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Original Article

Artigo Original

Profile of language and cognitive functions in children with dyslexia in speakers of Brazilian Portuguese

Perfil de linguagem e funções cognitivas em crianças com dislexia falantes do Português Brasileiro

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Keywords

Dyslexia
Cognition
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ABSTRACT

Objective: To verify the language and cognitive profile of children with dyslexia, contributing to the diagnosis of this condition in readers of a regular orthography, such as Brazilian Portuguese. **Methods:** In this study, 47 children with dyslexia (GD) and two controlled groups, one composed of 41 age controls (GCI) and the other with 31 reading controls (GCL), participated. All children were submitted to a battery involving the above-mentioned abilities. **Results:** GD demonstrated predominant deficits in phonological processing, which were not compatible with a delay in the development of such abilities, indicating an atypical development. The GD also obtained lower scores in both basic and more complex reading and writing skills (i.e., letters, words, pseudowords, and texts, respectively), as well as in other domains, such as language (syntactic processing and oral sentence comprehension), which may be a result of a deficit in phonological skills, that interfered with higher complexity linguistic skills. **Conclusion:** Phonological abilities demonstrated to be the main difficulty observed in children with dyslexia investigated in this study, corroborating previous studies in other languages. This demonstrates that, independently of the language regularity, phonological skills are fundamental to the diagnosis of developmental dyslexia.

Descritores

Dislexia
Cognição
Criança
Leitura
Linguagem

RESUMO

Objetivo: Verificar o perfil de linguagem e de habilidades cognitivas de crianças com dislexia, contribuindo para o diagnóstico desse quadro em leitores de uma ortografia regular, como o português brasileiro. **Métodos:** Participaram do estudo 47 crianças com dislexia (GD), 41 crianças pareadas por idade (GCI) e 31 crianças pareadas por nível de leitura (GCL), e foram submetidas a uma bateria envolvendo tarefas que avaliavam as habilidades citadas acima. **Resultados:** Verificamos predomínio de alterações das habilidades de processamento fonológico no GD, não compatíveis com um desenvolvimento atrasado, mas sim com um desenvolvimento atípico. Nas tarefas de leitura e escrita, o GD apresentou pior desempenho desde as unidades mais básicas até as mais complexas em relação à leitura e escrita (letras, palavras e pseudopalavras, textos, respectivamente). Por fim, observamos prejuízo de outras habilidades de linguagem (processamento sintático e compreensão oral de sentenças), o que pode ser resultado de alterações nas habilidades fonológicas que influenciam o desempenho de habilidades linguísticas de maior complexidade. **Conclusão:** O perfil de alteração de habilidades fonológicas foi a principal dificuldade encontrada nas crianças com dislexia nesse estudo, sendo esse resultado compatível com investigações realizadas em outras línguas. Isso sugere que, independente da regularidade da língua, a avaliação das habilidades fonológicas é fundamental para o diagnóstico da dislexia.

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INTRODUCTION

The learning of reading and writing involve many factors, such as biological and cognitive, emotional, family, environmental, socioeconomic, and pedagogical. Therefore, it is a multidisciplinary interest theme, both in educational and clinical settings.

Most children learn how to read and write without any problem, however, some have difficulties in the acquisition and development of these skills. In the Brazilian population[1], 30–40% children in the first school grades have a difficulty. Besides that, the complaints on learning difficulties represent 35% of the reasons for pediatric appointments and are responsible for 45% of the care for mental health worldwide.

The recent National Survey by Household Samples (*Pesquisa Nacional por Amostras de Domicílios*)[2] identified that 8% children and teenagers between 4 and 17 years of age are out of school and 51% children in the third grade of elementary school are delayed in reading; of those, probably some of them have specific learning disorders, such as dyslexia.

Dyslexia is a severe and specific difficulty in reading acquisition, which is unexpected in relation to other cognitive and academic abilities. This difficulty cannot be attributed to sensorial or neurological alterations and it is estimated that about 3–7% population are affected by dyslexia[3-5].

In the cognitive level, there is a consensus that most individuals with dyslexia have what is commonly called "phonological deficit", that is, an alteration in some aspects of the representation or of the processing of speech sound. Evidence of this phonological deficit comes from three main behavioral symptoms: difficulty in phonological awareness, phonological operational memory skills, and slowness in phonological lexical access.

Recently, many studies have been investigating whether the same cognitive skills are involved in reading acquisition and dyslexia, in other languages and orthographies, since most findings are a result of the investigation with English readers and speakers. Some of the languages studied were Finish, Hungarian, German, French, Dutch, and European Portuguese. The findings showed that, in all those languages, the phonological awareness tasks and rapid automatic naming related both to the development of reading and dyslexia[3,4,6,7].

Thus, the objective of this study was to contribute to the understanding of dyslexia in Brazilian children, characterizing the language and cognitive skills profile, contributing thus for the diagnosis of this condition among regular spelling readers, such as the Brazilian Portuguese.

METHODS

Participants

To carry out this study, 110 children from the Learning Disorders Ambulatory from NANI (*Núcleo de Atendimento Neuropsicológico Infantil Interdisciplinar*) were evaluated. They were all submitted to the interdisciplinary evaluation covering neuropsychological, speech-language pathology, and psychopedagogical aspects. When there was a clinical indication, based on the previous evaluations, the child would also be submitted to family, psychological, psychiatric, pediatric, or neuropediatric evaluation.

From the sample described above, 47 children with dyslexia were selected (group dyslexia [GD]), both genders, aged between 8 and 14 years. The criteria for the diagnosis of dyslexia were persisting reading and writing difficulties from the beginning of literacy, peculiar changes in reading and writing accuracy, and slowness in reading speed. The exclusion criteria were presence of comorbidities (attention deficit disorder and hyperactivity, dyscalculia, specific language disorder, developmental coordination disorder); presence of motor and language disorders; neurological and/or psychiatric alterations; pre-, peri-, or post-natal complications that may cause neurological alterations; and birth before 36 weeks of gestation or weighting less than 2000 g.

Also, 78 children with good academic performance, divided into two control groups, took part in the study: control group by age (GCI), consisting of 41 children paired up by age, gender, and type of school; and control group by reading level (GCL), consisting of 37 children paired up by reading level from the reading subtest of the Academic Performance Index (API)[8], gender, and type of school. These children were used in this survey. The exclusion criteria were presence of language, motor, or emotional disorders; neurological and/or psychiatric alterations; pre-, peri-, or post-natal complications, which may cause neurological alterations; and birth before 36 weeks of gestation or weighing less than 2000 g.

All children in the study have total IQs above 90 and their legal guardians signed the informed consent. All procedures in this study were previously approved by the Research Ethics Committee, CEP 0251/06.

Procedure

Each of the children was evaluated with a survey consisting of tests and tasks involving oral, reading, writing language, and operational and episodic memory, held in 2 sessions of, approximately, 1 h each. The survey is described below.

Academic Performance:

- Academic Performance Index – API[8] consists of three subtests: writing, reading and arithmetics.

Oral Language

Semantic Component:

- ABFW Vocabulary Test – Child Language Test[9]: naming 118 figures.

Syntactic Component:

- Completing Sentences[10]: completing sentences presented orally by the evaluator.

Phonological Component:

- Phoneme Discrimination Test[10]: pairs of words children should inform whether they are different or not.

- CONFIAS – Phonological Awareness: Sequential Assessment Instrument[11]: composed by a syllable level (synthesis, segmentation, identification of the initial syllable, rhyme identification, production of Word with the syllable given, identification of the medial syllable, production of rhyme, and exclusion and transposition) and a phoneme level (production of word beginning with the given sound, identification of the initial phoneme, identification of the final phoneme, exclusion, synthesis, segmentation, and transposition).

Oral comprehension:
- Comprehension of sentences[12]: pointing out to the figure representing the phrase said orally.

Reading
- Naming of letters.
- Reading of words and pseudowords[13]: selected 15 high-frequency words, 15-low frequency words, and 15 pseudowords, all distributed evenlly in relation to the regularity and length (Appendix).
- Silent reading and aloud reading rate: silent reading of a text and another one out loud. There were texts ranging complexity levels for each series ("*As duas rãs*", "*O Diamante*", "*História de Assombração*", "*Os três irmãos*").
- Reading comprehension: after the reading of the texts in the previous test, questions regarding each of them were made and answered orally.

At the end, the mistakes in reading tasks are summed up, turned into percentage, and classified according to the following criteria: auditory mistakes (mistakes involving graphemes that represent phonemes and are distinguished by the voicing parameter; e.g.: p/b, t/d, c/g/, f/v, s/z, ch/j), visual mistakes (substitutions between graphemes that are visually spatially alike, e.g., p/q, m/n), omissions, inversions, and extras. Other errors are classified as "others" (e.g., pedagogical errors besides the ones without classification).

Writing
- Dictations of letters.
- Spelling of words and pseudowords[13]: selected 15 high-frequency words, 15 low-frequency words, and 15 pseudowords, all distributed evenlly in relation to regularity and length (Appendix).
- Thematic writing: writing of a story from a thematic figure.

At the end, the spelling errors in the writing tasks were also summed up, converted into percentage, and classified according to the following criteria: auditory substitutions, visual substitutions, spelling errors, omissions, inversions, additions, and others (as described above).

Memory

Phonological Working Memory
- Digits (WISC-III)[14] – direct order (evaluates the storage component of the operational phonological memory) and the reverse order (evaluates the component of manipulations of the phonological working memory).
- Pseudoword Repetition Test for Brazilian Children – BCPR[15]: consisting of 40 pseudowords.

Visual-spatial Working Memory
- Corsi Blocks – direct order (evaluates the storage components of the visual-spatial working memory) and the reverse order (evaluates the component of manipulation of the visual-spatial working memory): consists of a white board with nine blue cubes. The examiner points out to some cubes and the examinee repeats the movement made by the examiner in the same order. Then, the same thing is done, but the examiner must repeat the movement in an indirect order.

Semantic Memory
- Semantic Fluency: spontaneous production of words that belonged to certain semantic categories (animals and fruit), during 1 min.
- Phonological Fluency (F. A. S.): spontaneous production of words beginning with a given letter (F, A, and S), during 1 min.

Episodic Memory
- Logic Memory: it is an immediate and late recall (after 30 min) of a story told orally.

STATISTICAL ANALYSIS

The statistical analysis was carried out using a statistical SPSS package, Version 18. The significance level adopted was 5%.

For the analysis of the nominal variables, a χ^2-test was performed. For the numerical variables, initially we used the Levene test to verify distribution. When the variables had normal distribution, the analysis of variance (ANOVA) test was performed, with a later Tukey test. As for the variables that do not have normal distribution, the non-parametric Kruskal–Wallis test was carried out followed by Mann–Whitney for the later analysis, using the Bonferroni correction. Thus, the significance level was 2%.

At last, the discriminant analysis was performed to verify which variables best discriminate the groups.

RESULTS

The mean reading performance in the GD groups was compatible to the second grade of elementary school. The characterization of the sample is described in Chart 1. There was no difference between gender and the type of school (p=0.7). The GD and GCI have a higher age range in relation to the GCL, which were already expected for the accomplished pairing ($p \leq 0.001$).

In oral language tasks, we verified that the GCL had significantly lower performance than groups GD and GCI (p=0.02 / p<0.001) in the vocabulary task (semantic aspect). However, these data are expected within language development, since the GCL components are younger than the components of the other

groups. In relation to the task of completing sentences (syntactic aspect), the GD had a significantly lower performance than groups GCI and GCL (p<0.001 / p<0.001). In the oral comprehension of sentences task, both the GD and the GCL (p=0.001 / p=0.001) had a significantly lower performance than the GCI group. This result is also expected within the language development for the GCL, but not for the GD, which has the same mean age of the GCI.

No differences between the groups in phoneme discrimination were observed. As for the phonological awareness, involving the score of syllabic, phonemic tasks, and the general total; we verified that the GD presented significantly lower performance than the GCI (p<0.001 / p<0.001 / p<0.001) and GCL groups (p<0.001 / p=0.003 / p<0.001) and the GCL had a significantly lower performance than GCI group (p=0.003 / p=0.002 / p=0.001). Thus, the performance of the GD is worse than the GCL which, in turn, is worse than the GCI. This result is also expected within the development of language for the GCL, but not for the same mean age of the GCI.

Figures 1 and 2 presented the analysis of each task of phonological awareness, at the level of syllable and phoneme, respectively.

In Table 1 each reading and writing task is analyzed (reading of letters, words, pseudowords, and texts) and in Table 2 the types of errors made in all those tasks.

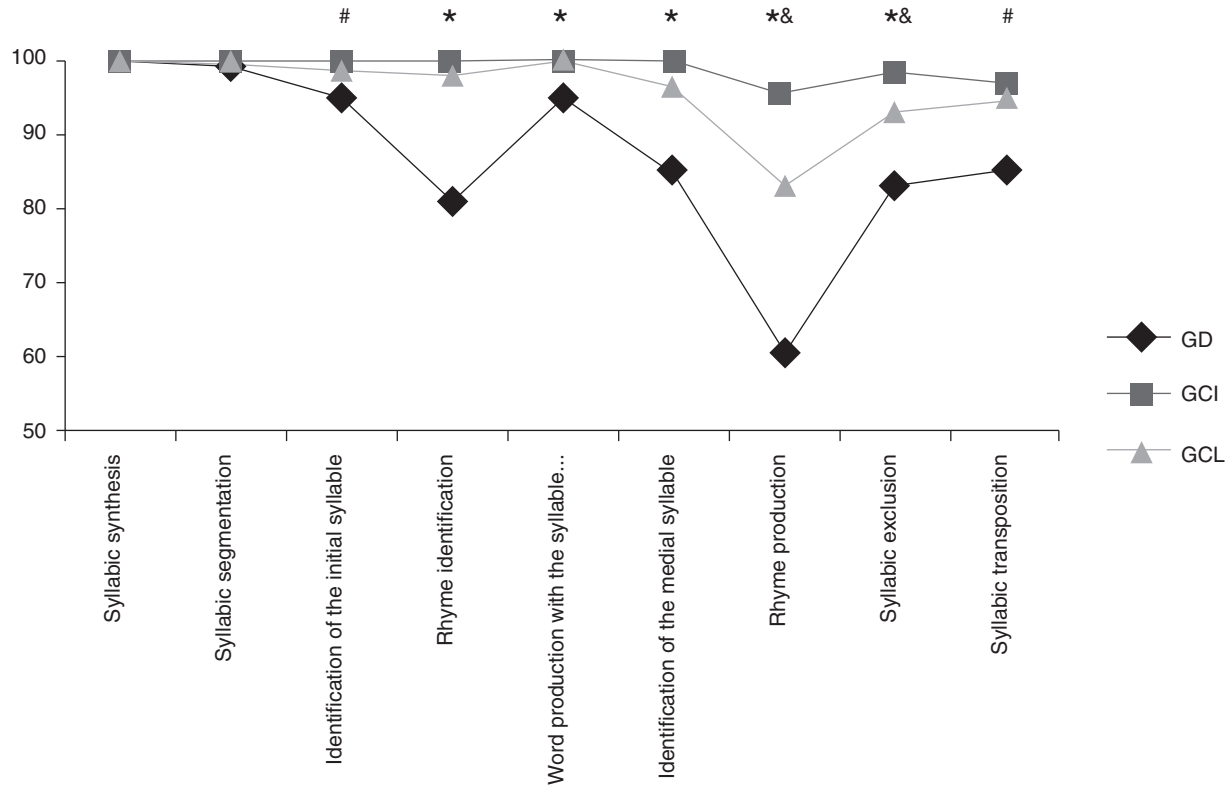
Table 3 describes the results of the visual–spatial phonological working memory tasks.

As for the semantic memory tasks, the GD had a worse performance than the GCI in all tasks, both semantic (animals and fruits: p<0.001) and phonological (F, p<0.001; A, p<0.001; S, p=0.001). The GCL also presented worse performance than the GCI in all tasks (animals: p=0.003 / fruit: p=0.001 / F: p<0.001 / A: p<0.001), with the exception of the letter "S" of the semantic task, considering these results are expected by the age difference.

In relation to the episodic memory task, we observed that the GCL had a worse performance in relation to the other two groups, both in immediate (GD: p<0.001 / GCI: p<0.001) and late recall (GD: p<0.001 / GCI: p=0.001), which is also expected by the age difference between them. It is noteworthy that the GD had the same performance than the GCI in this kind of memory.

Chart 1. Characterization of the sample according to the groups

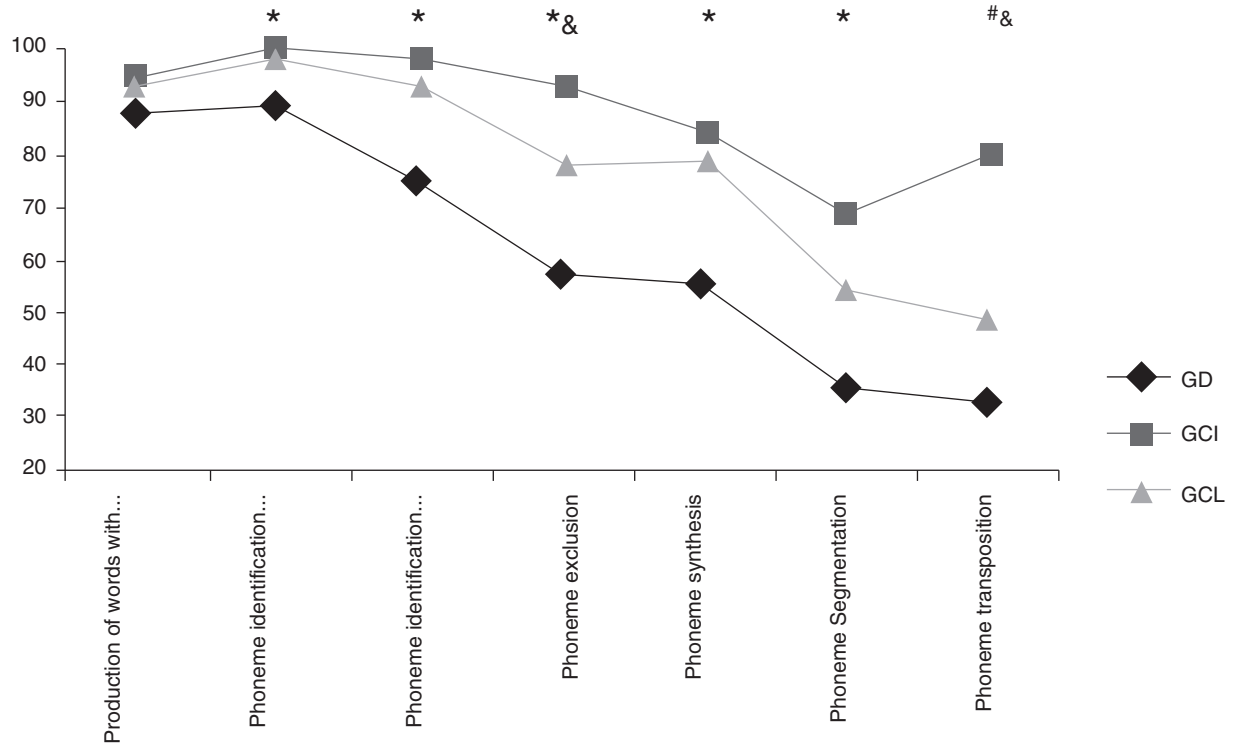
	GD	GCI	GCL
Gender			
Female	15	15	15
Male	32	26	22
Type of school			
Public	24	18	18
Private	23	23	19
Mean age (in years)	11.4 (±1.5)	11.4 (±1.6)	7.7 (±0.6)



#GD<GCI; *GD<GCI and GCL; &GCL<GCI

Figure 1. Mean percentage of corrects answers in syllabic tasks of phonological awareness

Finally, we presented the results of the discriminant analysis (Table 4), with the purpose of verifying which of the variables best discriminate the groups. Eight discriminant variables were found. The five first variables were the ones that the GD had worse performance in relation to the other groups. In turn, in the last 3 h, the GD showed adequate performance, that is the same as the GCI, but the GCL had a lower performance, since the mean age is lower than that in other groups.



*GD<GCI and GCL; &GCL<GCI; #GD<GCI

Figure 2. Percentage of correct answers in phonemic tasks of phonological awareness

Table 1. Mean correct answers and standard deviation in reading and writing tasks

	GD Mean(±SD)	GCI Mean(±SD)	GCL Mean(±SD)	*P*
Reading tasks				
Letters	24.9[b] (±1.8)	25.9 (±0.4)	25.8 (±0.6)	≤0.003
Words				
High frequency	12.3[b] (±3.4)	14.9 (±0.4)	14.5[a] (±0.9)	≤0.02
Low frequency	10.4[b] (±4.2)	14.9 (±0.4)	13.7[a] (±1.1)	<0.001
Pseudowords	9.2[b] (±3.9)	13.9 (±1.1)	12.9[a] (±1.1)	<0.001
Reading aloud				
Speed	41.2[b] (±19.3)	103.3 (±23.2)	84.8[a] (±30.0)	<0.001
Comprehension	7.0[b] (±2.9)	8.9 (±1.4)	8.6 (±1.1)	0.002
Silent Reading				
Speed	57.5[b] (±31.9)	136.7 (±50.2)	99.3[a] (±46.3)	≤0.005
Comprehension	4.3[b] (±3.3)	7.8 (±1.7)	6.2[a] (±2.5)	≤0.02
Writing tasks				
Letters	24.9[a] (±2.0)	25.9 (±0.4)	25.4[a] (±0.8)	≤0.001
Words				
High frequency	9.3[b] (±4.5)	14.9 (±0.4)	13.6[a] (±1.8)	<0.001
Low frequency	6.3[b] (±3.6)	13.2 (±1.3)	10.5[a] (±1.6)	<0.001
Pseudowords	7.3[b] (±4.5)	13.8 (±1.0)	12.1[a] (±2.0)	<0.001

[a]Statistically significant difference in relation to the GCI [b]statistically significant difference in relation to the other two groups.

Table 2. Mean error percentage and standard deviation in the reading and writing activities

	GD Mean(±SD)	GCI Mean(±SD)	GCL Mean(±SD)	p-value
Reading				
Auditory mistakes	3.8[b] (±4.8)	0.1 (±0.2)	0.3 (±0.4)	<0.001
Visual mistakes	0.5[a] (±1.3)	0.0 (±0.0)	0.2[a] (±0.4)	≤0.002
Omissions	3.4[b] (±4.2)	0.4 (±0.3)	0.7 (±0.6)	<0.001
Inversions	0.8[b] (±1.5)	0.02 (±0.1)	0.1 (±0.2)	<0.001
Additions	2.3[b] (±4.2)	0.5 (±0.4)	0.4 (±0.5)	<0.001
Others	10.8[b] (±12.3)	0.9 (±0.6)	2.6[a] (±1.9)	<0.001
Total	21.6[b] (±25.5)	1.9 (±1.1)	9.6[a] (±33.5)	<0.001
Writing				
Auditory mistakes	8.6[b] (±6.8)	0.5 (±0.6)	1.6[a] (±1.6)	<0.001
Visual mistakes	2.0[b] (±2.5)	0.1 (±0.2)	0.5[a] (±1.0)	<0.001
Orthographic errors	6.5[a] (±3.9)	1.5 (±1.3)	5.4[a] (±3.6)	<0.001
Omissions	10.2[b] (±9.7)	0.8 (±1.1)	3.6[a] (±3.2)	<0.001
Inversions	1.1[b] (±2.4)	0.02 (±0.2)	0.2 (±0.6)	<0.001
Additions	2.2[a] (±1.9)	0.7 (±0.9)	1.5[a] (±1.1)	<0.001
Separation and clumping of words	1.3[b] (±1.8)	0.3 (±0.6)	0.5 (±1.0)	<0.001
Others	17.5[b] (±19.4)	0.8 (±0.8)	4.3[a] (±3.7)	<0.001
Total	49.5[b] (±33.7)	4.6 (±3.1)	17.2[a] (±11.2)	<0.001

[a]Statistical significant difference in relation to the GCI; [b]statistical significant difference in relation to the other two groups.

Table 3. Mean correct answers and standard deviation in the working memory tasks

	GD Mean(±SD)	GCI Mean(±SD)	GCL Mean(±SD)	p-value
Phonological working Memory				
BCPR				
2 syllables	9.6 (±0.6)	9.9 (±0.5)	9.9 (±0.4)	0.6
3 syllables	9.3 (±0.6)	9.6 (±0.6)	9.5 (±0.8)	0.6
4 syllables	8.9[b] (±1.2)	9.5 (±0.6)	9.5 (±0.7)	≤0.02
5 syllables	7.7[b] (±2.1)	9.2 (±1.3)	8.8 (±1.1)	≤0.02
Total	35.5[b] (±3.3)	37.4 (±4.7)	37.7 (±1.8)	≤0.002
Digits				
Direct Order	4.4[a] (±0.8)	5.3 (±1.1)	4.5[a] (±0.6)	≤0.001
Indirect Order	3.2[a] (±0.9)	3.9 (±0.7)	3.4[a] (±0.8)	≤0.002
Visual-spatial working Memory				
Corsi Blocks				
Direct Order	5.1 (±1.3)	5.3 (±1.0)	4.5[b] (±0.9)	≤0.009
Indirect Order	4.7 (±1.2)	4.6 (±1.0)	4.1[b] (±0.9)	≤0.01

[a]Statistically significant difference in relation to the GCI; [b]statistically significant difference in relation to the other two groups.

Table 4. Discriminant analysis

Variables	GD		GCI		GCL		p-value
	Mean(±SD)	Fisher Coefficient	Mean(±SD)	Fisher Coefficient	Mean(±SD)	Fisher Coefficient	
Auditory mistakes in Reading	3.8 (±4.8)	8.1	0.1 (±0.2)	7.8	0.3 (±0.4)	7.1	<0.001
ABFW vocabulary	108.7 (±6.5)	5.4	110.5 (±3.7)	5.2	105.9 (±4.9)	5.1	<0.001
Low frequency Words writing	6.3 (±3.6)	1.9	13.2 (±1.3)	3.2	10.5 (±1.6)	2.5	<0.001
Corsi OI	5.1 (±1.3)	-1.9	5.3 (±1.0)	-3.4	4.5 (±0.9)	-3.3	<0.001
Completing sentences	14.5 (±3.6)	0.5	17.9 (±2.1)	0.8	18.0 (±1.8)	1.0	<0.001
Formal writing aspects	6.6 (±1.6)	-0.2	9.0 (±1.2)	0.4	6.4 (±2.0)	-0.5	<0.001
Aloud reading speed	41.2 (±19.3)	-0.2	103.3 (±23.2)	-0.1	84.8 (±30.0)	-0.1	<0.001
Immediate recollection of Story	21.2 (±4.6)	0.2	21.1 (±3.7)	0.02	16.8 (±5.5)	-0.2	<0.001

DISCUSSION

The objective of this study was to contribute to the understanding and the diagnosis of dyslexia among Brazilian children.

We verified that skills of phonological processing are hindered in the GD, especially in higher demand tasks. This is also due to the fact that the mean age is higher and the older children having already overcome difficulties within lower demand tasks, as in cases of phoneme discrimination, in which we did not observe differences between the groups. However, this task cannot be sensitive, for it allows the child to use their semantic and orthographic representations as a support[16]. Thus, the task that has proven itself sensitive in order to evaluate this skill is the phonological awareness, encompassing all levels of complexity (syllables and phoneme).

This was also seen in studies involving several languages, highlighting the importance of performing tasks of phonological awareness for the evaluation of dyslexia in alphabetic orthography, regardless of the orthographic consistency of its writing system[4,6,7,17].

Other tasks involving skills of the phonological processing and which are altered in the GD are the ones involving the MOF. In this one, once more it was observed that children with dyslexia are hindered in higher demand tasks, since in the Direct and Reverse Digits Order Test, they had worse performance than the GCI; and in the BCPR test, the performance was worse than in the two control groups, especially in the repetition of longer words (four and five syllables), which overload the memory system. Thus, these results confirmed that the repetition of pseudowords require a brief storage of unfamiliar phonological forms and, therefore, the subjects have to trust the ability of their phonological memory to decode and maintain the new phonological sequence for repetition, considerably more sensitive for the evaluation of the learning disorders[15].

In addition to that, the GD presented AA performance equal to the one of the GCI in the task involving the visual-spatial working memory skill (Corsi Blocks); and the GCL had worse performance than in the GD and GCI groups following the development pattern. Therefore, the model of affected working memory is domain-specific, that is, involving the storage and manipulation of verbal material, but not visual-spatial[18,19].

In the evaluation of the oral language, we could verify that the GD showed no difference between the control groups regarding vocabulary (semantic aspect), considering that it is still verified that dyslexics are based more in the semantic representation and in the semantic context for comprehension[20].

As for the syntactic (completing sentences) and oral comprehension (oral comprehension of sentences) aspects, the GD showed difficulties. However, it is possible that there is no specific deficit of these skills, but instead a reflex of the low performance in the phonological processing, since this would hinder the maintenance of the phrase and, consequently, its analysis for performing the activity[20].

When we observed the reading profile of the GD, we noticed difficulties from the most basic to the most complex units, that is, from letters to texts. The most important here is the fact that the GD not only has a worse performance than the GCI, but also that than the GCL. Therefore, children with dyslexia have a performance consistent with the disorder, once they have a different profile from children of their age and reading level[21,22].

Our results also meet other studies, which verified the importance of evaluation since the recognition of letters[3,23]. The knowledge of letter names strongly correlates with the initial progress in reading and writing. A reason for this is that letter names have the sound that it represents in the words, which may help the child to learn to correspond letters and sound and to read through phonological decoding. As a consequence, the learning of letter–sound correspondences becomes easier. However, the knowledge of the letter may suffer variations according to the abilities of the MOF, especially in its acquisition and of the long-term memory (lexical access) of the child. Therefore, if the learning of the name of the letters is not yet consolidated, it is one more factor to reveal the difficulty of the GD with the phonological aspects involved in reading and writing[24].

Regarding the reading of words, many studies have already reported higher impairment of children with dyslexia with the recognition of low-frequency words and pseudowords, as observed in this study. However, we also verified difficulties with high-frequency words. This suggests that the orthographic-lexical rout is also impaired. A possible explanation for that is the phonological processing presented by children with dyslexia results in flaws in the activation of the phonological route, which has always contributed for the visual recognition, even of high-frequency words. In normal learning, the practice of reading allows children the opportunity to visually familiarize themselves and memorize the words in the language. The child develops ability for self-teaching and, the more they read, the higher the possibility of learning new patterns of representation of the orthographic lexicon[24]. With the increased reading competence and the orthographic and semantic lexicon, the reading becomes rapid and automatic. Thus, if the grapheme–phoneme association is defective, the whole reading development process is compromised[22].

However, this reading profile can be best explained by the interactive reading model[25]. This is because, when the word is being processed in the orthographic processor, a stimulation is sent to the corresponding units of the phonological processor. If the sequence is pronounceable, then the phonological processor sends back the information that will contribute for the decoding of the written word. Therefore, the phonological processor provides an alphabetic support system, indispensable for the maintenance of speed and for the accuracy of word recognition necessary for the reading, for the words individually, essential for the comprehension of the text. Thus, according to the interactive model, all words are read with the help of the phonological processor. The only difference is that in the low-frequency items, there would be no help from the semantic or orthographic processor as in the high-frequency ones, which makes the reading of these words even more difficult.

As for the reading speed of the GD, it is inferior to the other two control groups, both in silence and out loud. This may be explained by the deficit in phonological abilities, which hinder and slow down the decoding of words. Furthermore, as

previously stated, the lexical route is also impaired, which makes reading even slower.

The performance in reading comprehension of the GD was also worse than the performance in both control groups, in both reading types, which may be a consequence from both the difficulty in decoding words and the alteration of the MOF. The GCL had a performance lower than in the GCI only in the silent reading comprehension. One hypothesis for that is, in reading aloud, we can also hear what we are reading and use one more sensory pathway, promoting understanding. In silent reading, there is no such support and the comprehension would be more difficult.

When analyzing reading mistakes, the GD showed a higher number in relation to the two control groups in all kind of mistakes, with the exception of the visual trades, which had a higher number then the GCI. This shows that, besides the difficulty and slowness in decoding words, the dyslexic children have many mistakes, more than the children in the GCL.

When we observe the writing performance in the GD, we verify that those children also have difficulties from letters to the writing of texts. However, in relation to letters, the GD did not show difference regarding the GCL, and both groups had lower performance than the GCI. This may suggest that, for the children in the GD, it is harder to evoke the name of the letters in reading than to remember their written form after hearing the name of the letter. As for the dictation of words, the GD also presented an inferior performance than the two control groups, both for the high- and for the low-frequency words and pseudowords. The changes in writing, or dysorthographies, are part of the dyslexia condition, once the deficiency of the phonological system causes alterations in the grapheme–phoneme conversion[22]. This way, the misspellings are due to difficulties in establishing and orthographic visual lexicon, presenting typical symptoms such as substitution, omission and inversion of graphemes, changes in word segmentation, persistence of the support on oral languagge, and difficulty in producing texts[26]. Therefore, we may suggest that the difficulties in writing are due to flaws in both the phonological and orthographic processing.

In relation to the types of writing, the GD had higher number of mistakes than in the two control groups as for the hearing and visual trades, omissions, inversions, separations and clumping of words, and others. In mistakes such as orthographic trades and additions, the number was higher than in the GCI. Most mistakes observed in this study are reported by several authors[22,27]. All these mistakes would be justified by the dysorthographic description mentioned above. One may also, still, group the mistakes found in dyslexia into three groups: errors due to changes in the phonological, orthographic, and visual processing. In this study, we found more mistakes due to flaws in the phonological processing and, then, due to difficulties in the orthographic processing, as well as the other data in the literature[27].

Therefore, as well as in reading, the GD has a different profile than the one it would be expected in younger children and in the beginning of the literacy process, for it shows a worse performance than the GCL, reinforcing that the profile of the disorder involves, also, the writing.

We observed difficulties in the verbal fluency task, both semantic and phonological, in the GD in relation to the GCI, as well as in other studies[28,29]. This task involves the fast access to the lexicon and may be influencing the worse performance of dyslexics, as already mentioned in other researches in several languages[4,6,7].

From the discriminant analysis, we were able to confirm the importance of the complete evaluation of the reading skills, specially the reading speed and the analysis of the kinds of mistakes. Besides that, the writing of words was also proven to discriminate the groups.

Other results to be stressed with the analysis were some variables in which the group of dyslexic children had adequate performance for their age, were also important in order to differentiate the groups (vocabulary, indirect Corsi order and immediate recollection of the story).

CONCLUSION

We concluded that there is a predominance of alterations in the skills of phonological processing in the GD, and which are not compatible with a delayed development, but instead as an atypical development, since the children with dyslexia have lower performance than the GCL in these abilities. This may be observed in phonological awareness tasks, phonological working memory, and rapid lexicon access (verbal fluency task). As a consequence, the development of both reading and writing is affected, considering that this patterns remains among older children.

Another important finding is that tasks of vocabulary and low demand phonological abilities (phoneme discrimination) were not relevant to determine the diagnosis of dyslexia. On the other hand, more complex tasks involving from the most basic units to the most complex reading and writing (letters, words and pseudowords, and texts) are indispensable for the diagnosis of dyslexia.

Finally, we observed hindering of other language skills (syntactic and oral comprehension of sentences), which may be the result of changes in basic linguistic skills that alter higher complexity skills. Other more specific studies must be carried out in order to better understand this aspect.

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APPENDIX

Words selected for the reading and writing tasks.

Reading

Low frequency words

Regular	Irregular	Regra
1. Isca	6. Boxe	11. Nora
2. Malha	7. Luzes	12. Vejam
3. Olhava	8. Gemido	13. Inglês
4. Chegada	9. Higiene	14. Receita
5. Medalha	10. Cigarro	15. Quietos

High frequency words

Regular	Irregular	Regra
1. Duas	6. Hoje	11. Gato
2. Chuva	7. Feliz	12. Papel
3. Depois	8. Amanhã	13. Gostou
4. Sílabas	9. Fazendo	14. Escreva
5. Palavras	10. Dezena	15. Pássaro

Pseudowords

Regular	Irregular	Regra
1. Puas	6. Himo	11. Gavo
2. Chuda	7. Saliz	12. Nabel
3. Pelois	8. Atanhã	13. Vestou
4. Vídacas	9. Razenco	14. Estreca
5. Posdava	10. Xeribe	15. Tavinha

Dictation

Low frequency words

Regular	Irregular	Regra
1. Vila	6. Hino	11. Unha
2. Marca	7. Órgão	12. Facão
3. Brigas	8. Xerife	13. Empada
4. Batalha	9. Admirar	14. Marreca
5. Chupeta	10. Tigela	15. Florido

High frequency words

Regular	IRREGULAR	REGRA
1. Fala	6. AZUL	11. CASA
2. Porta	7. HOMEM	12. NOITE
3. Letra	8. CABEÇA	13. COISAS
4. Gostava	9. CRIANÇA	14. GALINHA
5. Colegas	10. FAZENDO	15. REDAÇÃO

Pseudowords

Regular	Irregular	Regra
1. Isda	6. Foxe	11. Lora
2. Nalha	7. Ezal	12. Pejam
3. Vesta	8. Genico	13. Inflês
4. Chepala	9. Nezema	14. Neceida
5. Devalha	10. Ciparro	15. Quiados