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Occurrence of reading and writing cognitive processes and perception visual skills in students with Visual Dyslexia

Ocorrência dos processos cognitivos de leitura e escrita e habilidades perceptovisuais em escolares com Dislexia Visual

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Keywords

Dyslexia
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ABSTRACT

Purpose: to evaluate and classify visual dyslexic students, considering that developmental dyslexia subtypes are not differentiated in most diagnoses and that they affect a generalized approach. **Methods:** Cross-sectional, observational, analytical study composed of 80 students, divided into two groups, GA (dyslexics) and GB (without complaints of learning difficulties) using PROLEC (proof of assessment of reading processes), TVPS – 3 (Visual Test of Perceptual Skills) and TPMBO (Bruininks-Oseretsky Motor Proficiency Test) - subtests 7 and 8. **Results:** Comparing the groups, the students of GA presented inferior performance in all the PROLEC tests and in the TVPS3 tests. The TPMBO tests of visuomotor coordination and manual dexterity tests were inferior. In a second stage, screening the visual dyslexics, 12 (30%) schoolchildren were found, who presented better performance in reading frequent words, when compared to the performance in reading infrequent words and pseudowords. In the visual perceptual skills (TVPS-3), they obtained values below 50%, except for the subscale constancy of form. The occurrences of exchanges in reading aloud were in confusion of letters, syllables or words with little difference in the way of writing, but different in the direction, the same students did not present exchanges or confusions between letters, which have the same point and manner of articulation, and whose sounds are acoustically close. **Conclusion:** Thus, characterizing the dyslexia subtype is fundamental, because the application of therapeutic techniques will depend on the correct focus of the observed changes. Therefore, an accurate and multidisciplinary diagnosis is required.

Descritores

Dislexia
Leitura
Escrita
Percepção Visual
Estudantes

RESUMO

Objetivo: Avaliar e classificar escolares disléxicos visuais, considerando que, subtipos de dislexia do desenvolvimento não são diferenciados na maioria dos diagnósticos e que os mesmos incidem em uma abordagem generalizada. **Método:** Estudo transversal, observacional, analítico composto de 80 escolares, divididos em dois grupos, GA (disléxicos) e GB (sem queixa de dificuldade de aprendizagem) aplicando o PROLEC (prova de avaliação dos processos de leitura), o TVPS–3 (Teste Visual de Habilidades Perceptuais) e TPMBO (Teste de Proficiência Motora de Bruininks-Oseretsky) – subtestes 7 e 8. **Resultados:** Comparando os grupos, os escolares do GA apresentaram desempenho inferior em todas as provas do PROLEC e no teste do TVPS−3. A execução nos testes de coordenação visuomotora e destreza manual do TPMBO foram inferiores. Em uma segunda etapa, triando os disléxicos visuais foram encontrados 12 (30%) escolares, que apresentaram melhor desempenho na leitura de palavras frequentes, quando comparados ao desempenho na leitura de palavras não frequentes e pseudopalavras. Nas habilidades perceptuais visuais (TVPS-3), obtiveram valores abaixo de 50%, exceto na subescala constância de forma. As ocorrências de trocas na leitura em voz alta, foram em confusão de letras, silabas ou palavras com pouca diferença na forma de escrever, mas diferentes na direção, os mesmos escolares não apresentaram trocas ou confusões entre letras, que possuem mesmo ponto e modo articulatório, e cujos sons são acusticamente próximos. **Conclusão:** Assim caracterizar o subtipo da dislexia é fundamental, porque a aplicação das técnicas terapêuticas, dependerá do correto enfoque das alterações observadas. Portanto, é necessário um diagnóstico exato e multidisciplinar.

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INTRODUCTION

Developmental dyslexia is a Specific Learning Disorder of written language, of neurobiological origin and with a strong genetic tendency[1]. It is characterized by deficits in accuracy and/or fluency, in the recognition of written words that may or may not compromise, to varying degrees, reading comprehension, in addition to spelling that is also impaired[2]. It results from a deficit in the phonological component of language, persistent until adulthood[3].

Current estimate suggests that dyslexia affect between 3 and 10% of school-age children[4]. According to Friedman and Miyake[5], the highest incidence is in males. In clinical samples this proportion was verified more frequently (3.5 to 4.0 boys for a girl) than in family samples (1.5 to 1.8 boys for a girl). In terms of prevalence, this varies both nationally and internationally. In Brazil, Ciasca et al.[6] proposed that this condition may affect 5 to 15% of the general school population, while another study[7] found that only 1.3% of children with complaints of learning difficulties were diagnosed with dyslexia, with no difference between genders being verified.

There is a consensus in the literature regarding the deficits in phonological processing[8]. This cognitive processing allows the child in the early reading stage to understand the alphabetical principle and to be able to perform grapheme/ phoneme relationships. This mechanism becomes automated, allowing the reader to use cognition for more complex processes, related to the comprehension of texts[8,9]. However, in developmental dyslexia, this automatic process is impaired, impacting the accuracy and speed in word recognition[9].

Current studies in neuroscience have proven the theory[10,11] that the use of functional magnetic resonance allowed us to observe that the areas of phonological processing are hypoactivated, as well as the visual processing region, which becomes responsible, through brain plasticity, for the recognition of letters[11].

Research suggests that a deficiency in phonological processing is implicit in the reading difficulties of individuals with developmental dyslexia, and several explanations have been proposed, including deficits in phonological awareness and verbal memory[9].

With regard to interventions, the dyslexic responds slowly to specific therapeutic and educational interventions, and the prognosis depends on several facilitating factors such as: intellectual level, early diagnosis and family and school support[12].

As for the diagnosis, this occurs according to the criteria used based on speech, diagnostic, pedagogical and psychological diagnostic tests, and one of the forms accepted by the authors is the one that privileges the visual and auditory perceptions and memories[10,11].

Ellis[13] mentions in relation to the classification of developmental dyslexia, which manifests itself in three subtypes, the phonological subtype resulting from a dysfunction in the region of the upper temporal gyrus and temporo-parietal regions that cause changes in auditory processing. What supports the phonological deficit theory is the hypothesis that there is an alteration in auditory processing. This processing is related to the speed with which the amplitude of an acoustic signal is processed, after the appearance of a sound. The change in this processing will compromise the perception of smaller units of speech [13]. The visual subtype is due to dysfunction in the parieto-occipital regions, causing changes in visual processing and presenting as manifestations, the reading of words in an inverted form, difficulties in identifying the letters that are mirror images of each other (/p-q/, /p-b/, /m-w/), both in reading and writing situations. It is the mixed dyslexia subtype that deals with the difficulty in acquiring both procedures due to phonological, visual-perceptual and neurobiological problems [13].

According to the focus of Chyl et al.[14] on dysphonic dyslexia (phonological), children have difficulty in integrating letter - sound, revealing errors of auditory discrimination, difficulty in reading unknown words, confusing them with similar words, the most frequent errors are of character semantic ("woman" instead of "lady") and, difficulty in performing the analysis and synthesis of words. On the other hand, dyseidetic (visual) dyslexia, children with this type, have difficulties in perceiving the words globally, cannot join the set of letters that compose them, presenting a slow reading, spelling and decomposing the words in their phonemes, that is, they read phonetically, all the words as if they visualized them for the first time in the first school years and on the contrary, read quickly making visual errors, from the fourth year onwards, as they have already entered the orthographic stage. The most frequent errors are visuospatial inversions of letters/syllables/words ("b" instead of "d"; "em" instead of "me"; "bolo" instead of "lobo"). As for mixed dyslexia, a combination of both forms is observed[14].

Recent research has begun to suggest that developmental deficits in reading acquisition can also co-occur with visual processing deficits, which are particularly important for visually complex stimuli, but these deficits have received relatively little attention from researchers[10,15].

Dehaene[16] states that learning to read is not just associating letters in space, properly placed and with proper guidance. A dialogue must be established in the brain of the young reader, between the ventral visual pathway, which recognizes the identity of letters and words, and the dorsal pathway, which encodes the position in space and programs the movements of the eyes and attention. If one or other of these protagonists hesitate, all reading falters.

Seymour[17] reports that dyslexics are heterogeneous, varied and, this question was confirmed through methods, factor analysis and regression the existence of contrasting patterns - phonological/dysphonic and superficial/dyseidetic, and that distinctive functions are established and can be damaged differently, which should be researched.

In the intervention, Marchand-Krynski et al[18]. mentions that qualifying dyslexia is essential, because the application of therapeutic techniques will depend on the correct focus on the observed changes and for that, an accurate and multidisciplinary diagnosis must be counted on.

Given this context, the objective of this study was to identify the occurrences of cognitive processes, the visual and motor skills, which intervene in the reading of students with dyseidetic/visual dyslexia.

METHOD

This is an observational, analytical, cross-sectional study with a sample of 80 students, of both genders, divided into two groups: group of children with dyslexia (GA) with a mean age of 11.22±1.4 years and group of children without complaints of learning difficulties (GB) with a mean age of 11.37±1.28 years. The GA was composed of 40 students diagnosed with dyslexia, formalized through a medical report that followed the following criteria: absence of evident signs of neurological disease, identified through clinical evaluation, which included the traditional neurological examination; absence of evident signs of a reduction in mental age; identified through the application of the Weschsler Intelligence Scale - WISC -IV for children; absence of evident signs of ear disease, identified by otoscopy; absence of hearing loss confirmed by basic audiological evaluation, which consisted of pure tone audiometry; presence of school complaint related to learning and presence of dyslexia diagnosis. These students belong to the "Gato de Botas Project", a partnership between the Medical School of São Jose do Rio Preto (FAMERP) and the Municipal Department of Education of São Jose do Rio Preto/SP. It was created on September 28, 2000 due to the need to evaluate and assist children from public schools, complaining of learning difficulties. Criteria for referrals occur through the Department of Special Education at the Municipal Department of Education. Inclusion in care depends on the following criteria: being enrolled in a public (municipal) school; be in Elementary School; present learning difficulties; and having exhausted all the pedagogical possibilities of the school in which he studies. In this way, the student who is unable to overcome the stages of literacy, and does not retain content, is evaluated by the Project's interdisciplinary team, composed of a child neurologist, neuropsychologist, psychologist, pedagogue, speech therapist, occupational therapist and, when necessary, a child psychiatrist. After the evaluations are completed, through the case study, a diagnostic hypothesis with a global vision for learning is concluded, including the child in the intervention process in the areas requiring his diagnosis. The responsible for the Gato de Botas Project was contacted and informed about the research and granted authorization for data collection. The GB was composed of 40 students without learning difficulties, coming from a municipal public school. The choice of this school was due to the physical proximity to the Project. For the recruitment of participants initially, contact was made with the coordination of the municipal elementary school, to present the project, explain the objectives and procedures of the study. After the consent and signature of the term authorizing the research in a school environment, teachers were asked to indicate the children, who did not have any history or complaints of learning difficulties. Based on this indication from the teachers, the guardians were notified and invited to participate in the study by signing the informed consent form by the parents or guardians.GB students were paired, according to age, with 40 students from GA. The project was analyzed and approved by the Ethics Committee of the Medical School of São José do Rio Preto (CEP/FAMERP) under the number 2.074.858.

As instruments used to characterize the students in Groups A and B, an initial protocol was used, and to evaluate the reading processes, the students were submitted to the application of the Brazilian adaptation of the Assessment of the Reading Processes - PROLEC[19].

The TVPS – 3[20] tests were used to assess visual perception skills. This test assesses visual perceptual skills, with no need for motor skills to be involved in making a response. The test of visual perceptual skills is performed in individual sessions, lasting approximately 50 minutes. The TVPS-3 measures visual perception using seven subscales, each of which contains two practice items and 16 test items.

Confirmation of the visual subtype would be more reliable, according to the literature[21], adding to the assessment a test that analyze motor precision The Bruininks-Oseretsky Motor Proficiency Test (TPMBO)[22] was eligible in its reduced form and subtests 7 (visual motor control, 3 tests: 7.1 - drawing straight, 7.2 - drawing circle and 7.3 - drawing pencil) and 8 (speed and dexterity of the upper limb, 2 tests: 8.1 - Separate letters and 8.2 - Mark points) that would assist in the establishment of the fine visuomotor profile. These items measure the ability to integrate visual responses, with highly controlled motor responses, favoring safety and consistency to achieve the screening objective.

To classify Visual Dyslexia in the TPMBO test, the criterion used was only one subtest with a B score and the others with an IN score; IN scores in one or more subtests and the others with A scores and finally, all with IN scores. Schoolchildren who presented classification B, in two or more subtests, were excluded because they did not present visual-motor difficulties. The student who presented a classification B and the others being A, were also excluded. Finally, students who presented all parameters A, were also excluded.

As a procedure, the participation of children and parents was voluntary, with the prior written consent of the parents. For data collection, both groups were submitted to the same questionnaires.

After confirming the inclusion criteria, the students were assessed individually by means of a battery of tests in order to verify the common and different characteristics in the groups (GA and GB).

GB students were evaluated at their very school in a room designated for this purpose. The students from the Project (GA) had already been evaluated in this service, but the dyslexia subtypes (phonological or visual) had not been screened and this was done through the application of the instruments (Prolec and TVPS– 3 and subtypes 7 and 8 of the Bruininks Motor Proficiency Test - Oseretsky - TPMBO). These instruments are not used as markers in this service and constituted the first phase of the research in order to verify the common and different characteristics of each group.

In the second phase of the study, the students of the Project (GA) were evaluated by the speech therapist, using the TVPS –3 and PROLEC tests for the phonological processing of language, the reading and spelling processes, as well as the

visual perception skills and, by the physical educator examining visuomotor control and manual dexterity.

These joint assessments selected dyslexics who prefer to use the visual route. Finally, the cognitive processes of reading and the most compromised perceptual skills were analyzed in these students.

As this is an exploratory and descriptive study, descriptive statistics were used by means of frequency tables, central tendency and dispersion parameters, namely mean, standard deviation. The correlation between the variables in the groups was done through the application of the t test. The chosen error probability was $p < 0.05$. The computer system used in the treatment of data was the SPSS system, version 19. The score and correction criteria of the Prolec, TVPS –3 and TPMBO tests followed the criteria of the respective manuals.

The sample calculation (n = N.Z2.p. (1-p) / Z2.p. (1-p) + e2.N-1) was based on the number of children already diagnosed with dyslexia and admitted to the Project. This number varied between 45/50 dyslexics without comorbidities, obtaining a sample size of 40 students.

RESULTS

With regard to the first phase of the research, dyslexic groups with no learning complaints were compared in order to

Table 1. Assessment of the cognitive processes of reading, comparing the groups of dyslexics (GA) and the group without learning complaints (GB) according to the Battery of Evaluation of Processes of Reading (Prolec)

Reading Processes	Variables	Group	Mean ± SD	P value
Letter identification	LS	GA	18.4 ±1.7	.010*
		GB	19.6 ±0.5	
	DS	GA	17.0 ±2.7	.000*
		GB	18.6 ±2.0	
Lexical process	LD	GA	20.5±7.2	.005*
		GB	27.7±2.3	
	RW	GA	17.1±9.2	.000*
		GB	28.7±1.9	
	RPW	GA	12.9±8.1	.000*
		GB	25.6±4.1	
	RFW	GA	13.1±5.0	.000*
		GB	19.7±0.9	
	RNFW	GA	10.8±5.4	.000*
		GB	18.7±2.5	
	RWPW	GA	8.93±4.7	.000*
		GB	16.8±3.4	
Syntactic Process	GS	GA	9.15±3.0	.000*
		GB	12.4±2.7	
	AV	GA	3.2±1.3	.005*
		GB	4.0±1.0	
	PV	GA	3.1±1.4	.001*
		GB	4.0±0.9	
	FC	GA	2.6±1.3	.000*
		GB	3.9±0.9	
	MP	GA	8.9±.4.0	.000*
		GB	14.3±2.1	
Semantic Process	SU	GA	10.1±1.4	.000*
		GB	11.6±0.6	
	TU	GA	5.7±3.1	.000*
		GB	9.0±3.9	

Independent T-Test (t (df); p≤0.05) *Statistically significant difference
Caption: LS = sound/letters; DS = same/different; LD = lexical decision; RW = reading words; RPW = reading pseudowords; RFW = reading of frequent words; RNFW= reading infrequent words; RWPW = reading words and pseudowords; GS = grammatical structures; AV = active voice; PV=passive voice; FP = focused complement; MP = punctuation marks; SU = understanding of sentences; TU = understanding of texts

initially obtain reading and writing indicators. Table 1 presents as interpretation standards the average scores and standard deviations obtained by school years and by exam. The 5th school year in GB was used as a basis and in GA it varied from the 3rd to the 5th year.

Table 1 considers the total score of students in GA and GB. Table 2 makes an approach that allows the greatest difficulties to be distinguished by the number of students.

With regard to the visual perceptual ability of students from GA and GB, Table 3 characterizes and compares the visual perceptual performance of these groups, verifying the changes in their performance through the mean and standard deviation. Distribution of the mean, standard deviation and p value referring to the performance of students in GA (dyslexics) and GB (without complaints of learning difficulties) in the subtests of the TVPS-3.

Table 4 shows the performance of students according to the normative classification of the test application tables, being: MB (below average) students with scores between 1% and 14%; BM (low medium) between 15% to 49%, 50% NM (normal); MA (medium high) between 51% to 84%, and above 84% higher (SS).

The following graphs show the performance of each perceptual visual ability with the SKILLS Test of Visual Perceptual (TVPS-3)[20] in the GA and GB groups separately (Figures 1 and 2), paying attention to the very low and low performance values.

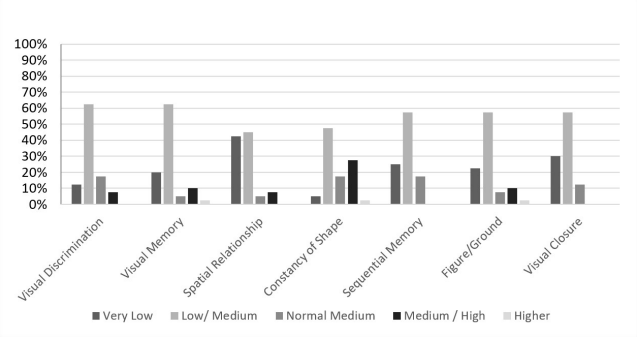

Figure 1. Performance of perceptual abilities in GA (dyslexic)

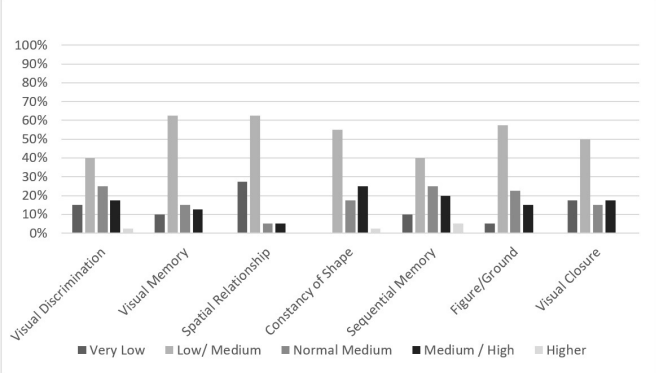

Figure 2. Performance of perceptual skills in GB (without complaint of learning difficulties)

Table 2. Comparison of normal classification (N), difficulty (D) and great difficulty (DD) in the PROLEC letter, lexical, syntactic and semantic identification tests, among dyslexic students (GA and those without complaints of difficulty) learning (GB)

Reading Process	Variable	Group	N	D	DD	TOTAL (n)
Letters Identification	LS	GA	14	15	11	40
		GB	29	11	0	40
	DS	GA	7	15	18	40
		GB	20	9	11	40
Lexical process	LD	GA	8	6	26	40
		GB	30	4	6	40
	RW	GA	10	18	12	40
		GB	28	8	4	40
	RPW	GA	2	1	38	40
		GB	23	3	14	40
	RFW	GA	29	7	04	40
		GB	35	2	3	40
	RNFW	GA	3	7	30	40
		GB	35	2	3	40
	RWPW	GA	2	1	37	40
		GB	24	6	10	40
Syntactic Process	GS	GA	17	7	16	40
		GB	3T3	3	4	40
	MP	GA	35	5	0	40
		GB	40	0	0	40
Semantic Process	SU	GA	5	26	9	40
		GB	30	9	1	40
	TU	GA	0	7	33	40
		GB	13	5	22	40

Caption: LS = sound/letters; DS = same/different; DL = lexical decision; RW = reading words; RPW = reading pseudowords; RFW = reading of frequent words; RNFW= reading infrequent words; RWPW = reading words and pseudowords; GS = grammatical structures; MP = punctuation marks; SU = understanding of sentences; TU = understanding of texts

Table 3. Visual perception assessment comparing the dyslexic groups (GA) and the group without learning complaints (GB) according to the TVPS–3

TVPS-3 Subtests	GROUP	Scaled score (mean)	Standard deviation	P value
Visual discrimination (VD)	GA	8.4	1.6	0.027*
	GB	8.9	2.5	
Visual memory (VM)	GA	7.8	2.4	.002*
	GB	8.5	1.5	
Spatial relationship (SR)	GA	7.1	2.1	.006*
	GB	7.5	1.4	
Constancy of shape (CS)	GA	9.4	2.0	.078
	GB	9.5	1.8	
Sequential memory (SM)	GA	8.4	2.6	.005*
	GB	9.6	2.1	
Figure–ground (FG)	GA	8.0	2.1	.001*
	GB	8.9	1.8	
Visual closure (VC)	GA	8.0	2.0	.000*
	GB	8.6	1.7	

Table 4. Performance in each perceptual skill expressed by the percentage of students in the GA and GB groups in the subtests of the TVPS–3

TVPS-3 Subtests	GROUP	VB %	ML %	N %	MH %	H %	TOTAL (n)
Visual discrimination (VD)	GA	12.5% (n=5)	62.5% (n=25)	17.5% (n=7)	7.5% (n=3)	0.0% (n=0)	40
	GB	15.0% (n=6)	40.0% (n=16)	25.0% (n=10)	17.5% (n=7)	2.5% (n=1)	40
Visual memory (VM)	GA	20.0% (n=8)	62.5% (n=25)	5.0% (n=2)	10.0% (n=4)	2.5% (n=1)	40
	GB	10.0% (n=4)	62.5% (n=25)	15.0% (n=6)	12.5% (n=5)	0.0% (n=0)	40
Spatial Relationship (SR)	GA	42.5% (n=17)	45.0% (n=18)	5.0% (n=2)	7.5% (n=3)	0.0% (n=0)	40
	GB	27.5% (n=11)	62.5% (n=25)	5.0% (n=2)	5.0% (n=2)	0.0% (n=0)	40
Constancy of shape (CS)	GA	5.0% (n=2)	47.5% (n=19)	17.5% (n=7)	27.5% (n=11)	2.5% (n=1)	40
	GB	0.0% (n=0)	55.0% (n=22)	17.5% (n=7)	25.0% (n=10)	2.5% (n=1)	40
Sequential memory (SM)	GA	25.0% (n=10)	57.5% (n=23)	17.5% (n=7)	0.0% (n=0)	5.0% (n=2)	40
	GB	10.0% (n=4)	40.0% (n=16)	25.0% (n=10)	20.0% (n=8)	5.0% (n=2)	40
Figure–ground (FG)	GA	22.5% (n=9)	57.5% (n=23)	7.5% (n=3)	10.0% (n=4)	2.5% (n=1)	40
	GB	5.00% (n=2)	57.5% (n=23)	22.5% (n=9)	15.0% (n=6)	0.0% (n=0)	40
Visual closure (VC)	GA	30.0% (n= 12)	57.5% (n=23)	12.5% (n=5)	0.0% (n=0)	0.0% (n=0)	40
	GB	17.5% (n=7)	50.0% (n=20)	15,0% (n=6)	17.5% (n=7)	0.0% (n=0)	40

Caption: VB=very low; ML=medium low; N=normal; MH=medium High=higher

Table 5. Analysis of the results obtained by Subtest 7 and 8 by the Bruininks-Oseretsky Motor Proficiency Test (TPMBO) in the groups (GA and GB)

TPMBO	Tests	Group	IN	A	G	Total
Subtest 7	Draw a line	GA	12	24	04	40
		GB	00	23	17	40
	Draw a circule	GA	02	25	13	40
		GB	0	07	33	40
	Draw pencil	GA	15	17	08	40
		GB	4	05	31	40
Subtest 8	Separate cards	GA	25	15	00	40
		GB	07	33	00	40
	Score points	GA	01	36	03	40
		GB	02	09	09	40

Caption: IN = Inappropriate; A = Adequate; G = Good; GA = dyslexics; GB = group without complaints of learning difficulties

Below (Table 5) the results of motor skills will be exposed from the TPMBO test, subtests 7 (visuomotor control) and 8 (speed and dexterity of the upper limb) comparing the performance in the groups (GA and GB).

Regarding the classification of Visual Dyslexia for GA, students from GA (n = 40) were submitted to the three tests (PROLEC, TVPS – 3 and TPMBO: subtests 7 and 8)[19-21]. In the 1st phase of PROLEC, the letter identification and lexical process tests were used as a criterion for screening visual dyslexics. Students with D and DD results in all tests, students with results from only one B test and all other tests that resulted in D and DD were selected. For GA adopting these criteria, 30 students were classified (n = 30) (Figure 3).

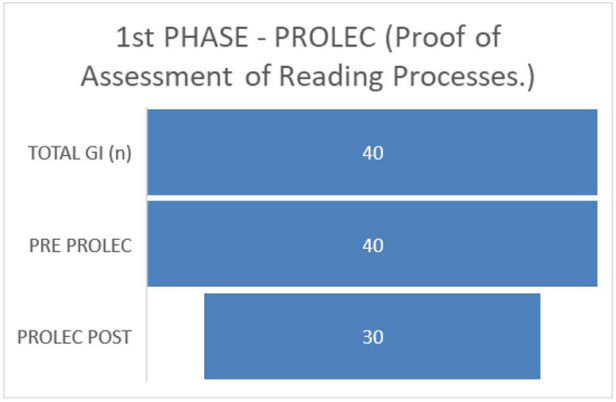

Figure 3. Application of PROLEC in the group of dyslexics (GA)

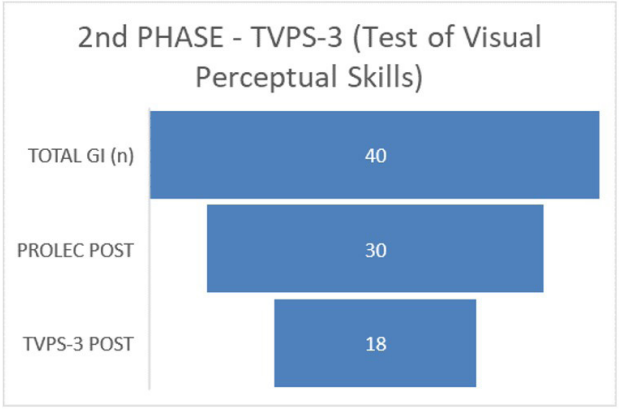

Figure 4. Application of TVPS – 3 in the group screened (GA) by PROLEC

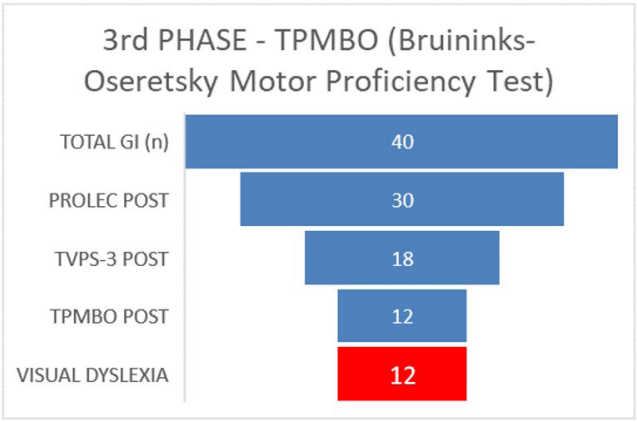

Figure 5. Application of TPMBO in the group screened (GA) by PROLEC and TVPS–3

Students screened by PROLEC (n = 30) were also analyzed using TVPS – 3 according to established criteria: students with MB (very low) and BM (low/medium) results; schoolchildren with MB E BM results and with only one N (normal), MA (medium/high) or SS (higher) result would be eligible. From the results of PROLEC (n = 30) and TVPS-3, we obtained as results 18 students (n = 18) (Figure 4).

The 3rd phase analyzed the results in the motor test (TPMBO), subtests 7 and 8, the criteria for classifying students were adopted: all students categorized IN (Inadequate) and students with IN results and only one result B (Good). The students resulting from the PROLEC and TVPS-3 tests, which totaled n = 18, met the criteria of this phase and derived from these 12 students (n = 12) (Figure 5).

Consequently, the results of the protocols chosen for the classification of Visual Dyslexia, of the 40 students in GA, 12 presented specific characteristics such as: reading difficulties, difficulties in visual perception and difficulties in controlling visual-motor coordination.

Corroborating with the quantitative data, it was extremely important to consider the types of errors that the visual dyslexic screened schoolchildren made when reading words aloud, faithfully transcribed by the evaluator.

These errors were produced randomly and their analysis allows to obtain more information about this group: 8 students presented exchanges **n/r**; 6 schoolchildren **b/d;** 5 schoolchildren **nh/nl**; 5 schoolchildren **m/n**; 4 schoolchildren **p/q**; 4 schoolchildren **l/t**; 3 schoolchildren **b/q**; 3 schoolchildren **q/g** and 2 schoolchildren **r/s**.

The results obtained revealed that the twelve schoolchildren screened (10 boys and 2 girls) showed better performance in reading frequent words when compared to the performance in reading infrequent words and pseudowords. These results suggest that, when reading words, the students preferentially used the lexical route.

It was found that dyslexics screened visually had an assessment of normal phonological processing verified in the slow reading speed, in the identification of words and, in the tests of TVPS−3 where in visual discrimination they mixed sequence of letters and had great difficulty in reading words that had the same sound, but they were spelled differently.

Regarding visual perceptual skills, the twelve students obtained values below 50% in the subscales, except for constancy of form, considering that for Martin[21], for a student to be within the average, he must have a percentile score of 50% or more.

And, in order to obtain representative information from visual dyslexic students about their motor skills, specifically visuomotor coordination and manual dexterity, which correlates the ability to control the movement of hands guided by vision, dyslexic students performed below the expected in the applied subtests, inferring that with these difficulties, confusion of letters may appear, inversions that can affect reading and writing.

Finally, we expose the words that serve to exemplify the mistakes made in reading words: /*quarto* for *quanto*/; /*corda* by *cosda*/; quintal by *quirtal*/; /*lenço* by *terço*/. The whole word: / crescer by *creche*/; /*planca* by *placa*/; among others, noticing that the time invested was very fast, that is, they read quickly.

Therefore, in this study, resulted from the analysis of reading changes, 12 students with Visual Dyslexia, 21 students with Phonological Dyslexia and 07 with Mixed Dyslexia.

DISCUSSION

The discussion of the data will be divided into two phases.

The present study, in a first phase, aimed to characterize the differences and similarities between dyslexic students (GA) and without complaints of learning difficulties (GB) in relation to the reading processes and perception-visual skills.

In the first phase, the results of students with dyslexia (GA) in this study showed a greater number of changes in the reading processes, compared to students without complaints of learning difficulties (GB), in the components of PROLEC (letter identification, lexical process, syntactic process and semantic process) corroborating the literature[23,24].

In the study by Oliveira et al.[25] in which the authors compared the performance of students with dyslexia, and students with good academic performance, it can be observed that students with dyslexia showed inferior performance compared to students considered to have good academic performance, demonstrating that when altered the ability of visual identification, this influences the performance of dyslexic students. They also state that this alteration, together with the other altered skills, compromises the learning of reading[25].

Regarding the choice of a control group, composed of students without complaints of learning difficulties in our study, it was based on the literature[26], which shows that even students without learning problems can present changes in literacy and this may be due to the lack of educational investment.

The results showed a statistically lower yield, demonstrating that the letter identification task and lexical process had a higher correlation. The other correlations were moderate.

Still reflecting statistically, it was observed that in the lexical decision tests and reading pseudowords of GA, the standard deviation was very high, which shows greater dispersion in the data, since the data points are spread over a wide range of values, characteristic of the heterogeneity of dyslexia[27].

Analyzing the groups together, through the classification, the difference between the students is outstanding by the fact that dyslexics (GA), present great difficulty (DD) in all tests, except punctuation marks, although still in greater number classified with difficulty (D), comparing with GB.

In relation to the lexical process, we found that the students of GA, in tests such as reading pseudowords and lexical decision presented the classification great difficulty (DD) in 95% of the sample. This result corroborates other researches, which prove that the dyslexic has difficulty in orthographic representations and in the conversion of grapheme – phoneme[28].

Components of the syntactic process (punctuation marks) revealed an interesting finding, where students from GA and GB obtained normal classification (N), 87.5% and 100% respectively, not corroborating other studies[29,30].

Studies[24,26] report on the evaluation of the syntactic process, which refers to reading and understanding grammatical structures such as: active voice, passive voice and focused complement, allowed to assess the student's ability to assign syntactic roles to the words that make up a sentence, and this activity in GA is statistically significant, reinforced by another study.

In turn, the semantic process (text comprehension) identified great difficulty in both groups (GA– 82.5% and GB – 55%). This fact demonstrated that not only dyslexics are bad readers and that other variables must be discussed in the students' learning. Research[19,23] suggest that educational strategies for students without complaints of difficulties, should include the stimulation of language, metalanguage and comprehension skills, which should not be taken into account only with the fluent and automatic recognition of words.

Alves et al.[30] found in their study that there was no statistically significant difference between dyslexics and students without complaints of learning difficulties in the analysis of text comprehension, pointing out that students are more exposed to narrative than expository texts and these are of easier understanding.

To assess visual perception skills of the groups, all subtests of the TVPS – 3 revealed a statistically significant difference, except in constancy of form. Expressed these values, in the classification very low performance (MB) and low/ medium (BM), also in the constancy of form subtest, these results were confirmed.

According to studies, the performance in these skills is associated with learning, because they form a visual image of the words, identify visual clues of shapes and words of similar appearance, discriminating them[8].

The literature examines the relationship between reading ability, eye movements and visual perceptual processes, showing that students with developmental dyslexia had more perceptual problems than those presented by proficient readers[8,26].

The use of standardized instruments, such as TVPS – 3, is recommended to monitor therapeutic efficacy, according to international studies. Their objective is to assist in visuomotor perceived intervention programs, both in students with difficulties and students without difficulties and learning disorders[13,21].

According to this test, the performance of GA students, in the visual perceptual ability in subtests of visual discrimination (62.5%), visual memory (62.5%), background figure, sequential memory and visual closure (57.5%) are below or far below the average for these skills.

Yang and Tan[24] describe that these perceptual aspects are crucial for reading, writing, spelling and mathematics, thus emphasizing that in reading, there are frequencies of words that are not phonetic, which are learned by visual recognition. In view of this fact, students with difficulty in sequential memory, are inclined to whisper while reading, and words that are not usual become difficult to write [24].

Friedman and Miyake[5] point out that problems with the background figure ability, demonstrate the inability to perceive and locate an object or a shape, in a given space, and this makes it difficult for the student to locate specific information within a text, affecting the levels of concentration and attention.

The results, regarding the constancy of form subscale, showed no statistically significant difference between the groups, exposed by the fact, according to Adlof and Hogan[2], that there may be a lack of school investments in activities that involve visual and visual-motor experiences, which are essential for development reading and writing.

Thus, the work of Provazza et al.[8] argues that students with developmental dyslexia present not only phonological impairments, but also difficulties in processing visual materials. This aspect has received limited attention in the literature and represents a new aspect to be studied.

As for motor skills verified in both groups, GA showed that visuomotor control (drawing straight and drawing pencils)

speed and dexterity of the upper limb, have a greater number of students with inadequate performance, when compared with GB.

In this context, several studies[11,22] are mainly focused on the description of linguistic-cognitive behaviors, related to reading and writing, despite presenting changes in motor skills in these populations, they are little researched.

Yang and Tan[24], in their work, demonstrated that dyslexics can present cerebellar dysfunctions, due to the fact that this organ has connections with the pre-motor and frontal areas, including the Broca region, responsible for language that would negatively affect automatic and motor skills.

In this study, two subtests of a motor proficiency battery were eligible, aiming to characterize visuomotor coordination, dexterity and speed of the upper limb, analyzing kinesthetic perception, fine motor control, sustained attention and hand manipulation. This was done with the aim of considering a diverse range of skills, instead of limiting its focus to phonological skills.

Cao et al.[11] relate low motor indices and dyslexia, suggesting that this lack of ability can contribute negatively to learning.

The second phase of this study was to screen visual dyslexics within a heterogeneous sample (GA) and substantiate this screening through tests that verified difficulties in reading processes, perceptual skills and fine motor skills, looking for the distinctions that reside in the preference of lexical route.

In this context, students with great difficulty (DD) and difficulty (D) marked in the components of letter identification (equal/different), lexical decision (reading words and pseudowords) and comprehension of texts determined a predilection for visual reading. Perceptual skills were then associated, where all of them were impaired, but those with the highest number of very low (MB) and low/medium (BM) classification such as: visual discrimination, visual memory, sequential memory, background figure, spatial relationship and visual Closure, were decisive in the selection of students, resulting in great difficulties in visual perceptual skills. Finally, adding a motor test, since dyslexia affects not only reading, spelling, writing, expression, mathematics, but also body and social aspects, choosing to verify the inadequate performance in visual-motor coordination and manual dexterity. According to studies[25,26] these aspects of the investigation of fine motor movements, may reflect the integrity and maturity of the brain and are related to perceptovisuomotor alterations, easily identifiable during the speech therapy evaluation and in the educational context.

The choice of these instruments was based on the reasoning that reading needs a detailed visuospatial analysis to access phonology and semantics, and through these, the goal was to verify, among a diverse group of dyslexics, those who prefer to access the visual route. We did not find studies in the literature that classified the subtypes: visual and phonological.

Research shows that perception problems, in dyslexia, are closely related to: body notion, temporal notion and sometimes with rhythm[21,27], due to this fact we added a motor test.

In view of the results, twelve visual dyslexics (30% of the sample), twenty-one mixed and seven phonological were found. Only one study by Seymour[17] reports the relationship between some visual processing skills and written language, in about 20% of cases of dyslexia, and, in most cases, it consists merely of a correlation.

We highlight the study by Gabay et al.[29] who reveal, the most striking evidence of the heterogeneity of DD, comes from studies that show that not all individuals with dyslexia, manifest phonological impairment and that specific approaches for this group, must be implemented because different patterns of performance occur.

Phonological deficits, including impaired phonological representation and speech sound processing, are presented in most dyslexics. There is a huge amount of research on the brain mechanism of phonological processing deficits in dyslexics, how these deficits affect the development of reading and can be alleviated by phonological training, however this does not occur, when the visual processing is more damaged, as they are particularly important and have received relatively little attention from researchers.

In this study, it was understood that the ability of visual recognitions, including reception, visual discrimination and memory, are closely related to reading and writing, so it is possible to recognize through the exchanges presented by GA students, that they committed exchanges or confusion of letters, syllables or words, with little difference in the way of writing, but different in the direction ("n" - "r", "b" - "d", "nh" - "nl", "p" - "q", "L" - "t", "b" - "d", "q" - "g", "r" - "s"), the same, did not occur in exchanges or confusion between letters that have the same point and articulatory mode, and whose sounds are acoustically close: /p/ - /b/, /t/ - /d/, /j/ - /ch/, /f/ - /v/, /k/ - /g/, /s/ - /z/. Another reinforcer is the presence of a lexicality effect, since these students identified real words more quickly and accurately, than pseudowords, reinforcing that they performed the reading by the lexical route. These GA students invested a very short time in the task, that is, they read very quickly.

These results corroborate other studies[8,24] that report that visual dyslexics refer to individuals who have a type of dyslexia that is not related to phonological processing, compromising the way in which an individual interprets letter combinations. A "b" can be interpreted as a "d". Likewise, a child may have difficulties with letters constructed with the same basic shapes and differentiated only by small marks, such as dots or crosses, as in: "l" and "t", "q" and "g", "n" and "r" among others.

However, new studies should be carried out, especially with a larger number of students so that the phonological deficits almost omnipresent in DD and studied in most researches, may give rise to another abnormal and slow entry of visual pathways that do not allow grapheme-phoneme matching efficiently. This identification could potentially lead to effective remediation strategies whose effects could be seen in neurodevelopment as a complex multidimensional concept, which could help to increase positive results in terms of cognitive and motor interventions.

CONCLUSION

- Summarizing, the results obtained, in a first phase, which was to evaluate and compare dyslexic students (GA) with students without complaints of learning difficulties (GB),

in order to verify characteristics common and different between groups, it is concluded that: students from GA presented a worse performance in all PROLEC tests with a statistically significant difference, inferior performance in the subscales of TVPS – 3, visual discrimination, visual memory, background figure, sequential memory and visual Closure, except for constancy of form and, visual motor control and manual dexterity considered inadequate;

- In a second phase, we aimed to analyze and identify the priority use by one of the preferential reading routes of dyslexic students (GA), thus finding 12 (30%) visual dyslexics who showed better performance in reading frequent words when compared to the performance in reading infrequent words and pseudowords. In the visual perceptual skills, they obtained values below 50%, except in the subscale constancy of form, while the motor skills showed a performance below the expected when compared with the GB;
- The occurrences of exchanges presented by visual dyslexic students, were in confusions of letters, syllables or words with few differences in the way of writing, but different in directions ("n" - "r", "b" - "d", "nh" - "nl", "p" - "q", "l" - "t", "b" - "d", "q" - "g", "r" - "s") the same students did not present exchanges or confusion between letters, which have the same point and articulation mode and whose sounds are acoustically close /p/ - /b/, /t/ - /d/, /j/ - /ch/, /f/ - /v/, /k/ - /g/, /s/ - /z/. Another reinforcer is the presence of a lexicality effect, since these students identified real words more quickly and accurately, than pseudowords, reinforcing that the reading was performed using the lexical route.

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Author contributions

SM: study design, data collection, tabulation, text writing and revision; RRM: collection, tabulation of data, analysis and creation of tables and figures; RCHMR and AMM: revision of the text and addition of significant parts; MRIM: study design, study writing, review and general guidance