



# Syntactic and phonological processing of children with learning disabilities

Processamento sintático e fonológico de crianças com dificuldades de aprendizagem

Procesamiento sintáctico y fonológico de niños con dificultades de aprendizaje

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## Abstract

**Introduction:** Learning difficulties are well known for poor school performance, however, it is important to differentiate them and understand their origins and symptoms. **Objective:** This study aimed to verify phonological and syntactic processing skills in students with learning difficulties and to investigate whether changes are overlapping, which may indicate possible changes in the underlying language. **Methods:** This study involved 30 schoolchildren, ages seven to 11, of both genders, from 2nd to 5th grade, divided into experimental and control group. Tools were used to evaluate the rapid naming of figures, repetition of pseudowords, reading of words and pseudowords, phonological awareness and understanding of syntactic processing. The results were analyzed through statistical tests. **Results:** A statistically significant difference was observed between the performances of participants with and without learning difficulties for most phonological processing skills, indicating better control group results. In addition, there was an age-related performance difference for the experimental group in phonological processing tasks, with better yields for older children. Regarding syntactic processing, no significant statistical differences were found between the groups, and a subtle difference between ages was observed only in relation to the understanding of the relative fit of object with transitive verb. **Conclusion:** The performance of children with learning difficulties is shown to have changed only for phonological processing skills. Regarding syntactic processing, the groups showed similar results; however it is necessary to increase the sample size for conclusive results.

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### Authors' contributions

IPG: Study conception and design. Data collection and analysis, manuscript drafting.

TB: Study conception, design and supervision, data analysis. Manuscript drafting and revision.

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**Keywords:** Child Language; Language Development; Language Development Disorders; Learning; Learning Disabilities.

## Resumo

**Introdução:** As dificuldades de aprendizagem são muito conhecidas pelo baixo desempenho escolar, porém, é importante diferenciá-las e entender suas origens e sintomas. **Objetivo:** Este estudo teve como objetivos verificar habilidades de processamentos fonológico e sintático em escolares com dificuldades de aprendizagem e investigar se alterações são sobrepostas, podendo indicar possível alteração de linguagem. **Métodos:** Participaram deste estudo 30 escolares, na faixa etária de sete a 11 anos, de ambos os gêneros, do 2º ao 5º ano do Ensino Fundamental, divididos em grupo experimental e controle. Foram avaliadas a nomeação rápida de figuras, repetição de pseudopalavras, leitura de palavras e pseudopalavras, consciência fonológica e compreensão do processamento sintático. Os resultados foram analisados por meio de testes estatísticos, **Resultados:** Observou-se diferença estatisticamente significativa entre os desempenhos dos participantes com e sem dificuldades de aprendizagem para a maioria das habilidades de processamento fonológico, indicando melhores resultados do grupo controle. Além disso, houve diferença de desempenho em função da idade para o grupo experimental nas tarefas de processamento fonológico, com melhores rendimentos de crianças mais velhas. A respeito do processamento sintático, não foram verificadas diferenças estatísticas significativas entre os grupos, sendo observada uma sutil diferença entre as idades apenas em relação à compreensão das relativas encaixadas de objeto com verbo transitivo. **Conclusão:** O desempenho das crianças com dificuldades de aprendizagem demonstra-se alterado somente para as habilidades de processamento fonológico. Quanto ao processamento sintático, os grupos apresentaram resultados semelhantes; no entanto é necessário aumentar o tamanho da amostra para resultados conclusivos.

**Palavras-chave:** Linguagem Infantil; Desenvolvimento da Linguagem; Transtornos do Desenvolvimento da Linguagem; Aprendizagem; Deficiências da Aprendizagem.

## Resumen

**Introducción:** Las dificultades de aprendizaje son bien conocidas por el bajo rendimiento escolar, sin embargo, es importante diferenciarlas y comprender sus orígenes y síntomas. **Objetivo:** Este estudio tuvo como objetivo verificar habilidades de procesamientos fonológico y sintático en estudiantes con dificultades de aprendizaje y investigar si cambios se superponen, que puede indicar un posible cambio en el lenguaje subyacente. **Metodos:** Participaron de este estudio treinta estudiantes, de 7 a 11 años, de ambos sexos, de 2º a 5º de la primaria, divididos en grupo experimental y control. Se evaluó la denominación rápida de figuras, repetición de pseudopalabras, lectura de palabras y pseudopalabras, conciencia fonológica y comprensión del procesamiento sintático. Los resultados fueron analizados mediante pruebas estadísticas. **Resultados:** Se observó una diferencia estadísticamente significativa entre desempeños de participantes con y sin dificultades de aprendizaje para mayoría de las habilidades de procesamiento fonológico, indicando mejores resultados del grupo control. Además, hubo una diferencia en el desempeño en función de la edad para el grupo experimental en tareas de procesamiento fonológico, con mejores rendimientos de niños mayores. En relación al proceso sintático no se observan diferencias estadísticas considerables entre los grupos, observándose una pequeña diferencia entre edades solamente relacionada a la comprensión de relativas adecuadas de complemento con verbo transitivo. **Conclusión:** El desempeño de niños con dificultades de aprendizaje se muestra alterado solamente para habilidades de procesamiento fonológico. En cuanto al procesamiento sintático, los grupos mostraron resultados similares, sin embargo, es necesario aumentar el tamaño de la muestra para obtener resultados concluyentes.

**Palabras clave:** Lenguaje Infantil, Desarrollo del Lenguaje; Trastornos del Desarrollo del Lenguaje; Aprendizaje; Discapacidades para el Aprendizaje.

## Introduction

While all learning difficulties can lead to poor academic performance in children, the origins and manifestations of these conditions may vary, and it is important to distinguish between them. Learning difficulties consist of alterations in reading, writing, or mathematics in children with no sensory, motor, cognitive or intellectual impairments<sup>1</sup>.

The etiology of these conditions is variously described in the academic literature<sup>2</sup>. These studies can be divided into those that attribute learning difficulties to intrinsic causes, and those that ascribe these difficulties to extrinsic factors. The former category focuses on neurological issues and tends to use the term 'Learning Disorders,' while the latter discusses pedagogical or sociocultural factors<sup>2</sup>.

Some studies draw an association between learning difficulties and phonological alterations given the influence of phonological processing on the development of reading and writing skills<sup>3</sup>. Therefore, it is important to understand the skills involved in this process and how each one may affect children's learning.

Phonological processing is defined as the "use of phonological information in oral and written language processing"<sup>4</sup> and, according to the literature<sup>4</sup>, includes three main skills: phonological awareness, lexical recall, and working memory.

Phonological awareness is the ability to understand and manipulate the sounds that constitute words, known as phonemes, which can be combined in different ways to generate new syllables and words<sup>5</sup>. These skills are crucial for the development of reading and writing abilities.

Lexical recall, also known as lexical access, is associated with reading fluency<sup>3,6</sup>. Studies show that children with learning difficulties may struggle with rapid naming and fluency tasks given the importance of rapid lexical access for performance in these activities<sup>7,8</sup>.

Phonological working memory, also known as phonological short-term memory, is an aspect of phonological processing that involves the temporary storage of information<sup>9</sup>. It is also important for many other cognitive functions so that alterations in this skill can lead to impairments in language, learning, and mathematical reasoning<sup>10</sup>.

Some studies note that alterations in syntactic processing may also have an impact on both language development and learning<sup>7,8</sup>. However, other

investigations note that in these cases, the impairments are associated with alterations in phonological processing, especially phonological awareness, as these are positively correlated with phonological awareness and learning alterations<sup>11,12</sup>.

Syntactic processing is involved in the comprehension and production of simple and complex sentences, which have different computational costs. Sentences with higher computational costs involve syntactic movement, or the transposition of a segment from its original place, and therefore require greater processing power for their comprehension or production. Examples include sentences in the passive voice, questions beginning with what/who, and subject/object-relative and embedded clauses. Object dislocation is associated with a greater computational cost than subject dislocation, with object relative sentences having the greatest computational cost or largest syntactic processing demands<sup>13</sup>.

Part of the literature on syntactic processing in learning and language alterations supports the hypothesis that impairments in phonological processing should interfere with sentence retention for subsequent analysis and comprehension<sup>7,14</sup>. On the other hand, some studies demonstrate that these alterations are not just a consequence of phonological limitations, even though syntactic and phonological processing share some underlying mechanisms such as auditory working memory and metalinguistic skills<sup>8</sup>.

In the context of syntactic impairments in language alterations, difficulties in the comprehension of sentences with a high computational cost tend to be associated with Specific Language Disorders (SLDs). Studies conducted in several languages confirm that children with SLDs struggle with this type of sentence<sup>13</sup>. While the term SLD is no longer used, it has been largely replaced by the term Language Development Disorder (LDD), which will therefore be used in this article.

According to Leonard (1998), LDD involves exclusively linguistic alterations of different types, including syntactic, phonologic, morphological, pragmatic, and lexical difficulties, and may be caused by neurobiological factors<sup>15</sup>. However, "syntactic SLD" is a typical manifestation of SLD. School-aged children with LDD often have learning alterations<sup>13</sup>.

As previously discussed, the main manifestation of LDD is syntactic impairment and many

children with learning disorders show alterations in phonological processing. In light of these observations, the aim of this study was to analyze the performance of children with reported learning difficulties on measures of phonological and syntactic processing. We also aim to investigate whether alterations in phonological processing accompany or overlap with syntactic processing alterations. This would allow for the differentiation between participants with LDD as well as learning alterations and those with only learning difficulties or disorders.

This information could contribute to our knowledge of how these conditions manifest, improving their diagnosis and treatment through future interventions. To achieve this goal, it is also important to examine the performance of participants with typical learning development to compare it with that of children with alterations in this process.

## Method

This study was approved by the Research Ethics Committee of the Health Institute of Nova Friburgo at the Universidade Federal Fluminense under protocol number 2.555.867 and by the Secretary of Education of the City of Nova Friburgo under administrative protocol 24.527/2017.

In order to achieve the goals of this study, an exploratory cross-sectional study was conducted. Participants were divided into two groups: an experimental group (EG) composed of children with reported learning difficulties and a control group (GP) of children with typical language and learning development.

Study procedures were only performed after informed consent forms were presented to and approved by participating institutions. Participants in the EG were recruited from a Speech Pathology Teaching Clinic at the Universidade Federal Fluminense based on an analysis of medical records, with the approval of clinic administrators and internship supervisors. Before recruiting the CG, a meeting was held with the directors and professors of Municipal School Jardel Hottz in the city of Nova Friburgo to select eligible students based on our inclusion and exclusion criteria and adequate academic performance, as defined by mean grades over 6.00. This figure was calculated based on students' average grades in the following subjects,

in the first term of 2018: Portuguese, mathematics, science, history, and geography. The average grade across these subjects was used as the student's mean score. Only the grades in the first term were analyzed since the study began in the second term of the school year.

Subsequently, the legal guardians of eligible EG participants were contacted and given an explanation of the study as well as the informed consent form. At the school, the informed consent forms were sent to students' guardians who signed and returned them. An assent form was also given to the children who had received parental consent for participation. The children, as well as their parents or guardians, were informed that participation was voluntary and that they could withdraw from the study at any time without penalty.

At the end of the study, all participants received feedback on their overall performance in the assessment. Participants in the EG were also given the quantitative results of all tests administered.

The sample was composed of 30 participants of both genders, aged 7 years to 11 years and 11 months. To facilitate the analysis and comparison of performance, participants in the EG and CG were further divided into two subgroups: group 1 (G1), composed of children aged 7 to 9 years, and group 2 (G2), for children aged 10 to 11.

The EG contained 10 children with reported learning difficulties, including three girls and seven boys. At the time of the study, all EG participants were being treated at the Speech Pathology Teaching Clinic of the Universidade Federal Fluminense and had attended a maximum of two assessment and/or treatment sessions for reading and writing difficulties, or were on a waiting list after an initial screening process.

Completion of the initial screening process was one of the inclusion criteria for this study, as this procedure allowed for the identification of main clinical complaints and any other patient needs, facilitating referrals to specialized services for detailed assessment and possible treatment interventions. The screening process included interviews with parents or guardians and the administration of the adapted PROADE (Academic Difficulty Assessment) protocol. This instrument evaluates speech and narrative skills, recognition of upper and lower case letters, as well as reading and writing, and is used whenever the interview reveals issues related to these abilities.

Children who attended more than two treatment sessions for learning difficulties or who did not undergo screening, as well as those with a complaint or diagnosis related to hearing, neurological, psychiatric, or syndromic conditions were excluded from the study.

Children who received up to two sessions of speech pathology intervention for reading and writing skills before signing the consent form were included in the study, since the first treatment sessions do not usually result in significant improvement of the difficulties and alterations presented by the patients, given the time required to establish a rapport, conduct initial assessments and begin the treatment process.

The CG consisted of 20 children aged 7 to 11 years, including 12 girls and 8 boys attending second to fifth grade in morning classes at Municipal School Jardel Hotzz. All children had good academic performance as determined by mean grades of at least 6.0 in the first term of 2018.

Those with a history of grade repetition; complaints or suspected language and learning alterations; syndromes; chronic non-progressive encephalopathy; hearing impairment, neurological or psychiatric alterations were excluded from the CG.

This study focused on children who were at least in the second grade and had no diagnosed learning disabilities but might have either difficulties or a learning disorder, as they had alterations in their learning skills. The EG was therefore referred to as having reported learning difficulties or being at risk for learning disorders or difficulties. The same educational criteria were used to select participants for the CG, who had no reported learning difficulties.

Participants were administered the following assessment instruments:

#### a) *Phonological Assessment:*

Rapid Automatic Naming<sup>16</sup>: the rapid automatic picture naming task from the processing speed portion of the Cognitive-Linguistic Skills Assessment Protocol was used to evaluate visual input and access to meaning. In this task, the participant is asked to name the images on a chart as quickly as possible. The stimuli consist of four pictures presented repeatedly in random order. The therapist is responsible for timing the task.

*Brazilian Children's Test of Pseudoword Repetition*<sup>17</sup>, adapted: this instrument was used to evaluate phonological working memory. Participants were asked to repeat a total of 40 pseudowords divided according to their degree of similarity to real words. Ten had low similarity, 20 had medium similarity, and 10 had high similarity to real words. Phonological processes identified in prior assessments or during spontaneous speech were not considered errors. Though the test categorizes stimuli based on their similarity to real words, this division was not considered in the present study, which used only the total score on the task.

Anele 1 collection - Assessment of Isolated Word and Pseudoword Reading<sup>18</sup>: this instrument evaluates the skills involved in word and pseudoword reading. Throughout the test, respondents are shown 59 words classified into the following categories: short, regular, frequent (5); long, regular, frequent (5); short, regular, infrequent (4); long, regular, infrequent (5); short, irregular, frequent (5); long, irregular, frequent (5); short, irregular, infrequent (5); long, irregular, infrequent (5); short pseudowords (10); long pseudowords (10). Though the test divides stimuli based on length and frequency, only the regularity and frequency classifications were considered in the present study. Therefore, all pseudowords were analyzed together.

Sequential Assessment Instrument for Phonological Awareness (*Consciência Fonológica Instrumento de Avaliação Sequencial*; CONFIAS)<sup>19</sup>: this test was used to assess intrasyllabic (rhyme), syllabic and phonemic aspects of phonological awareness through activities involving syllable synthesis; syllable segmentation; initial syllable identification; rhyme identification; production of words starting with a given syllable; medial syllable identification; rhyme production; syllable exclusion; syllable transposition; production of words starting with a given sound; initial phoneme identification; final phoneme identification; phoneme exclusion; phoneme synthesis; phoneme segmentation; phoneme transposition. Each correct answer receives a point. The task has a maximum score of 70 points: 32 for syllable-level items, eight for rhyme items, and 30 for phoneme-level items. Though the test only divides items based on their focus on syllable or phonemic awareness, we also conducted a separate analysis of items that evaluate intra-syllable awareness.



**b) Syntactic Assessment:**

MABILIN Linguistic Skill Assessment Modules. This test evaluates complex sentence comprehension in Brazilian Portuguese. We investigated the processes involved in the comprehension of reversible and irreversible active and passive sentences; branching subject-object relative clauses; subject-object wh-questions; subject-object wh+n questions; and embedded relative clauses with a subject and transitive verb (TV), intransitive verb (IV), and object (transitive and intransitive verb), with the latter constituting the most complex type of sentence examined.<sup>13</sup>

During the assessment, the examiner reads out sentences with the aforementioned structures and the participant is asked to point out images that match each sentence. The images are shown using a computer software. When the respondent points to an image, the therapist selects it and moves on to the next sentence. At the end of the test, the program generates a report describing the child's performance on each type of sentence and classifies their performance into one of the following categories: no difficulties, significant difficulties, moderate difficulties, and very serious difficulties.

Each child took part in two assessment sessions lasting approximately 40 minutes each. The ses-

sions were conducted on separate days to prevent fatigue or inattention due to an excess of tasks. The MABILIN and ANELE 1 were administered in the first session, while the CONFIAS, the rapid naming task, and the phonological working memory test were administered in the second session.

After testing, the measures of syntactic and phonological processing were compared between the EG and CG. Statistical analyses were conducted using the non-parametric Mann-Whitney test and the parametric Student's t-test, with a significance (p) level of 0.05.

**Results**

In this section, we will compare the performance of the EG and CG in phonological and syntactic processing tasks. First, we will discuss our overall comparison of all participants in the EG (n = 10) and CG (n = 20). Subsequently, we will display our comparisons of participants by age group (G1 and G2).

The Tables below (1 to 4) illustrate the groups' performance on measures of rapid naming, phonological memory task, isolated word, and pseudo-word reading, and phonological awareness.

**Table 1.** Comparison of total time in the rapid naming task between the EG and CG.

Skill	Groups	Mean	Median	Standard Deviation	Mann-Whitney Test <sup>1</sup> (p)	Result
Total time (min)	EG	0.81	0.72	0.31	0.001*	EG > CG
	CG	0.53	0.53	0.10		

Note: <sup>1</sup>Mann-Whitney U Test; EG = experimental group; CG = control group; p < 0.05

As seen in Table 1, children with no reported learning difficulties required less time than those with learning difficulties to complete the rapid

naming task. This difference was statistically significant (p < 0.05).

**Table 2.** Comparison of overall accuracy between the EG and CG on the phonological working memory task.

Skill	Group	Mean	Median	Standard Deviation	Mann-Whitney Test <sup>1</sup> (p)	Result
Total phonological memory (40)	EG	33.2	34.0	6.0	0.001*	EG < CG
	CG	38.7	39.0	2.0		

Note: <sup>1</sup>Mann-Whitney U Test; EG = experimental group; CG = control group; p < 0.05

Table 2 shows that the control group had a higher mean accuracy on the phonological memory task than the experimental group. This difference was also statistically significant.

**Table 3.** Comparison of total reading accuracy, frequent/infrequent and regular/irregular word reading, and pseudoword reading between the EG and CG.

Skill	Group	Mean	Median	Standard Deviation	Mann-Whitney Test <sup>1</sup> (p)	Result
Total reading (59)	EG	23.8	22.5	20.0	<0.001*	EG < CG
	CG	54.9	54.0	2.4		
Frequent regular (10)	EG	5.70	6.50	4.19	0.005*	EG < CG
	CG	9.80	10.00	0.41		
Infrequent regular (9)	EG	3.90	3.50	3.41	0.002*	EG < CG
	CG	8.45	8.00	0.51		
Frequent irregular (10)	EG	4.30	4.50	3.86	<0.001*	EG < CG
	CG	9.60	10.00	0.60		
Infrequent irregular (10)	EG	2.90	2.50	2.64	<0.001*	EG < CG
	CG	9.15	10.00	1.09		
Pseudowords (20)	EG	7.00	5.50	6.68	<0.001*	EG < CG
	CG	17.9	18.0	1.55		

Note: <sup>1</sup>Mann-Whitney U Test; EG = experimental group; CG = control group; p < 0.05

Table 3 shows that children with no learning difficulties had a higher mean number of correct answers than those with reported learning difficulties. This difference was statistically significant and occurred on all variables analyzed, including total reading score, reading of frequent regular words, infrequent regular words, frequent irregular words, infrequent irregular words, and pseudowords.

As shown in Table 4, phonological awareness skills were compared using the Mann-Whitney test for most variables, except for phoneme-level items, which were compared using the parametric Student's T-test, as this was the only variable that did not significantly deviate from a normal distribution.

**Table 4.** Comparison of phonological awareness skills between the EG and CG.

Skill	Group	Mean	Median	Standard Deviation	Mann-Whitney or Student's T-test <sup>1</sup> (p)	Result
Syllable level (32)	EG	24.2	25.0	4.7	<0.001*	EG < CG
	CG	30.6	31.0	1.1		
Rhyme level (8)	EG	4.70	4.50	1.89	0.001*	EG < CG
	CG	7.15	7.50	1.04		
Phoneme level (30)	EG	12.80	12.50	3.71	<0.001*	EG < CG
	CG	21.20	19.50	4.14		
Total phonological awareness (70)	EG	41.70	40.50	9.55	<0.001*	EG < CG
	CG	58.90	58.00	4.75		
Syllable synthesis (4)	EG	4.00	4.00	0.00	1.000	EG = CG
	CG	4.00	4.00	0.00		
Syllable segmentation (4)	EG	3.70	4.00	0.67	0.502	EG = CG
	CG	3.95	4.00	0.22		
Initial syllable identification (4)	EG	2.90	3.00	0.88	0.015*	EG < CG
	CG	3.75	4.00	0.44		
Rhyme identification (4)	EG	3.10	3.00	0.88	0.028*	EG < CG
	CG	3.80	4.00	0.37		
Production of words starting with a given syllable (4)	EG	3.60	4.00	0.70	0.198	EG = CG
	CG	4.00	4.00	0.00		
Middle syllable identification (4)	EG	3.40	4.00	0.97	0.350	EG = CG
	CG	3.80	4.00	0.41		
Rhyme production (4)	EG	1.60	1.00	1.17	0.001*	EG < CG
	CG	3.30	3.50	0.86		
Syllable exclusion (8)	EG	4.40	4.50	2.37	<0.001*	EG < CG
	CG	7.55	8.00	0.76		
Syllable transposition (4)	EG	2.20	2.50	1.81	0.109	EG = CG
	CG	3.50	4.00	0.61		
Production of words starting with a given sound (4)	EG	2.80	3.00	0.92	0.008*	EG < CG
	CG	3.70	4.00	0.57		
Initial phoneme identification (4)	EG	3.40	4.00	0.84	0.619	EG = CG
	CG	3.65	4.00	0.49		
Final phoneme identification (4)	EG	2.00	2.00	0.94	0.005*	EG < CG
	CG	3.20	3.00	0.89		
Phoneme exclusion (6)	EG	2.00	2.00	1.56	<0.001*	EG < CG
	CG	4.95	5.00	0.69		
Phoneme synthesis (4)	EG	1.40	1.50	0.70	<0.001*	EG < CG
	CG	2.80	3.00	0.89		
Phoneme segmentation (4)	EG	0.90	0.50	1.20	0.559	EG = CG
	CG	1.35	1.00	1.53		
Phoneme transposition (4)	EG	0.30	0.00	0.67	0.022*	EG < CG
	CG	1.55	1.50	1.43		

Note: <sup>1</sup>The non-parametric Mann-Whitney test was used for most variables except for phoneme-level scores, which were analyzed using Student's T-test; EG=experimental group; CG=control group; p < 0.05.



Table 4 also shows significant group differences on syllable-level skills; rhyme; phoneme-level abilities; total phonological awareness; initial syllable identification; rhyme identification and production; syllable exclusion; production of words starting with a given sound; final phoneme identification; and phoneme exclusion, synthesis, and transposition. In all cases, the CG displayed greater accuracy than the EG. The remaining variables

(syllable synthesis and segmentation; production of words starting with a given syllable; initial syllable identification; syllable transposition; initial phoneme identification and phoneme segmentation) did not significantly differ between groups.

The results of group comparisons of syntactic comprehension skills for sentences with different levels of computational complexity are shown below.

**Table 5.** Comparison of comprehension skills for sentences with different computational costs between the EG and CG.

Skill	Group	Mean	Median	Standard Deviation	Mann-Whitney Test <sup>1</sup> (p)	Result
Active (8)	EG	7.7	8.0	0.5	0.880	EG = CG
	CG	7.7	8.0	0.6		
Irreversible passive (8)	EG	7.9	8.0	0.3	1.000	EG = CG
	CG	7.9	8.0	0.3		
Reversible passive (8)	EG	7.20	7.50	1.03	0.746	EG = CG
	CG	7.15	7.00	0.81		
Branching subject relative clauses (8)	EG	7.90	8.00	0.32	0.530	EG = CG
	CG	7.75	8.00	0.44		
Branching object relative clauses (8)	EG	6.90	7.00	1.20	0.397	EG = CG
	CG	7.40	7.00	0.60		
Subject wh-questions (8)	EG	8.00	8.00	0.00	1.000	EG = CG
	CG	8.00	8.00	0.00		
Object WH-questions (8)	EG	7.60	8.00	0.52	0.198	EG = CG
	CG	7.90	8.00	0.31		
Subject WH+N questions (8)	EG	7.70	8.00	0.48	0.619	EG = CG
	CG	7.75	8.00	0.64		
Object WH+N questions (8)	EG	7.00	7.00	0.94	0.286	EG = CG
	CG	7.35	8.00	0.93		
Embedded subject relative TV(8)	EG	7.30	8.00	1.25	0.983	EG = CG
	CG	7.50	8.00	0.69		
Embedded object relative TV (8)	EG	6.10	6.50	2.08	0.350	EG = CG
	CG	6.65	8.00	1.84		
Embedded subject relative IV (8)	EG	6.80	7.00	1.40	0.267	EG = CG
	CG	7.45	8.00	0.76		
Embedded object relative IV (8)	EG	6.30	6.50	1.49	0.286	EG = CG
	CG	6.90	8.00	1.37		

Note: <sup>1</sup>Mann-Whitney U Test; EG = experimental group; CG = control group; TV=transitive verb; IV=intransitive verb; p < 0.05

As can be seen in Table 5, none of the syntactic comprehension variables differed significantly between groups, as all  $p$  values  $> 0.05$ .

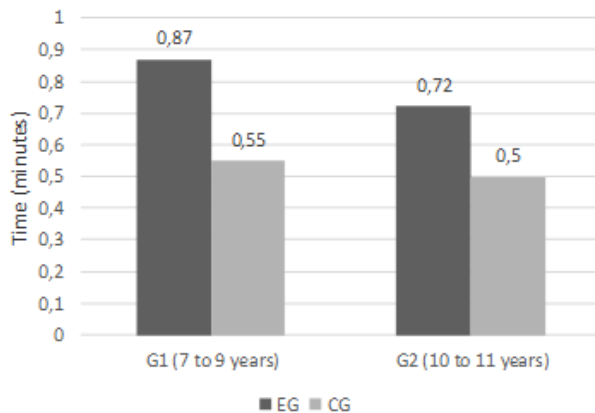
Though group differences in syntactic processing were not statistically significant, mean accuracy did differ between groups for some sentence types.

Therefore, syntactic processing was analyzed by comparing the comprehension of sentences with different syntactic structures, with a focus on measures where differences  $\geq 0.50$  in mean accuracy were observed between the CG (children with no difficulties) and the EG (children with reported difficulties). The following sentence types were compared: branching object-relative clauses, embedded object-relative clauses with transitive verbs, embedded subject-relative clauses with intransitive verbs, and embedded object-relative clauses with intransitive verbs.

As shown in Table 5, children with reported learning difficulties performed worse than their

peers on all variables analyzed, including the comprehension of branching object-relative clauses, embedded object-relative clauses with transitive verbs, embedded subject-relative clauses with intransitive verbs, and embedded object-relative clauses with intransitive verbs.

To allow for a more detailed analysis of performance in each group, participants were divided by age into two groups. The first was composed of children aged 7 to 9 years (G1) while the second included those aged 10 to 11 (G2). This allowed for a comparison of similar age groups across the EG and CG (between groups) and of the two age groups within the EG and CG (within-group). These comparisons were conducted for the following variables: phonological working memory, rapid naming, isolated word and pseudoword reading, phonological awareness, and comprehension of syntactic structures. These results are shown in the figures below (1 to 5).

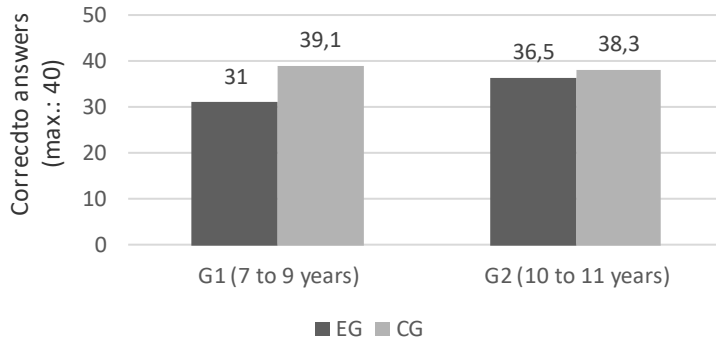


Note: EG=experimental group; CG=control group; G1= group 1; G2=group 2

**Figure 1.** Comparison of mean scores on the rapid naming task between age groups in the EG and CG.

As shown in Figure 1, participants with learning difficulties in both age groups (G1 and G2) needed more time to complete the tasks than participants with no learning difficulties. However,

significant differences in performance between age groups were only observed in children with reported learning difficulties, where older children (G2) outperformed younger ones (G1).

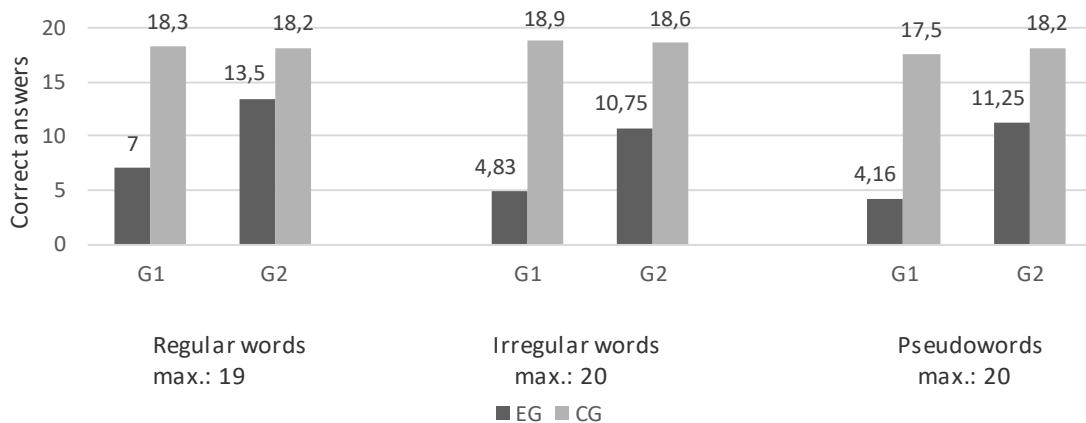


Note: EG=experimental group; CG=control group; G1= group 1; G2=group 2; max = maximum

**Figure 2.** Comparison of mean phonological working memory scores per age group in the EG and CG.

As shown in Figure 2, participants with no learning difficulties had better performance than those with learning difficulties in the same age group. The comparison of age groups within the GE and GC revealed that significant differences were only present in children with learning difficulties, where older individuals (G2) outperformed younger ones.

To analyze reading performance in each age group, we opted to focus on word reading and regularity. As a result, word frequency and length were not analyzed in this part of the study. The results of these comparisons are shown in Figure 3 below.



Note: EG=experimental group; CG=control group; G1= group 1; G2=group 2; max = maximum

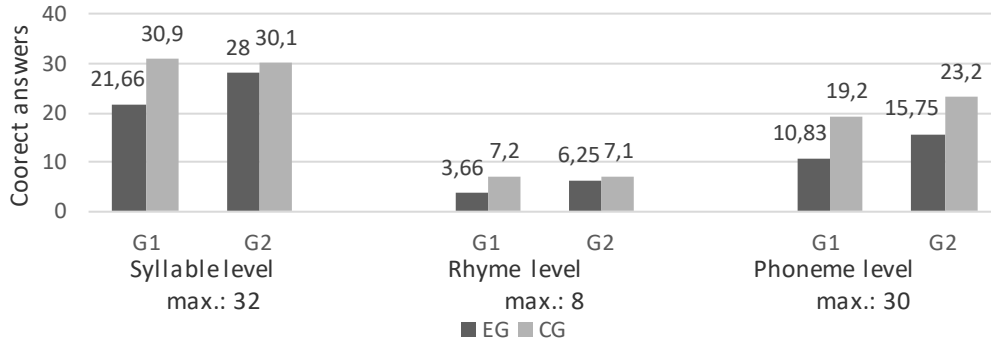
**Figure 3.** Comparison of mean scores on isolated word and pseudoword reading per age group in the EG and CG.

Figure 3 illustrates the superior performance of children with no learning difficulties relative to those with difficulties in both regular and irregular word reading as well as pseudowords across both

age groups. Once again, age differences within groups were only observed among participants with reported learning difficulties, where older children (G2) obtained better scores than younger ones (G1).

The analysis of phonological awareness per age group focused only on syllable-, rhyme-, and phoneme-level scores rather than the individual

tasks that evaluated these skills given the high number of variables involved. The results of these analyses are illustrated in Figure 4.



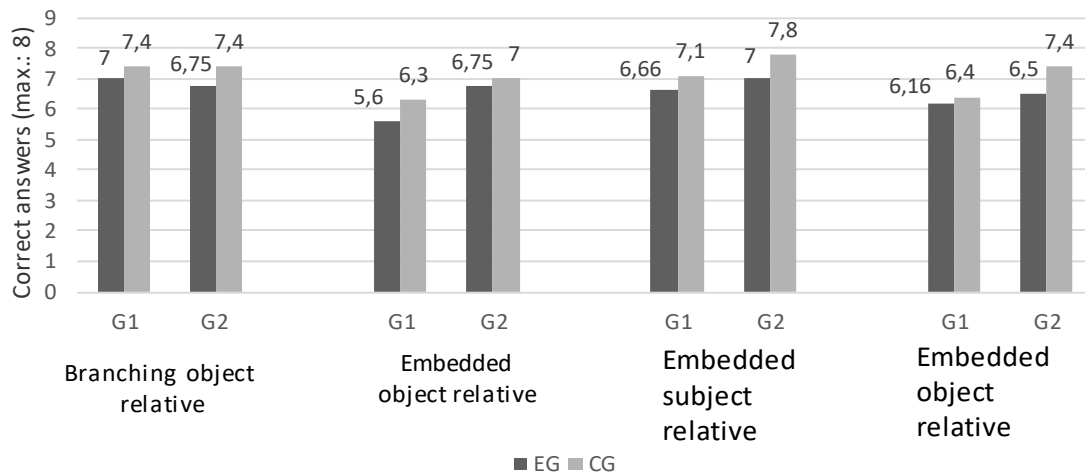
Note: EG=experimental group; CG=control group; G1= group 1; G2=group 2; max = maximum

**Figure 4.** Comparison of mean phonological awareness scores per age group in the EG and CG

Figure 4 shows that children with learning difficulties performed worse at syllable-, rhyme- and phoneme-level items than those with no difficulties across all age groups. The analysis of age group scores among children with learning difficulties revealed major differences on all variables, while in children with no reported difficulties, age-group scores only differed for phoneme-level items. In

these cases, older children (G2) showed better performance than younger ones (G1).

A more detailed analysis of sentence comprehension per age group was then performed by comparing the mean scores which differed by  $\geq 0.5$  between the GE and GC due to the large number of variables analyzed. The results of these analyses are illustrated in Figure 5.



Note: EG=experimental group; CG=control group; G1= group 1; G2=group 2; TV= transitive verb; IV=intransitive verb; max = maximum

**Figure 5.** Comparison of mean syntactic comprehension scores per age group in the EG and CG.

Figure 5 shows a large difference ( $\geq 0.5$ ) between the scores of young children (G1) with and without reported learning difficulties in the comprehension of embedded object-relative sentences with transitive verbs and embedded subject-relative sentences with intransitive verbs, with children in the CG performing better than those in the EG. Older children, on the other hand (G2), differed in the comprehension of branching object-relative sentences, embedded subject-relative sentences with intransitive verbs, and embedded object-relative sentences with intransitive verbs. Once again, scores were higher in children with no reported learning difficulties. Age group differences in the EG (children with reported learning difficulties) were only noted in the comprehension of embedded object-relative sentences with transitive verbs, while in the CG (children with no reported learning difficulties), these differences were observed for embedded object-relative sentences with transitive verbs, embedded subject-relative sentences with intransitive verbs and embedded object-relative sentences with intransitive verbs. In both cases, scores were higher among 10- and 11-year-olds.

It is important to note that age groups could not be statistically compared due to the small number of participants in each subgroup (G1 and G2). As a result, these analyses were conducted through the visual comparison of mean scores.

## Discussion

Overall, our findings demonstrated that children with reported learning difficulties performed worse than the control group on most measures of phonological skill.

In the rapid naming test, a statistically significant difference was observed between the control and experimental groups. The GE (children with learning difficulties) required more time to complete the test than the GC (children with no reported learning difficulties). The mean scores of both groups were categorized as superior based on the standards of the Cognitive-Linguistic Skill Assessment Protocol<sup>16</sup>. Nevertheless, mean scores were lower among individuals with learning difficulties. The analysis of individual scores revealed that most participants in the EG (60%) needed over 0.66 minutes to complete the task. This was the maximum time required by participants in the control group,

and as such, these findings suggest that children in the EG had lower processing speed than the CG.

The present findings are in agreement with those of previous studies of the performance of children with learning difficulties or disorders on measures of rapid automatic naming. These children display alterations in processing speed, which influences, among other skills, the ability to quickly process visual symbols, which is crucial for reading<sup>21</sup>.

On measures of phonological working memory, school-age children who reported learning difficulties performed worse than participants with no such difficulties. The difference between groups was statistically significant. The results obtained in this study agree with previous findings that indicate that working memory alterations can be a feature of children with learning difficulties<sup>22</sup>.

The present results also showed that children in the EG had poorer word and pseudoword reading skills than the CG, as observed on all variables tested. Studies of word and pseudoword reading in children with learning difficulties have found that these children display alterations in grapheme-phoneme conversion, which may interfere with the phonological reading route<sup>23,24</sup>. Group differences in this study were statistically significant for all variables analyzed, but were most expressive in pseudoword reading, indicating impairment in the phonological route, as observed in the aforementioned study. However, these children also had major difficulties in irregular word reading, which indicates impairment to the lexical route.

Another factor to influence performance in both participant groups was word frequency, since frequent regular and irregular words were easier to read than infrequent words, as has also been observed in other studies<sup>7</sup>. The reading performance of children with reported learning difficulties may be affected by impairments in rapid automatic naming, since some studies suggest that this skill may influence reading ability<sup>21</sup>. According to some authors, irregular word reading, for instance, is associated with rapid serial naming skills, since both types of tasks involve the learning of arbitrary word-symbol relationships, which may explain the poorer results of children with reported learning difficulties (EG) on both these activities<sup>25</sup>.

Similarly, the assessment of phonological awareness demonstrated that children with reported learning difficulties (EG) performed worse than

children with no difficulties (CG) on measures of this skill. This difference was statistically significant for total phonological awareness as well as scores at the syllable, rhyme, and phoneme levels. Differences were also observed on the following tasks: initial syllable identification; rhyme identification and production; syllable exclusion; production of words starting with a given sound; final phoneme identification; and phoneme, exclusion, synthesis, and transposition. Other measures of phonological awareness did not statistically differ between groups. Our results showed that children with reported learning difficulties differed significantly from the CG on nearly all tasks involving phoneme-level processing.

Though the CG outperformed the EG on all aforementioned variables, participants with no learning difficulties did not approach the maximum score on phoneme-level tasks, which contrasts with the group's performance on other measures. This suggests that difficulties in phoneme-level processing may not be exclusive to children with learning alterations, and may be attributed to the absence of formal instruction regarding the alphabetic principle which would have addressed and stimulated phonemic awareness<sup>24</sup>.

Previous studies of phonological awareness in children with learning difficulties or disorders have also found that these children perform worse than those with no difficulties on this type of task, confirming the results of the present study<sup>24,25</sup>. Additionally, many authors point to an association between phonological alterations and reading impairment in these children, since the ability to analyze and manipulate phonological units is crucial for learning phoneme-grapheme correspondence rules and carrying out the coding and decoding processes involved in reading and writing<sup>5</sup>.

Phonological awareness is also associated with phonological working memory skills since the manipulation of phonological units requires the ability to retain the memory of this information<sup>26</sup>. For example, in the phoneme synthesis activity, the child relies on their phonological working memory to temporarily store the phonemes produced by the examiner in order to combine them into a word. In a similar vein, the development and enhancement of phonological awareness skills increase the likelihood that information will remain in short-term memory and be available for subsequent activities<sup>27</sup>. These factors may have influenced the results of

the present study, where children with reported learning difficulties performed worse than their peers in both phonological working memory and phonological awareness tasks.

Learning difficulties can be primary (caused by extrinsic factors such as psychological, familial, or pedagogical issues) or secondary to other alterations (sensory, neurological, or psychiatric disorders, mental illness, or syndromes). Learning disorders, on the other hand, which are also associated with poor academic performance, have intrinsic causes (neurobiological alterations)<sup>28</sup>. Furthermore, learning disorders can be concurrent with or caused by other language alterations, as in the case of children with LDD. As such, some children with LDD may also experience learning difficulties, and these conditions can be present even in the absence of neurological, cognitive, intellectual, or sensory impairments<sup>13</sup>. Studies of LDD<sup>29</sup> indicate that children with this condition struggle with syntactic processing; as such, individuals with learning difficulties who exhibit phonological impairments as well as syntactic processing difficulties when faced with sentences with a high computational cost may be diagnosed with an LDD.

Our findings regarding syntactic comprehension revealed no statistically significant differences between the performance of children with and without learning difficulties on any of the variables analyzed. However, the visual comparison of mean scores revealed that the largest differences ( $\geq 0.5$ ) between groups were observed in the comprehension of branching object-relative clauses, embedded object-relative sentences with a transitive verb, embedded subject-relative sentences with an intransitive verb, and embedded object-relative sentences with an intransitive verb.

The lack of statistically significant differences between the CG and EG in syntactic comprehension tasks and the absence of syntactic impairment in children with learning difficulties in this study are not sufficient to determine the presence of LDD. The establishment of this diagnosis would also require an assessment of the production of sentences with high computational costs, as well as a larger sample size.

The comparison of age groups within and between the EG and CG could not be conducted through statistical methods due to the small number of participants in each group (G1 and G2). These comparisons were therefore made based on



a visual analysis of mean scores among children with and without reported learning difficulties. To determine whether these differences are statistically significant, future studies should examine them in larger samples.

The assessment of phonological processing revealed that EG participants aged 10 to 11 years (G2) outperformed those aged 7 to 9 (G1) in the same group on measures of rapid naming, phonological working memory, word, and pseudoword reading, and phonological awareness. In the CG, no significant differences were observed between age groups, both of which performed at a superior level on the tasks administered. This suggests that children with no learning difficulties develop phonological skills earlier than those with difficulties so that by ages 7 to 9, they approach the maximum score on these measures. Children with learning difficulties, on the other hand, only approach this level of performance by ages 10 to 11, and even then, may not match the scores of the CG.

On measures of phonological awareness, even older children (10 to 11 years) in the EG failed to perform at a satisfactory level; this may be because phonemic skills are intrinsically tied to the acquisition of the alphabetic principle and the mastery of reading and writing, which were not fully developed in these children due to their learning difficulties<sup>9</sup>.

Age group differences were not as large in the assessment of syntactic processing. The only sentences where a considerable difference in performance ( $\geq 0.5$ ) was observed between age groups were embedded object clauses with transitive verbs. Overall, our results suggest that these sentences are more difficult for children, regardless of the presence of learning difficulties. Additionally, they indicate that age may not play a defining role in the development of syntactic comprehension skills, supporting previous findings on the difficulties associated with the comprehension of sentences with a high computational cost, especially embedded object clauses, in both children and adults<sup>30</sup>.

## Conclusion

The present findings demonstrate that participants with reported learning difficulties performed worse than their peers on most measures of phonological processing, including rapid automatic figure naming, phonological working memory, isolated

word, and pseudoword reading, and phonological awareness.

The results of phonological processing tasks varied as a function of age only in children with reported difficulties, where performance across all variables was superior in older children (10 to 11 years) in relation to younger ones (7 to 9 years). Children with no learning difficulties appeared to develop phonological skills earlier than those with difficulties since the performance of 7- to 9-year olds did not differ from that of 10- to 11-year olds in this participant group.

The assessment of phonological awareness demonstrated that the EG showed poorer performance than the CG on nearly all tasks involving phoneme-level skills, and even older children (ages 10 and 11) in the EG failed to achieve satisfactory performance on these tasks. This may be attributed to the fact that these children may not have fully developed their reading and writing skills due to their learning issues.

As for syntactic processing, we conclude that despite the lack of statistically significant differences between the performance of children with and without reported learning difficulties, scores were lower in the comprehension of relative sentences than other sentence types, and lower for object-relative sentences than subject-relative ones, given their higher computational costs and greater processing demands. Additionally, we found that age was not a determinant of better performance in sentence comprehension tasks.

In conclusion, participants with reported learning difficulties showed statistically significant alterations only in phonological processing. However, our data cannot conclusively demonstrate that syntactic processing difficulties are absent in children with learning difficulties given the small sample size of the present study. We therefore recommend that future studies be conducted with larger EG and CG, and consequently, a greater number of children per age group. We also suggest that studies focus on the production of complex sentences in Brazilian Portuguese and adopt a longitudinal approach to the study of children with LDD to investigate the incidence of learning difficulties concurrent with or caused by these conditions.

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