ISSN: 2573-9565

Research Article

Journal of Clinical Review & Case Reports

Neuropsychological Correlates of Reading and Writing in Brazilian Children with Developmental Dyslexia

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Submitted: 17 Mar 2019; **Accepted**: 22 Mar 2019; **Published**: 08 Apr 2019

Abstract

Due to the close relationship between reading and quick naming, people with developmental dyslexia (DD) would have difficulty reading words accurately and quickly, writing by phonographic coding and reading by grapheophic decoding. Cognitive abilities of reading and writing were evaluated in two groups of primary school students: 23 with DD and 23 with typical development (DT) of the state of São Paulo, Brazil. The Reading Age Test (TIL), the Rapid Automatized Naming (RAN) test and the writing subtest of the 3DM Battery were used. There was a high association and similarity ($p < 0.01$) between TIL (total of correct answers, sentence read per second and final note) and RAN (time to recognize the stimuli). DT read 80.6% of sentences, scored 75%; the DD read 50% and hit 44.4%. DT obtained better performance in the time variable for all RAN stimuli. The stimulus "Letters, numbers and Colors" revealed a greater distance of result between the groups, with difference of 21,14 seconds. DT obtained better performance for the writing test (8.7 errors, $\sigma = 2.7$; 5.5 hits, $\sigma = 2.8$) than the DD (15.5 errors, $\sigma = 5.7$; 47.3 hits, $\sigma = 6.2$). Of the 357 errors, DD presented a higher incidence of errors in words with irregular grapheme-phoneme correspondence (186), complex graphemes (72), contextual grapheme-phoneme (56) and simple grapheme-phoneme (48). The DD revealed inferior performances compared to the DT and difficulty in reading gramophonetically irregular words, speed, accuracy and fluency, expressing significant difficulty in accessing the lexicon. The phonological component didn't reveal to be the central cause of deficits for children with DD in this study, suggesting that the deficit in visual and visual-orthographic attention interacts with language problems, causing reading deficits even before access and phonological recovery.

Keywords: Developmental Dyslexia, Reading,Writing, Rapid Automatized Naming

Introduction

Developmental dyslexia-DD presents multiple disorders and subtypes, revealing difficulties in defining or having conclusions about the nature of this disorder [1]. The actual approachsabout the DD have not yet stablished a consensus about the cases, diagnostic and strategiesof treatment, having the deficiencies of reading experience the main reasonfor the desagree about the cases of dyslexia [2, 3].

The DD variesbetween light and serious and not even have the same manifestation, since that different individuals may have various symptoms of DDin varying degrees [4]. However, the various casesfound for dyslexia and, therefore, the variabilityof the secondary symptomswould not be an inconvenience, but developerto informthe diagnosis and appropriate treatment when approachedin a interdisciplinary perspective [2].

Children with dyslexia have perceptual abnormalities, phonological processing deficits, spelling and phonological connections or limitations of fluency, such as automaticity, executive coordination and speed, presenting poor phonological awareness, impaired phonological memory, deficit in speech processing and difficulty in sequencing and automatic cognitive processing that understands the difficulty in learning to read depending on cognitive difficulties of constitutional and functional origin, and a suspension or deceleration in the normal sequence of acquisition of the different procedures of word identification [5-9].

Authors of cognitive psychology and neuroscience have conducted studies and found that the deficits of people with RD developmental dyslexia are lexical, especially in the appointment of objects and concepts, expressing difficulties in reading words accurately and quickly, suggesting a close relationship between reading and rapid appointment; this is considered as a precursor of reading [4]. In addition to presenting memory deficits and storage capacity lower than typical readers, indicating that language and phonemic awareness are important factors for the development of cognitive skills related to reading ability, as well as for the etiology of DW [10-12].

Due to the contributions of the various researches carried out in this area, the current understanding of dyslexia is that it is a specific

learning disability of neurobiological origin, characterized by difficulties with precision and/or recognition of fluent words and by poor spelling and decoding skills, resulting from an unexpected deficit of the phonological component of independent language of school instruction [13].

Materials and Methods

Cognitive reading and writing skills were evaluated in two groups of elementary school students: 23 with developmental dyslexia (DD) and 23 with typical development (DT) between 9 and 14 years of age with a mean age of 12 years with standard deviation of 1.46 from public and private schools in the state of São Paulo, Brazil. The children diagnosed with DD were evaluated by the Brazilian Association of Dyslexia - ABD through a multidisciplinary team composed of speech therapists, psychopedagogues, psychologists and neuropsychologists. The children in the control group were indicated by their selected teachers based on: school performance, no complaints of learning disorders, brain injuries, somatic or psychiatric condition, behavior disorders and phonological disorder and/or phonological intervention. And they were subjected to the same battery of cognitive characterization tests and confirmation of being children with typical development.

The Reading Age Test (TIL), the Rapid Automatized Naming and Rapid Alternating Stimulus Tests - RAN/RAS and the Writing Subtest of the 3DM Battery were applied to this study. The Reading Age Test -TIL (Sucessa & Castro, 2006) built from the French test Lobrot L3 (1973) validated for Portuguese children and adapted to Brazilian Portuguese consists of silently reading 36 isolated and incomplete sentences where the child must select an option among the five existing options, underlining an adequate word to complete the sentence. Among the correct options there are four distratores, (1) without any similarity to the target word (SQS); 2) visually close to the target word (VP); 3) phonologically close to the target word (FP); (4) semantically close to the correct word (SP) that occupy different positions throughout the 36 test sentences, corroborating so that the child actually reads all the words and options and uses the decoding and understanding skills.

Rapid Automatized Naming and Rapid Alternating Stimulus Tests - RAN/RAS [14]. Participants are invited to read aloud the stimuli presented in the Ran test (object, colors, letters and numbers) and in the RAS test (letters and numbers, and letters, numbers and colors) are composed of five high frequency stimuli that are randomly repeated ten times in a matrix of five lines, totaling fifty items for each stimulus.

And the Maastricht-3DM Differential Diagnostic Dyslexia Battery writing subtest Blomert & Vaessen, 2008, validated for Portuguese from Portugal by Reis, Castro, Inácio, Pacheco, Araújo, Santos, et. al. 2011, adapted for Brazilian Portuguese (corpus linguístico de Pinheiro, 2015) according to procedures used by Reis and collaborators (2011). This subtest is composed of 64 words written in lowercase letters, presented one by one in auditory and visual format simultaneously. In the visual format part of the word to be exposed is incomplete, represented by a dash, aiming at the participant choosing the missing part of the word. The four options were: correct answer; visual distrator with changed letters; phonological distrator with exchange of phonologically close consonants; and the filler option where all letters were different from the correct one.

The missing part of the word was organized into four levels: Level 1: simple phoneme-grapheme correspondence; Level 2: correspondence to complex graphemes; Level 3: contextual phoneme-grapheme correspondence; and Level 4: irregular phoneme-grapheme correspondence. Each level with sixteen items divided into eight high-frequency words and eight low-frequency words, controlled in terms of number of syllables, syllable structure and position of the omitted syllable (beginning, middle and end). The task was programmed and executed by means of the "presentation" software, installed on a laptop computer (lap top), software developed by Neurobehavioral Systems.

The tasks were applied individually and within the ABD for children with DD and within the school space for children with DT. The room selected for the application of the tasks was appropriate, free of distractors such as noises or visual stimuli that could attract the child and blur their attention from the activity. With the purpose of verifying how the variables behave and of diagnosing with greater propriety the effect of the factors and relationships expected for this study, the participants were grouped according to school network, Basic Education Development Index (IDEB) of the school, gender, age, education.

Results / Discussion

In similarity with the results of the researches found in the literature, the data obtained in this study also revealed inferior performances for the DD group when compared with the TD in relation to the three tests applied. In the RAN/RAS test, children with DD had difficulties in reading words with precision and speed and, consequently, lower reading speed, because the group with DD tended to have lower performances, suggesting a close relationship between reading and rapid appointment.

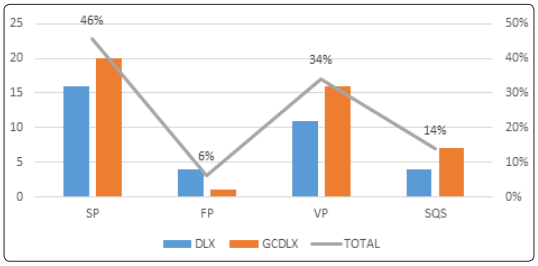
It was observed that being older or younger was not a determining factor in obtaining the results of the TIL, because the correlations between the results presented and the age of students did not exceed $(\rho)|0.10|$, suggesting that the variable age did not influence the results. In the same way, the schooling variables and the type of education network showed very weak correlations, lower than $(\rho)<|0.15|$.

The comparative study carried out between the two groups revealed that the number of sentences read was lower in the DD group, because of the 36 sentences presented the DT group, on average, could read 29 (80.6%) and hit 27 (75% of the total and 94% of the readings), resulting in a score of 76 on a scale from 0 to 100. In turn, the DD group obtained the following average results: read 18 sentences (50%), hit 16 (44.4% of the total and 90% of the readings), obtaining a score of 44. The result of the application of the t-test revealed the level of significance ($P < 0.05$) that there was a significant difference in the performances presented by the groups.

Among the types of errors, it was found that the DD group presented more phonological errors (4) than the DT group(1), but the difference for this type of error was not significant between the groups. There was also no significant difference between the types of errors presented within the group with DD, revealing that phonological deficit for this group would not be the central cause for lower performance when compared to the DT group. The greatest incedence was for SP and PV errors, respectively. And even if the SP type error involves, to a certain extent, the meaning of the word related to spelling and pronunciation, the importance of the role

of visual perception and visual attention for reading difficulties was highlighted (Sigurdardottir, Danielsdottir, Gudmundsdottir, Hjartarson, Thorarinsdottir & Kristjánsson, 2017).

Test TIL



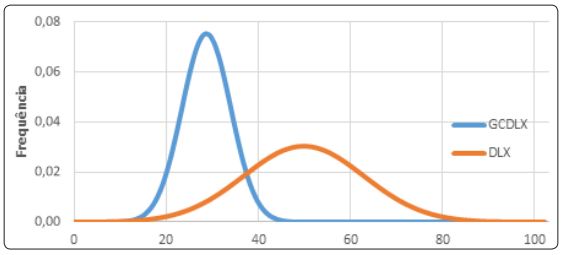
DLX: developmental dyslexia group. **GCDLX:** control group

Type Erros for the RAN/RAS test it can also be observed that there was no interdependence between the results and the variables age (ρ)<|0.20|, education (ρ)<|0.120| and type of school network (ρ)<|0, 16|, because they resulted in weak correlations. As expected, the DT group, when compared to the DD group, obtained the best performance for the "time" variable in all six tests.

It is noteworthy that for both groups the stimulus Color (μ:61.50 for the DW and μ:40.48 for the DT), followed by the stimulus object (μ :53.37 for the DW and μ :37, 89 for the DT) were the ones that demanded more time for appointment. On the other hand, the number stimuli (μ:36.65 for the DW and μ:24.47 for the DT) and Letter (μ: 38.77 for the DW and μ: 24.69 for the DT), respectively, were those that required the least time to perform the test and the performance of the groups showed significant differences. These findings suggest that the visual discrimination and identification of letters and patterns of letters are linked both to visual processes and require the subject to integrate the visual resource with spelling and phonological resources [14].

As for the mean time of performance of the SAN test, which directs attention to contextual patterns when performing the task of rapid appointment composed of letters, numbers and colors, differentiated the groups and presented the greatest distance of result between the two groups of subjects, with a difference of 21.14 seconds. The types of errors in the appointment were categorized into visual, attentional, visual and phonetic. There were no phonetic errors, however, the attentional errors were evidenced in all stimuli, more intensely in the color stimulus. On the other hand, visual errors only appeared in stimuli where there were letters, either alone or in combination with other stimuli, such as in the RAS test (letters and numbers; letters, numbers and colors).

RAS
stimulus letters, numbers and colors



DLX: developmental dyslexia group. **GCDLX:** control group

Time

Such findings suggest deficits in the visuoperceptual functions for the DD group, since subtle difficulties in visual attention may occur, even though the central deficit of dyslexia tends to be the phonological deficit of speech sound processing and its mental representation, revealing that speech representations preserve much more than phonemes and, therefore, that phonological development in DW is not restricted to phonemic representations, suggesting other dimensions of speech flow, such as the deficit in visual attention. And even if this is not responsible for the early speech/language phenotype, it may represent an additional cognitive difficulty that would interact with language problems to cause reading failures [15, 16].

Of the total of 64 responses to the 3DM battery writing subtest, DT performance (μ:55, σ=2.8; μ:8.7 errors, σ=2.7) was higher than DD (μ: 47 grafts, σ = 6.2; μ:15,5 errors, σ = 5.7). It was found that the TD data are more homogeneous when compared to the DD group. In the composition of the 584 total errors recorded, type N4 error showed a higher incidence with 341 cases, followed by type N2 with 95, then N3 with 82, and finally 72 type N1 errors. To a large extent, this composition follows the behavior of the DD group, whose N4 type error presents the greatest quantity, followed by the N2 error, then N3 and N1. And when compared to the DT group (N1:24; N2: 23; N3: 26; N4: 155), the DD group (N1:48; N2: 72; N3: 56; N4: 186) presented quantitatively more errors at all levels for this test. In this test there was also a significant difference between the types of errors revealed by the groups. The high association and similarity (p <0.01) between the TIL test (total of correct answers, sentence read per second and final score) and RAN (time of recognition of stimuli and item read per second) stands out.

The performance in the writing subtest of the 3Dm battery differentiated the groups since the DT group presented higher scores of correct answers and lower scores of errors than the DD group. Irregular graphema-phonema-matching error had a higher incidence, followed by complex graphematching, indicating the existence of difficulty in reading words when the spelling for the sound is irregular, characteristic of selective difficulty in using the lexical procedure, due to difficulty in recognizing whole words [1].

The age and level of education of the participants were not determining factors in obtaining the results for all the tests applied, suggesting that children with dyslexia, despite the years of schooling and relative improvements in performance after intervention processes, tend not to catch the typical readers [17-19].

Conclusion

As expected, the DT group when compared to the DD group obtained better performance in all applied reading and writing tests, confirming the significant difficulty of children with DD with reading and writing, specifically to read words accurately and quickly when compared to children with DT, suggesting a close relationship between reading and rapid appointment. However, the phonological component did not reveal to be the central cause of deficits for children with DD in this study, indicating that the deficit in visual and visual-orthographic attention may be difficult that would interact with language problems causing reading deficits before access and phonological recovery.

Acknowledgement

Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - CAPES

Associação Brasileira de Dislexia – ABD

ToRonald Nascimento da Silva

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