuguese and presented results within normal limits on Basic Audiological Assessment (tonal audiometry, speech audiometry and immitanciometry). Furthermore, the participants presented no apparent cognitive, psychological or neurological alterations or oral language acquisition delays.

The group of children with ADHD was recruited through the outpatient clinic of Attention Deficit Hyperactivity Disorder of Hospital das Clinicas, FMUSP. All children from this group were diagnosed by a psychiatrist specialized in ADHD, according to the criteria established by DSM-IV (20). The Brazilian Association of Dyslexia was responsible for the diagnosis and referral of the study group. Dyslexia diagnosis was based on the following criteria: intelligence score at or above the mean according to Wechsler Intelligence Scale for Children-III (scores of 90 or more on verbal and nonverbal intelligence tests); reading skills and phonological awareness with a two year delay compared to chronological age; and anamnesis obtained from parents to research any other problems that could interfere on reading such as

education or teaching method.

All participants underwent a series of procedures: reading and signing of a consent form; clinical history; and complete audiological evaluation composed by otoscopy, immittance, pure tone and speech audiometry. Participants who did not meet the above mentioned criteria were excluded from the study and referred to a specialist. In the case of presenting an alteration on auditory processing, a formal auditory training was suggested and available at the institution.

The behavioral assessment of auditory processing consisting of the following tests was carried out: Speech in noise (21), Dichotic listening test (21) and Frequency Pattern test (22). Such tests were selected according to the hearing ability analyzed by each of them (auditory closure, binaural integration and temporal ordering, respectively). Theses abilities are considered essential in an auditory processing assessment.

Two-way Analyses Of Variance (ANOVA) were used for statistical analysis assuming equal variances and normal distribution. In case of statistical significance, the Tukey test was used to further analyze the interaction. The adopted significance level was 5%.

Results

Table 1 displays the mean age in each group. No significant difference among the mean ages was observed (p = 0.291). The mean score of each group (in percentage), the standard deviation of each test as well as the p-value for each analysis (group or ear effect) are also presented in Table 1.

For the dichotic listening test a group effect between the control group and the group with ADHD (p <0.001) was observed. The group with ADHD presented poorer performance as compared to the control group. The group of children with dyslexia presented performance between the control and ADHD group, but the differences were not statistically significant. Ear effect with statistically significant poorer left ear performance on the group with ADHD as compared to the right ear of the group with dyslexia and to the right and left ears of the control group (p = 0.047) was observed.

For the Speech in Noise test, there was a group effect with significantly poorer performance being observed for the ADHD group when compared to the two other groups (p-value <0.001). This difference was observed independently of the ear analyzed.

For the Frequency Pattern Test, poorer performance of the group with ADHD was observed when compared to the other two groups. This difference can be considered as statistically significant - p-value close to significance level (p = 0.056).

TABLE 1. Accuracy percentage and standard deviation of scores presented by each group

	Control (n=10)		Dyslexia (n=10)		ADHD (n=10)	
Age (mean)	9.9		10.3		9.1	
DICHOTIC OF DIGITS	RE	LE	RE	LE	RE	LE
Mean (%)	97.25	96.25	91.25	86	87	75.75
Standard Deviation	2.49	3.95	11.26	8.01	11.6	19.83
Group effect (p-value)	<0.001* (Control>ADHD)					
Ear effect (p-value)	0.047* REdyslexia, REcontrol, LEcontrol > LEADHD					
SPEECH IN NOISE	RE	LE	RE	LE	RE	LE
Mean (%)	84.8	86.4	82.4	85.6	70.8	73.6
Standard Deviation	7.96	9.08	7.82	6.31	14.97	11.96
Group effect (p-value)	<0.001* (Control, Dyslexia > ADHD)					
Ear effect (p-value)	0.336					
FREQUENCY PATTERN	RE/LE		RE/LE		RE/LE	
Mean (%)	66		42		33.1	
Standard Deviation	23.9		29.93		35.3	
Group effect (p-value)	0.056					

Note: * statistically significant, RE=right ear, LE= left ear

Discussion

Results of the current study showed statistically poorer performance of the group with ADHD in all tests of auditory processing as compared to the other two groups, proving poorer performance regarding the abilities of auditory closure, binaural integration, background noise, and temporal patterns.

Agreeing to the present study, several other authors have also demonstrated auditory processing disorder in children with ADHD confirmed by electrophysiological measurements or other tests of auditory processing (9-11, 13, 23). Riccio et al. (23), for example, found alterations on the abilities of binaural integration and background noise observed through a different test (SSW - Staggered Spondaic Words).

Cavadas et al (4) also investigated the hearing abilities in children with ADHD and compared their performance to the ones of a control group and a group of children with possible learning and communication disorders. Unlike the results of present study, the authors observed poorer performance on the group with learning disabilities on the Speech in Noise test when compared to the other groups. On SSW, the group with ADHD and the group with learning disabilities presented poorer performance as compared to the control group. The authors concluded that the alteration on AP was more associated to the group with learning disability - when compared to the group with ADHD - and attributed this result to the hypothesis that children with ADHD present alterations in auditory processing as a phenomenon secondary to inattention.

According Schochat et al (2), despite the attention deficits usually characterize the two disorders, there really exist differences in the nature of inattention observed: attention deficit in children with ADHD is usually persistent and supramodal, whereas children with auditory processing disorders have a limited alteration in auditory attention. Still, the auditory processing alteration is frequently observed in children with ADHD. Cook et al (24), for example, analyzed the degree of symptom overlap between ADHD and auditory processing disorder in a study with 15 children with ADHD and ten controls. The results showed that 12 children with ADHD had auditory processing disorders. They concluded that ADHD and auditory processing disorders are closely related disorders, which corroborate the results of this study.

Thus, perhaps the differences observed when comparing the results of the present study and the results of Cavadas et al. (4) can be attributed to differences between the groups of the two studies. Furthermore, the hearing tests applied in both studies were not the same, which may have also influenced the results.

According to some authors (25-26), children with ADHD usually do not present different performance when comparing the two ears on verbal dichotic tests. The same is not noted in children with primary auditory processing disorders or learning disabilities. This is explained by the fact that children with ADHD have poor performance due to inattention - which is presented in the same way in both ears - and not due to an alteration specifically in auditory processing. If we consider the results of current study regarding the dichotic listening test, there is a statistically significant poorer performance of the left ear of the group with ADHD as compared to the right ear of the group with dyslexia and the right and left ears of the control group ($p = 0.047$). This result questions the hypothesis described above because, in this case, the group with ADHD also showed a specific deficit of auditory processing (binaural integration). Another hypothesis is the existence of a possible language alteration in the group with ADHD. However, it should be highlighted that the language alteration variable was considered an exclusion criteria for the group. Such characteristics might have, therefore, differentiated the ADHD group of the present study from the group assessed by Cavadas et al (4).

In relation to dyslexia, several authors attribute this language deficit to temporal deficits (5-8). This hypothesis suggests that individuals with dyslexia have sensory alterations that involve the processing of rapid acoustic information changes - as changes observed on the formant transitions. This deficit, therefore, affect the typical acquisition of phonological representations that are crucial for phoneme-grapheme associations (5). Thus, considering this hypothesis, a low performance in tests of temporal auditory processing in children with dyslexia is expected. In this study, the group of children with dyslexia showed significantly poorer performance when compared to the control group, supporting the hypothesis described above.

For the Speech in Noise and the Dichotic Listening test, the group with dyslexia did not show significant difference when compared to the control group, suggesting no alteration regarding this ability. These results confirm, once again, the

hypothesis that considers the temporal ability as the most impaired one in children with dyslexia.

Murphy and Schochat (7) also investigated the performance of Brazilian children with reading disorders in tests involving auditory temporal processing and phonological awareness. In that study, 60 children aged between nine and 12 years of age were assessed - 27 in the control group and 33 study group. An adaptation of the "Repetition Test" (8) was developed and applied. The Repetition Test is composed by four tests of frequency discrimination and ordering, and four tests of duration discrimination and ordering. The results showed that children with reading disabilities presented significant different performance when compared to the control group on tests related to reading, phonological awareness and temporal auditory processing. However, no correlation between the performance in tests of temporal auditory processing and reading - or even phonological awareness - was observed for both groups. The only observed correlation was the one between reading and phonological awareness test. The authors concluded that the existence of some ability that is common for reading and temporal processing is suggested by the lower performance presented by the study group in all auditory processing tests. Furthermore, perhaps the lack of correlation observed could be explained by the fact that reading is not an isolated process, i.e. it also depends on other processes that are not necessarily involved in temporal auditory processing.

Conclusion

This study observed that the group of children with dyslexia showed a statistically poorer performance on the Frequency Pattern test when compared to the control group, suggesting the existence of a relationship between temporal abilities and reading disorder. The group of children with ADHD showed a statistically poorer performance than the control group did on all tests, suggesting the existence of a close relationship between the abilities tested and the Attention Deficit Hyperactivity Disorder. Further studies are necessary to better investigate the correlation between each altered hearing ability and the symptoms resulting from the primary alterations presented by each disorder and/or disability.

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