

Reading performance, temporal ordering, motivation and school complaints: preliminary study

Desempenho em leitura, ordenação temporal, motivação e queixas escolares: estudo preliminar

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ABSTRACT

Purpose: To verify the association between reading performance of children and adolescents and the presence of school complaints, hearing ordering ability and school motivation. **Methods:** Cross-sectional observational study with a convenience sample composed of 36 participants. The instruments used were the Sociodemographic and School Characterization Questionnaire, the Economic Classification Criterion of Brazil, the auditory evaluation, the Memory Tests for Verbal and Non-verbal Sounds in Sequence, the Frequency and Duration Pattern Tests, the School Performance Test, the Assessment of Reading Processes and the Scale for Assessing Children's School Motivation. The response variable in this study was the reading process. Pearson's Chi-square and Fisher's Exact tests were used for association analyzes. **Results:** The association analysis revealed that most participants who presented changes in reading tasks also presented adequacy of simple temporal ordering and inadequacy in complex temporal ordering. There was no statistically significant association between reading performance and the presence of school complaints, temporal ordering auditory ability and school motivation. However, it was observed that most participants with reading disorders complained of school difficulties, poor academic performance, average school motivation, adequacy of simple temporal ordering and inadequacy of complex temporal ordering. **Conclusion:** Although it did not show statistical significance in most of the associations performed, the present study showed that there is a relationship between the reading performance of children and adolescents and the presence of school complaints, temporal ordering auditory ability and school motivation.

Keywords: Auditory perception; Hearing tests; Reading; Child; Motivation

RESUMO

Objetivo: verificar a associação entre o desempenho em leitura de crianças e adolescentes e a presença de queixas escolares, habilidade auditiva de ordenação temporal e motivação escolar. **Métodos:** estudo observacional analítico transversal, com amostra de conveniência composta por 36 participantes. Os instrumentos de coleta foram questionário de caracterização, Critério de Classificação Econômica do Brasil, avaliação auditiva, testes de Memória para Sons Verbais, Não Verbais em Sequência, Padrão de Frequência e de Duração, Desempenho Escolar, as Provas de Avaliação dos Processos de Leitura e a Escala para Avaliação da Motivação Escolar Infantojuvenil. A variável resposta deste estudo foi "processos de leitura". Os testes Qui-quadrado de Pearson e Exato de Fisher foram utilizados para as análises de associação. **Resultados:** as análises de associação revelaram que a maioria dos participantes com alteração nas tarefas de leitura apresentou, também, adequação da ordenação temporal simples e inadequação da ordenação temporal complexa. Não houve associação com significância estatística entre o desempenho em leitura e a presença de queixas escolares, habilidade auditiva de ordenação temporal e motivação escolar. Contudo, observou-se que a maioria dos participantes com alteração na leitura apresentou queixa de dificuldades escolares, baixo desempenho acadêmico e motivação escolar média. **Conclusão:** embora não tenha indicado significância estatística na maioria das associações realizadas, o presente estudo evidenciou que há relação entre o desempenho em leitura de crianças e adolescentes e a presença de queixas escolares, habilidade auditiva de ordenação temporal e motivação escolar.

Palavras-chave: Percepção auditiva; Testes auditivos; Leitura; Criança; Motivação

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INTRODUCTION

Reading is a complex process, activating several interrelated cognitive processes, such as the ability to process, store and retrieve information; memory, attention, reasoning, logic; as well as auditory and visual processing skills^(1,2). The basic reading processes are also present in this context, including word recognition, which is the decoding of words, and the extraction of meaning from printed words. It is noteworthy, however, that, even being necessary requirements, these processes are not enough for comprehension to occur^(3,4). Moreover, for the reading to be really effective, it is essential that the reader understands the material read and is able to use the knowledge acquired afterwards⁽⁵⁾.

Therefore, the importance of reading for literacy processes becomes evident, since it is the basis for learning many areas of knowledge⁽⁵⁾. School failure, i.e., unsatisfactory performance in the learning of subjects is caused, especially, by difficulties in reading and writing⁽⁴⁾. Thus, the study of reading is justified in light of the presence of school complaints.

Among the factors that may influence the learning of school skills and the development of reading, school motivation can be mentioned. A Brazilian study⁽⁶⁾ evidenced the relevant contribution of motivation for reading comprehension in elementary school students, precisely because cognitive and motivational aspects interact to produce success in academic tasks. It is therefore pertinent to state that “constructing meaning during reading is a motivated act”^(6,55).

Against this background, the processing of auditory information also plays a key role. Auditory processing is the ability of the central nervous system (CNS) to use auditory information efficiently and effectively⁽⁷⁾, and encompasses different abilities.

The present study was centered on the auditory ability of temporal ordering, i.e. to the processing of several auditory stimuli in the order in which they occur⁽⁸⁾. Thus, it is expected that a person can identify the exact order in which sounds are presented⁽⁸⁾. This ability, together with temporal resolution, plays an important role in speech perception and understanding, and for this reason, both are prerequisites for the development of language skills⁽⁹⁾. Alterations in auditory perception may culminate in orthographic difficulties and in the encoding/decoding of both words and sentences⁽⁹⁾.

Auditory processing tests are constantly used to investigate the association between school difficulties and alterations in the development of auditory skills⁽⁹⁾. Therefore, individuals presenting complaints regarding school difficulties commonly present worse performances in the auditory processing evaluation, a result explained by the delay in the maturation of auditory skills, which are primordial for learning to read and write⁽¹⁰⁾.

The importance of the study of reading, associated with auditory skills and motivation is therefore evident. The understanding of the relationship between these aspects will contribute to advances in the practice of clinical speech-language pathology, allowing the development and construction of better strategies to assist the public with learning difficulties. For this purpose the present study aimed to verify the association between the reading performance of children and adolescents and the presence of school complaints, temporal ordering auditory skills and school motivation.

METHODS

This is a cross-sectional analytical observational study, with convenience sampling, encompassing 36 participants, between 9 and 12 years. To compose the sample, two different approaches were used: an invitation to those responsible for the children seen at the Speech-language Pathology Outpatient Clinic of the Hospital das Clínicas, Federal University of Minas Gerais (UFMG) (HC-UFMG) and dissemination of the research through social networks.

The Research Ethics Committee of the Federal University of Minas Gerais - UFMG, cleared the study under opinion 2.093.022. The guardians signed the Informed Consent Form - ICF, and the participants signed the Informed Assent Form - IAF.

The inclusion criteria for the participants were: between 9 and 12 years old and regularly enrolled in an educational institution, regardless of having or not school complaints. Exclusion criteria were: hearing loss or complaints of cognitive, neurological, neuropsychiatric, or motor alterations that would prevent the tests from being carried out; giving up during the application of the tests.

The research procedures comprised:

- Questionnaire for sociodemographic (age and sex) and school characterization (type of school - public or private -, school year and presence of complaint of school difficulties);
- Criterion of Economic Classification of Brazil (CCEB 2018)⁽¹¹⁾, which classifies participants into classes A (higher purchasing power) to E (lower purchasing power), according to the level of education of the head of the household, ownership of material goods, street conditions, and the origin of water used in the household;
- Hearing evaluation, which consisted of tonal audiometry and tympanometry, in order to check the integrity of the auditory system^(12,13);
- Evaluation of the auditory skill of simple temporal ordering⁽¹⁴⁾ by means of the Memory Tests for Verbal Sounds (TMSV in the Portuguese acronym) and Nonverbal Sounds (TMSNV in the Portuguese acronym) in Sequence. During the TMSV, the child was asked to repeat, as he/she heard, the three sequences in which the syllables /pa/, /ta/, /ca/, /fa/ were presented by the examiner⁽¹⁴⁾. In the TMSNV, the child was asked to point out the correct order of the three sequences in which the four instruments (bell, rattle, coco, agogo) were presented⁽¹⁴⁾. The tests were performed without using visual clues;
- Auditory skill evaluation of complex temporal ordering⁽¹⁴⁾, by means of the Tests of Frequency Pattern (TPF in the Portuguese acronym) and Duration Pattern (TPD in the Portuguese acronym), performed in diotic listening. For the TPF, participants were presented with sequences of three and four sounds, with different combinations of low (440 Hz) and high (493 Hz) frequency stimuli. In TPD, sequences of three and four sounds were also presented, this time with different combinations of fixed frequency (440 Hz) long duration (2000 ms) and short duration (500 ms) sounds. The marking was done by the participants as follows: X for high/thin sounds, O

for low/thick sounds, long dash for long sounds and dot for short sounds⁽¹⁵⁻¹⁷⁾;

- The School Performance Test - TDE in the Portuguese acronym⁽¹⁸⁾, applied to assess writing, reading and arithmetic skills, with their respective subtests. The classification was made from the raw scores of each subtest and the total raw score, according to the school year. Scores classified as superior and medium were considered as “good school performance”, and scores classified as inferior were considered as “poor school performance”;
- Tests for Evaluation of Reading Processes - PROLEC in the Portuguese acronym⁽¹⁹⁾, applied in a reduced version, consisting of the following tests: test 2 - equal-different in words and pseudowords; test 5 - pseudoword reading; test 7 - grammatical structures; test 10 - text comprehension. Scores were obtained by test and results were interpreted according to the reference criteria for the participants’ schooling year⁽¹⁹⁾;
- Scale for Evaluation of School Motivation for Children and Youth - EAME-IJ in the Portuguese acronym⁽²⁰⁾, which measures the sources of motivation (intrinsic and extrinsic), as well as its intensity. The scale was read by the applicator so that the participant could answer orally. Considering the scores of intrinsic and extrinsic motivation and the overall sum, the results were classified as low, medium or high motivation, according to the examinee’s education.

Data collection was carried out at the Functional Health Observatory in Speech-language Pathology of the Medical School of UFMG. The tests were applied in individual sessions, requiring two sessions, each lasting one hour. The auditory tests were applied in an acoustically treated room, and the others in a room with less noise exposure.

The data collected were entered, checked, and categorized in a database. Descriptive analyses of absolute and relative frequency distribution of all categorical variables and analysis of measures of central tendency and dispersion of continuous variables were performed. With the purpose of the association analyses, the following groupings were performed: the TDE domains were divided into two categories: “lower school performance” and “average/higher school performance”, according to the total sum of subtests; the socioeconomic classes of the CCEB were grouped into classes A/B and classes C/D-E; the PROLEC results were reorganized into “normal” and “altered”, and the altered results encompassed the performances classified as “difficulty” and “high difficulty” and the results of the TMSV and TMSNV, TPD and TPF tests (three and four sounds) were categorized as “adequate” and “inadequate”, according to the reference criteria established in the literature⁽¹⁴⁾. Pearson’s chi-square test and Fisher’s exact test were used for association analysis, considering as statistically significant those with $p \leq 0.05$.

For the purposes of data entry and processing we used SPSS software, version 21.0.

RESULTS

In this research, the sample was composed of 36 participants, with the majority (61.1%) being male. The age range varied

from 9 to 12 years, 11 months, and 29 days, with a mean age of 10 years and 2 months and a median of 10 years (Figure 1).

Regarding schooling, the sample was distributed between the third and seventh grades (elementary and junior high), and most were in the sixth grade (30.6%), were enrolled in public educational institutions (88.9%), had lower school performance (80.6%), and only 19.4% had no complaints of school difficulties (Figures 1 and 2).

Regarding socioeconomic classification, 52.8% of the sample was concentrated in classes C and D-E. The guardians of one participant did not answer the CCEB and, therefore, the sample for this questionnaire totaled 35 participants (Figure 1).

Regarding school motivation, 50.0% (n=18) showed low intrinsic motivation, 44.4% (n=16) showed medium extrinsic motivation, and 50.0% (n=18) showed medium overall motivation (Figure 2).

The Tests of Evaluation of Reading Processes - PROLEC were applied to 36 participants and it was found that the performance within normal standards, in each test, was 52.8% in test 2 (Equal-different in words and pseudowords); 61.1% in test 5 (Reading pseudowords); 66.7% in test 7 (Grammatical structures) and 50.0% in test 10 (Comprehension of texts).

In addition, 75.0% of participants showed adequacy of simple temporal ordering for verbal sounds and 86.1% for non-verbal sounds in sequence.

In the TPF, 8 participants (22.2%) showed adequate results in the sequence of 3 sounds, while 10 (27.8%) obtained adequacy in the sequence of 4 sounds. In the TPD, 9 children and teenagers (25.0%) presented adequate answers in the sequence of 3 sounds, while 21 (58.3%) were adequate in the sequence of 4 sounds. By these results, and considering the results obtained in the evaluation of complex temporal ordering, it can be affirmed that a large part of the participants obtained inadequate results.

In the association analysis of the PROLEC tests with gender, we noticed that male participants presented a higher percentage of difficulty when compared to females. In the analysis of the association of PROLEC with age, we observed that in tests 2 (Equal-different in words and pseudowords), 5 (Reading pseudowords), and 10 (Comprehension of texts) the highest number of alterations was concentrated at age 9, while in test 7 (Grammatical structures), the distribution of participants who presented difficulties was similar at ages 9 and 11. However, it should be noted that these associations were not statistically significant (Table 1).

Finally, in the association of socioeconomic classification with PROLEC, the participants who presented difficulties in the tests belonged mostly to classes C/D-E (Table 1).

There was no statistical significance in the analysis of the association of schooling with PROLEC. However, it was possible to verify that most of the inadequate results came from students from the public school network, with complaints of school difficulties and low academic performance. Furthermore, statistical significance was observed in the association of test 7 (grammatical structures) with general school motivation, as well as in the association of tests 2 (equal-different in words and pseudowords) and 7 (grammatical structures) with TDE reading. (Table 2).

In the association between PROLEC and simple temporal ordering it was found that most participants with alteration in the reading tasks presented adequacy of temporal auditory skills. It is worth noting that the only association that showed statistical

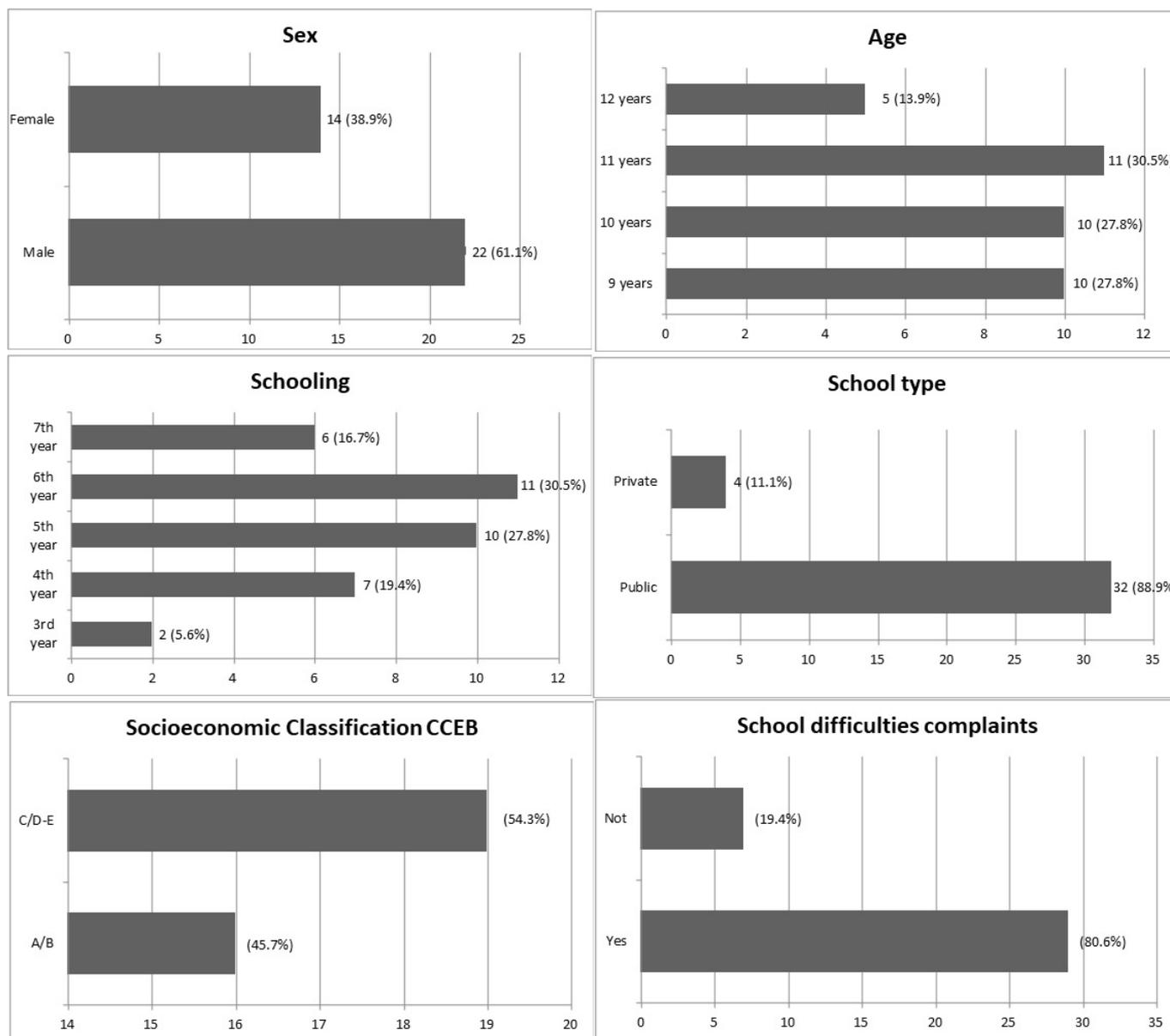


Figure 1. Sociodemographic, socioeconomic and school characterization graphs of the sample22
Subtitle: CCEB = Economic Classification Criterion of Brazil

significance was between Test 5 (Reading pseudowords) and TMSNV (Table 3).

In the association between PROLEC and complex temporal ordering, it was observed that almost all participants with difficulties in the reading tasks also presented inadequacy in the Frequency Pattern and Duration Pattern tests, both in the sequences with 3 sounds and with 4 sounds. The only exception was in the TPD (4-tone), in which the sample was similarly divided: half of the participants with altered results on Test 10 (Reading Comprehension) had adequate results on the TPD (4-tone), and the other half had inadequate results on the TPD (4-tone) (Table 4).

The association of tests 2 (Equal-different in words and pseudowords) and 5 (Reading pseudowords) with TPF (three

sounds) and TPD (four sounds) showed statistical significance (Table 4).

DISCUSSION

Regarding the response variable, the highest percentage of inadequate results in the PROLEC occurred in test 10 (Comprehension of texts), followed by Test 2 (Equal-different in words and pseudowords), Test 5 (Reading pseudowords), and 7 (Grammatical structures), suggesting that the performance in the semantic process (text comprehension) is compromised by the difficulty presented in the letter identification process (equal-different in words and pseudowords), lexicon (pseudoword reading), and syntactic process (grammatical structures)⁽²¹⁾. By

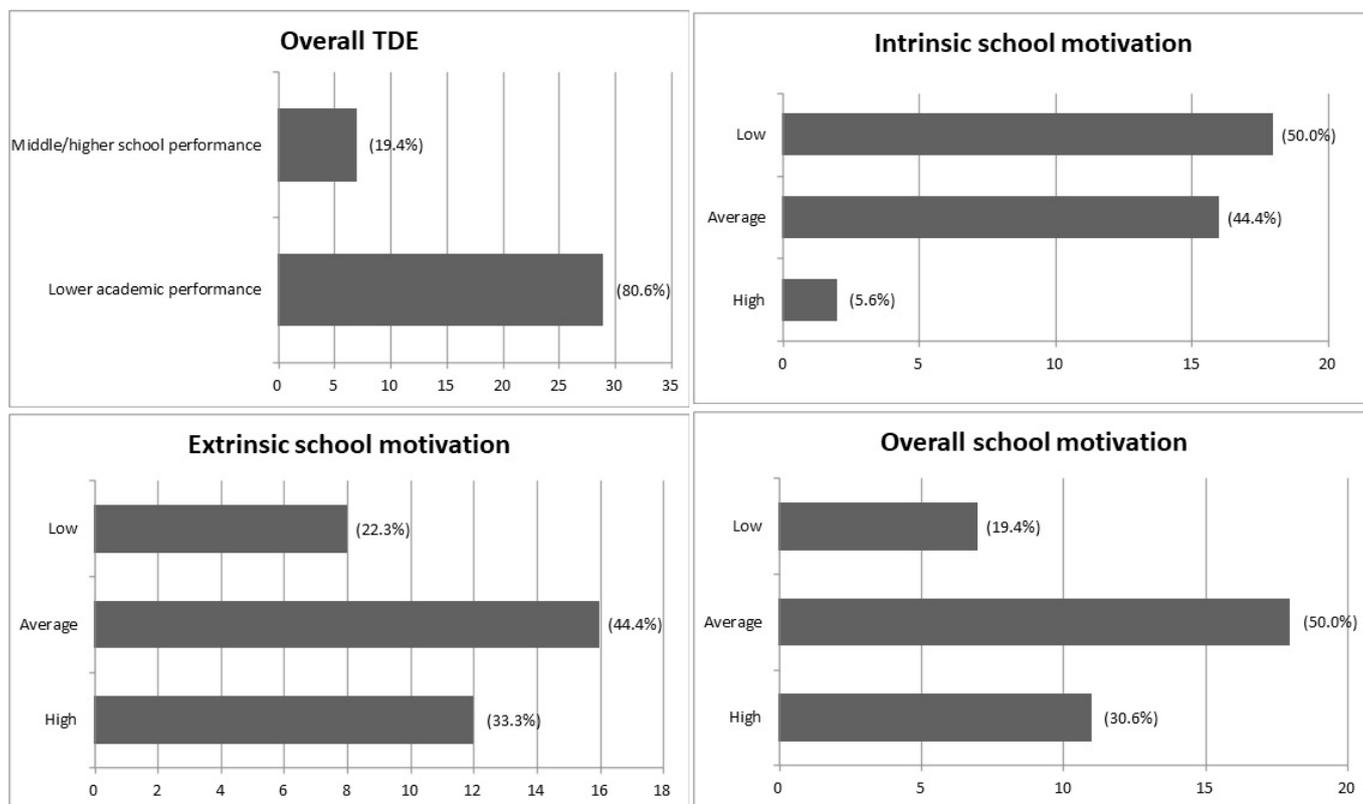


Figure 2. Characterization charts of school performance and motivation
Subtitle: TDE = The School Performance Teste – TDE in the Portuguese acronym

Table 1. Association between the results of the Reading Processes Assessment Tests and the sociodemographic and socioeconomic variables

PROLEC		Age				Sex		CCEB	
		9	10	11	12	F	M	A/B	C/D-E
		N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
Test 2 Equal-different in words and pseudowords	Normal	2 (10.5)	7 (36.9)	8 (42.1)	2 (10.5)	9 (47.4)	10 (52.6)	9 (50.0)	9 (50.0)
	Altered	8 (47.2)	3 (17.6)	3 (17.6)	3 (17.6)	5 (29.4)	12 (70.6)	7 (41.2)	10 (58.8)
	Total	10 (27.8)	10 (27.8)	11 (30.6)	5 (13.8)	14 (38.9)	22 (61.1)	16 (45.7)	19 (54.3)
	p-value		0.055 *			0.270 *		0.600 *	
Test 5 Pseudowords reading	Normal	5 (22.7)	7 (31.8)	7 (31.8)	3 (13.7)	9 (40.9)	13 (59.1)	12 (57.1)	9 (42.9)
	Altered	5 (35.7)	3 (21.4)	4 (28.6)	2 (14.3)	5 (35.7)	9 (64.3)	4 (28.6)	10 (71.4)
	Total	10 (27.8)	10 (27.8)	11 (30.6)	5 (13.8)	14 (38.9)	22 (61.1)	16 (45.7)	19 (54.3)
	p-value		0.829 *			0.755 *		0.096 *	
Test 7 Grammatical Structure	Normal	6 (25.0)	7 (29.2)	7 (29.2)	4 (16.6)	11 (45.8)	13 (54.2)	13 (56.5)	10 (43.5)
	Altered	4 (33.3)	3 (25.0)	4 (33.3)	1 (8.4)	3 (25.0)	9 (75.0)	3 (25.0)	9 (75.0)
	Total	10 (27.8)	10 (27.8)	11 (30.6)	5 (13.8)	14 (38.9)	22 (61.1)	16 (45.7)	19 (54.3)
	p-value		0.874 *			0.292 **		0.152 **	
Test 10 Text Comprehension	Normal	4 (22.2)	5 (27.8)	7 (38.9)	2 (11.1)	9 (50.0)	9 (50.0)	9 (52.9)	8 (47.1)
	Altered	6 (33.3)	5 (27.8)	4 (22.2)	3 (16.7)	5 (27.8)	13 (72.2)	7 (38.9)	11 (61.1)
	Total	10 (27.8)	10 (27.8)	11 (30.6)	5 (13.8)	14 (38.9)	22 (61.1)	16 (45.7)	19 (54.3)
	p-value		0.701 *			0.171 *		0.404 *	

*Pearson's chi-square test;**Fisher's exact test

Subtitle: PROLEC = Tests for Evaluation of Reading Processes; F = Female; M = Male; CCEB = Criterion of Economic Classification, Brazil; N = number of participants; % = percentage; A/B, C/D-E = economic classes

this reasoning it is possible to state that the low performance presented in word and pseudoword reading reflects the difficulty in phonological awareness and, consequently, the difficulty to perform grapheme-phoneme conversion⁽²¹⁾. Therefore, it is

necessary to evaluate not only the general reading ability, but also the lexical, syntactic, and semantic processes in order to identify the difficulties presented in reading and the level at which they occur⁽²²⁾.

Table 2. Association between Reading Process Assessment Test results and school variables

PROLEC		School year					Type of School		School Difficulties Complaints		Reading Performance		Overall school motivation		
		3 rd	4 th	5 th	6 th	7 th	Private	Public	Yes	No	DEMS	DEI	High	Medium	Low
		N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)				
Test 2 Equal-different in words and pseudowords	Normal	0 (0.0)	2 (10.5)	7 (36.8)	7 (36.8)	3 (15.9)	3 (15.8)	16 (84.2)	13 (68.4)	6 (31.6)	8 (42.1)	11 (57.9)	6 (31.6)	11 (57.9)	2 (10.5)
	Altered	2 (11.8)	5 (29.5)	3 (17.6)	4 (23.5)	3 (17.6)	1 (5.9)	16 (94.1)	16 (94.1)	1 (5.9)	1 (5.9)	16 (94.1)	5 (29.4)	7 (41.2)	5 (29.4)
	Total	2 (5.6)	7 (19.4)	10 (27.8)	11 (30.6)	6 (16.6)	4 (11.1)	32 (88.9)	29 (80.6)	7 (19.4)	9 (25.0)	27 (75.0)	11 (30.6)	18 (50.0)	7 (19.4)
	p-value			0.230 *			0.605 **		0.092 **		0.020 **				0.339 *
Test 5 Pseudowords reading	Normal	0 (0.0)	4 (18.2)	7 (31.8)	7 (31.8)	4 (18.2)	4 (18.2)	18 (81.8)	16 (72.7)	6 (27.3)	7 (31.8)	15 (68.2)	9 (40.9)	10 (45.5)	3 (13.6)
	Altered	2 (14.3)	3 (21.4)	3 (21.4)	4 (28.6)	2 (14.3)	0 (0.0)	14 (100.0)	13 (92.9)	1 (7.1)	2 (14.3)	12 (85.7)	2 (14.3)	8 (57.1)	4 (28.6)
	Total	2 (5.6)	7 (19.4)	10 (27.8)	11 (30.6)	6 (16.6)	4 (11.1)	32 (88.9)	29 (80.6)	7 (19.4)	9 (25.0)	27 (75.0)	11 (30.6)	18 (50.0)	7 (19.4)
	p-value			0.459 *			0.141 **		0.209 **		0.432 **				0.202 *
Test 7 Grammatical Structure	Normal	0 (0.0)	5 (20.8)	7 (29.2)	8 (33.3)	4 (16.7)	4 (16.7)	20 (83.3)	18 (75.0)	6 (25.0)	9 (37.5)	15 (62.5)	7 (29.2)	15 (62.5)	2 (8.3)
	Altered	2 (16.7)	2 (16.7)	3 (25.0)	3 (25.0)	2 (16.7)	0 (0.0)	12 (100.0)	11 (91.7)	1 (8.3)	0 (0.0)	12 (100.0)	4 (33.3)	3 (25.0)	5 (41.7)
	Total	2 (5.6)	7 (19.4)	10 (27.8)	11 (30.6)	6 (16.6)	4 (11.1)	32 (88.9)	29 (80.6)	7 (19.4)	9 (25.0)	27 (75.0)	11 (30.6)	18 (50.0)	7 (19.4)
	p-value			0.367 *			0.278 **		0.384 **		0.016 **				0.032 *
Test 10 Text Comprehension	Normal	0 (0.0)	3 (16.7)	6 (33.3)	7 (38.9)	2 (11.1)	3 (16.7)	15 (83.3)	14 (77.8)	4 (22.2)	5 (27.8)	13 (72.2)	6 (33.3)	9 (50.0)	3 (16.7)
	Altered	2 (11.2)	4 (22.2)	4 (22.2)	4 (22.2)	4 (22.2)	1 (5.6)	17 (94.4)	15 (83.3)	3 (16.7)	4 (22.2)	14 (77.8)	5 (27.8)	9 (50.0)	4 (22.2)
	Total	2 (5.6)	7 (19.4)	10 (27.8)	11 (30.6)	6 (16.6)	4 (11.1)	32 (88.9)	29 (80.6)	7 (19.4)	9 (25.0)	27 (75.0)	11 (30.6)	18 (50.0)	7 (19.4)
	p-value			0.402 *			0.603 **		0.674 *		0.700 *				0.890 *

*Pearson's chi-square test; **Fisher's exact test

Subtitle: PROLEC = Tests for Evaluation of Reading Processes; TDE Reading Performance = Test of School Performance - reading subtest; DEI = Lower School Performance; DEMS = Middle/Superior School Performance; N = number of participants; % = percentage**Table 3.** Association between the results of the Tests for the Evaluation of Reading Processes and simple temporal ordering

PROLEC		TMSV		TMSNV	
		Adequate	Inadequate	Adequate	Inadequate
		N (%)	N (%)	N (%)	N (%)
Test 2 Equal-different in words and pseudowords	Normal	16 (84.2)	3 (15.8)	16 (84.2)	3 (15.8)
	Altered	11 (64.7)	6 (35.3)	15 (88.2)	2 (11.8)
	Total	27 (75.0)	9 (25.0)	31 (86.1)	5 (13.9)
	p-value		0.255 **		1.000 **
Test 5 Pseudowords reading	Normal	21 (95.5)	1 (4.5)	18 (81.8)	4 (18.2)
	Altered	6 (42.9)	8 (57.1)	13 (92.9)	1 (7.1)
	Total	27 (75.0)	9 (25.0)	31 (86.1)	5 (13.9)
	p-value		0.001 **		0.628 **
Test 7 Grammatical Structure	Normal	20 (83.3)	4 (16.7)	20 (83.3)	4 (16.7)
	Altered	7 (58.3)	5 (41.7)	11 (91.7)	1 (8.3)
	Total	27 (75.0)	9 (25.0)	31 (86.1)	5 (13.9)
	p-value		0.102 *		0.646 **
Test 10 Text Comprehension	Normal	16 (88.9)	2 (11.1)	15 (83.3)	3 (16.7)
	Altered	11 (61.1)	7 (38.9)	16 (88.9)	2 (11.1)
	Total	27 (75.0)	9 (25.0)	31 (86.1)	5 (13.9)
	p-value		0.121 **		1.000 **

*Pearson's chi-square test; **Fisher's exact test

Subtitle: PROLEC = Tests for Evaluation of Reading Processes; TMSV = Test for Sequential Verbal Sound Memory; TMSNV = Test for Sequential Sound Memory Nonverbal; N = number of participants; % = percent

Table 4. Association between the results of the Reading Processes Assessment Tests and complex temporal ordering

PROLEC		TPF 3 sons		TPF 4 sons		TPD 3 sons		TPD 4 sons	
		Adequate	Inadequate	Adequate	Inadequate	Adequate	Inadequate	Adequate	Inadequate
		N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
Test 2 Equal-different in words and pseudowords	Normal	7 (36.8)	12 (63.2)	8 (42.1)	11 (57.9)	6 (31.6)	13 (68.4)	14 (73.7)	5 (26.3)
	Altered	1 (5.9)	16 (94.1)	2 (11.8)	15 (88.2)	3 (17.6)	14 (82.4)	7 (41.2)	10 (58.8)
	Total	8 (22.2)	28 (77.8)	10 (27.8)	26 (72.2)	9 (25.0)	27 (75.0)	21 (58.3)	15 (41.7)
	p-value	0.044 **		0.065 **		0.451 **		0.048 *	
Test 5 Pseudowords reading	Normal	8 (36.4)	14 (63.6)	9 (40.9)	13 (59.1)	8 (36.4)	14 (63.6)	16 (72.7)	6 (27.3)
	Altered	0 (0.0)	14 (100.0)	1 (7.1)	13 (92.9)	1 (7.1)	13 (92.9)	5 (35.7)	9 (64.3)
	Total	8 (22.2)	28 (77.8)	10 (27.8)	26 (72.2)	9 (25.0)	27 (75.0)	21 (58.3)	15 (41.7)
	p-value	0.013 **		0.054 **		0.062 **		0.028 *	
Test 7 Grammatical Structure	Normal	7 (29.2)	17 (70.8)	8 (33.3)	16 (66.7)	7 (29.2)	17 (70.8)	16 (66.7)	8 (33.3)
	Altered	1 (8.3)	11 (91.7)	2 (16.7)	10 (83.3)	2 (16.7)	10 (83.3)	5 (41.7)	7 (58.3)
	Total	8 (22.2)	28 (77.8)	10 (27.8)	26 (72.2)	9 (25.0)	27 (75.0)	21 (58.3)	15 (41.7)
	p-value	0.224 **		0.438 **		0.685 **		0.151 *	
Test 10 Text Comprehension	Normal	5 (27.8)	13 (72.2)	7 (38.9)	11 (61.1)	7 (38.9)	11 (61.1)	12 (66.7)	6 (33.3)
	Altered	3 (16.7)	15 (83.3)	3 (16.7)	15 (83.3)	2 (11.1)	16 (88.9)	9 (50.0)	9 (50.0)
	Total	8 (22.2)	28 (77.8)	10 (27.8)	26 (72.2)	9 (25.0)	27 (75.0)	21 (58.3)	15 (41.7)
	p-value	0.691 **		0.264 **		0.121 **		0.310 *	

*Pearson's chi-square test; **Fisher's exact test.

Subtitle: PROLEC = Tests for Evaluation of Reading Processes; TPF = Test of Frequency Pattern; TPD = Test of Duration Pattern; N = number of participants; % = percentages

Regarding the ability of simple temporal ordering, as seen in a previous study⁽²³⁾, the highest frequency of alterations occurred in the TMSV in sequence. A possible explanation for such a finding is that, both in the present study and in the aforementioned study⁽²³⁾, the participants with learning disabilities were the ones who presented the most alterations in auditory processing. It is also worth mentioning that the assessment of simple temporal ordering is used as an auditory processing screening, as it is quick and easy to apply.

Related to the complex temporal ordering, this study showed altered results in approximately three-quarters of the sample and, as in a Brazilian study⁽¹⁷⁾, the best performances occurred in tasks involving duration when compared to frequency tasks, both for sequences of three and four sounds. This finding can be justified by the Portuguese language phonetics itself. It is hypothesized that because Portuguese phonemes have longer duration (as far as acoustics is concerned) than those in other languages, this provides for better performance in duration resolution when compared to frequency resolution⁽¹⁶⁾. Additionally, a finding of the present study differed from the national literature^(16,17): the higher number of correct answers in the four-sound TPD, since in the other studies^(16,17), the number of correct answers was higher in the three-tone TPD. It is worth mentioning that the tests were always applied starting with the 3-tone TPD and, right after that, the 4-tone TPD. For this reason, we hypothesized a possible learning effect of the test. In other words, the participant learned the task with the 3-tone test and, therefore, obtained a better performance with the 4-tone test.

When association analysis of the PROLEC results with age was performed, the data found in this study, although they did not show statistical significance, confirm a previous study⁽²⁴⁾, by showing worse results in younger participants - in this case, at the age of 9 years. This can be explained because it is expected that, with advancing age, the better use of the lexical route, the increase in fluency and comprehension provide better performance during reading⁽²⁴⁾.

The analysis of the association of the PROLEC results with schooling, found that the highest frequency of alterations occurred in participants in the fourth, sixth, and seventh grades. This finding differs from that found by other authors⁽²⁵⁾, since it is expected that from the fourth year on, due to greater mastery of orthography, the lexical route is more used and, consequently, reading is faster and more accurate.

It is believed that in the association of PROLEC with age and education, the absence of statistical significance may be explained by the sample size. Considering that the sample of the present study was limited, the stratification by age and education generated groups with scarce numbers of participants, which made it difficult to find more robust results, with statistical significance.

Regarding the analysis of the association of PROLEC with school motivation, the present study indicated that most participants with altered performance in reading processes presented average school motivation. However, it is needed to emphasize the subjectivity of the test that evaluates school motivation, which may have contributed to such results. Only the association of test 7 (grammatical structures) with general school motivation was statistically significant. This finding differs from that found in other studies^(6,26), which showed that motivated students have better academic performance and also higher motivation and better results in tasks involving reading. It is also important to highlight that motivation may be influenced by several external factors, including socioeconomic and emotional issues⁽²⁶⁾.

Regarding the association of the reading subtest of the TDE with the PROLEC, the present study found that most participants with altered performance in reading processes also had low school performance for this TDE subtest. Although only two PROLEC tests (test 2: Equal-different in words and pseudowords and test 7: Grammatical structures) showed statistical significance in this association, this finding concurs with the findings of another study, which states that reading is one of the foundations for

learning several areas of knowledge⁽⁵⁾ and that difficulties in reading may lead to gaps in learning in different school subjects and, consequently, to poor school performance⁽⁴⁾.

Regarding the association between PROLEC and auditory skills for simple temporal ordering, this study showed that more than two-fifths of the sample with adequate results in the auditory processing tests presented altered results in reading. The only exception was in the association between test 5 (reading pseudowords) and the verbal sequential memory test, in which most participants with altered reading scores also showed inadequacy in simple temporal ordering for verbal sounds. Although we only found statistical significance in the association of a PROLEC test with simple temporal ordering, the findings is in agreement with the literature^(9,27) in showing that alterations in auditory skills are frequently related to difficulties in reading, writing and learning. A possible explanation for the presence of statistical significance in this association is that, for pseudoword reading, verbal sequential memory is even more necessary to perform decoding, since there is no way to search the memory of pseudowords in the lexicon.

Finally, regarding the association between PROLEC and complex temporal ordering, the results found in the present study confirm the findings of other authors, who found frequent presence of alterations in auditory skills, especially temporal processing, in participants with reading and learning alterations^(28,29).

Additionally it is worth remarking the important relationship between temporal auditory processing and reading. Temporal auditory skills play an essential role, both for speech and language understanding and, when altered, may reflect in orthographic and coding/decoding difficulties, both for words and sentences^(9,30).

The findings of the present study constitute a step forward in the debate of the performance of school-aged children and adolescents in reading process tasks (PROLEC) with auditory abilities of simple and complex temporal ordering. For that reason it is worth noting that this research opens paths for the continuity of studies in this area to be used for health promotion in the school setting, as well as for the improvement of intervention in the population that presents difficulties in these skills.

Because this was a study with a small sample, the results cannot be extrapolated to another contexts. Moreover, the non-equivalence of the distribution of subjects in the groups of age and education made it impossible to perform more robust analyses of associations between the data.

Moreover, this research demonstrated the feasibility of the study and the effectiveness of the instruments used in the collection. However, its continuity with more robust samples is necessary, for a more complete investigation, having in mind the purpose of incorporating the results to the speech-language pathology and educational practice.

The importance of the study in investigating the association between reading, temporal auditory processing, complaints and school motivation is emphasized, since the interrelation of these aspects is essential for the proper development of children and adolescents. It is expected that this study will contribute to the increasing inclusion of auditory skill evaluations in patients with school difficulties, so that the therapeutic strategies may be more assertive and effective. As a plus, it is also aimed at contributing to the dissemination of knowledge for teachers and educators so that, once they know about the association between these aspects that are so important for learning, and

in this way they can help children and adolescents to have satisfactory school performance.

CONCLUSION

The study evidenced a relationship between the response variable (reading processes) and the explanatory variables (auditory temporal ordering ability, sociodemographic data, and school aspects). However, it was not able to indicate statistical significance in most associations.

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