

Natália Fusco<sup>1</sup>  
 Giseli Donadon Germano<sup>2</sup>  
 Simone Aparecida Capellini<sup>3</sup>

### Keywords

Rehabilitation  
 Visual Perception  
 Dyslexia  
 Handwriting

### Descritores

Reabilitação  
 Percepção Visual  
 Dislexia  
 Escrita manual

### Correspondence address:

Simone Aparecida Capellini  
 Departamento de Fonoaudiologia,  
 Faculdade de Filosofia e Ciências,  
 Universidade Estadual Paulista “Júlio de Mesquita Filho”  
 Avenida Hygino Muzzy Filho, 737,  
 Campus Universitário, Marília (SP),  
 Brasil, CEP: 17525-900.  
 E-mail: sacap@uol.com.br

Received: 01/24/2014

Accepted: 10/15/2014

CoDAS 2015;27(2):128-34

## Efficacy of a perceptual and visual-motor skill intervention program for students with dyslexia

### *Eficácia de um programa de intervenção percepto-viso-motora para escolares com dislexia*

### ABSTRACT

**Purpose:** To verify the efficacy of a perceptual and visual-motor skill intervention program for students with dyslexia. **Methods:** The participants were 20 students from third to fifth grade of a public elementary school in Marília, São Paulo, aged from 8 years to 11 years and 11 months, distributed into the following groups: Group I (GI; 10 students with developmental dyslexia) and Group II (GII; 10 students with good academic performance). A perceptual and visual-motor intervention program was applied, which comprised exercises for visual-motor coordination, visual discrimination, visual memory, visual-spatial relationship, shape constancy, sequential memory, visual figure-ground coordination, and visual closure. In pre- and post-testing situations, both groups were submitted to the Test of Visual-Perceptual Skills (TVPS-3), and the quality of handwriting was analyzed using the Dysgraphia Scale. **Results:** The analyzed statistical results showed that both groups of students had dysgraphia in pretesting situation. In visual perceptual skills, GI presented a lower performance compared to GII, as well as in the quality of writing. After undergoing the intervention program, GI increased the average of correct answers in TVPS-3 and improved the quality of handwriting. **Conclusion:** The developed intervention program proved appropriate for being applied to students with dyslexia, and showed positive effects because it provided improved visual perception skills and quality of writing for students with developmental dyslexia.

### RESUMO

**Objetivo:** Verificar a eficácia de um programa de intervenção com habilidades percepto-viso-motoras para escolares com dislexia. **Métodos:** Participaram 20 escolares do terceiro ao quinto ano do Ensino Fundamental público da cidade de Marília (SP), de 8 anos a 11 anos e 11 meses de idade, sendo distribuídos nos seguintes grupos: GI (dez escolares com dislexia do desenvolvimento) e GII (dez escolares com bom desempenho acadêmico). Foi aplicado um programa de intervenção percepto-viso-motora composto de exercícios para a coordenação viso-motora, a discriminação visual, a memória visual, a relação viso-espacial, a constância de forma, a memória sequencial, a figura-fundo visual e a clusura visual. Em situação de pré e pós-testagem, ambos os grupos foram submetidos à aplicação do Teste de Habilidades Perceptivas Visuais (TVPS-3), e a análise da escrita foi realizada através da Escala de Disgrafia. **Resultados:** Os resultados estatísticos analisados evidenciaram que ambos os grupos de escolares apresentaram disgrafia na pré-testagem. Nas habilidades de percepção visual, o GI apresentou desempenho inferior em relação ao GII, assim como na qualidade da escrita. Após ser submetido ao programa de intervenção, o GI aumentou as médias de acerto no TVPS-3 e melhorou a qualidade de escrita. **Conclusão:** O programa de intervenção elaborado se mostrou apropriado para ser aplicado em escolares com dislexia, assim como mostrou efeitos positivos, pois proporcionou melhora das habilidades de percepção visual e na qualidade da escrita de escolares com dislexia do desenvolvimento.

Study carried out at the Laboratory for Investigation of Learning Disabilities, Speech Language Pathology and Audiology Department, School of Philosophy and Sciences, Universidade Estadual Paulista “Júlio de Mesquita Filho” – UNESP – Marília (SP), Brazil.

(1) Graduate Program in Speech Language Pathology and Audiology, School of Philosophy and Sciences, Universidade Estadual Paulista “Júlio de Mesquita Filho” – UNESP – Marília (SP), Brazil.

(2) Laboratory for Investigation of Learning Disabilities, Speech Language Pathology and Audiology Department, School of Philosophy and Sciences, Universidade Estadual Paulista “Júlio de Mesquita Filho” – UNESP – Marília (SP), Brazil.

(3) Speech Language Pathology and Audiology Department, School of Philosophy and Sciences, Universidade Estadual Paulista “Júlio de Mesquita Filho” – UNESP – Marília (SP), Brazil.

**Conflict of interests:** nothing to declare.

## INTRODUCTION

Visual-motor perceptual skills are important predictors for handwriting performance, including both readability and writing speed<sup>(1,2)</sup>. The perceptual processes of writing consist of visual skills (copy tasks) and hearing (dictation tasks), motor coordination, and visual-motor integration (hand-eye coordination)<sup>(3)</sup>. Cognitive processes involved in writing can be divided into visual and visual-motor processes, cognitive planning and working memory processes<sup>(5)</sup>, and language skills, such as phonological and orthographic codification<sup>(6)</sup>.

Dyslexia can manifest in three subtypes, with the phonological subtype resulting from a dysfunction in the superior temporal gyrus and temporoparietal regions, causing auditory processing disorders. Authors<sup>(6)</sup> indicated that the decreased ability to process auditory information can be the basis of speech disorders in this subtype. What supports the theory of phonological deficit is the hypothesis that there is an alteration in auditory processing. This processing is linked to the speed with which the amplitude of an acoustic signal is processed after the onset of a sound. An alteration in this processing causes difficulties in the perception of smaller units of speech, for instance, the perception that words can be segmented into syllables and phonemes. In addition, an important factor related to auditory processing, underlying the segmentation of speech, is the processing of rhythm that will influence the perception of initial phonemes (alliteration skills) and suprasegmental elements (rhyme and prosody). So, if subtle differences in auditory processing are not registered, there will be, as a result, alterations in the acquisition of phonological skills.

The visual subtype, according to the literature<sup>(7)</sup>, occurs because of a dysfunction in the parieto-occipital regions, resulting in visual processing disorders, and the mixed subtype is a result of a dysfunction in temporo-occipito-parietal regions.

Students with dyslexia of the visual subtype present as manifestations reading words in an inverted position<sup>(8)</sup>, difficulties to identify letters that are mirror images of each other (p-q, p-b, m-w) in both reading and writing situations<sup>(9)</sup>. In addition, they may have deficits in fine motor skills, which cause disturbances in letter drawing and calligraphy in copy tasks<sup>(10)</sup>, difficulties in bimanual coordination, and manual dexterity that would justify the occurrence of dysgraphia in this population<sup>(11)</sup>. Authors<sup>(12)</sup> reported that the motor development and the cognitive development are interrelated because their processing involves areas from the prefrontal cortex and cerebellum. Thus, the hypothesis of automaticity deficit was proposed by the authors, associating cognitive deficits and motor skill. According to this hypothesis, students with dyslexia experience difficulty to perform automatic activities, such as reading and writing, due to the failure to carry out movements and automatic sequentialization which are necessary to perform the eye movements for reading and the visual-motor movements for handwriting.

The need to investigate and to characterize perceptual and visual-motor performance of these students with dyslexia lies in the fact that many of the alterations in writing, identified as misspellings, can actually be covering up errors of calligraphic nature, for example, poor tracing of the letter that triggers an

unintelligible writing<sup>(13)</sup>. Thus, it is necessary to propose studies using standardized procedures for perceptual and visual-motor assessment, so that intervention programs are developed to reduce the impact of poor letter tracing on the writing of these students with dyslexia.

Although there are international studies<sup>(12,14)</sup> investigating the visual-motor perception relation, reading, and writing in the population of students with dyslexia, in Brazil, these studies are limited, making the establishment of the visual-motor profile of this population more difficult<sup>(13)</sup>. As Speech-Language Pathology and Audiology is the area that investigates the deficits in information processing and their impact on the acquisition and development of language, it is up to the speech-language pathologist and audiologist to propose intervention programs aimed to minimizing the impact of these deficits on the spelling and handwriting of these students.

Based on the points explained earlier, this study aimed to verify the efficacy of an intervention program with visual-motor perception skills for students with dyslexia.

## METHODS

This study was conducted after being approved by the Research Ethics Committee of the School of Philosophy and Sciences, Universidade Estadual Paulista “Júlio de Mesquita Filho” (UNESP), Marília (SP), Brazil, under the protocol number 0149/2009.

The study included 20 students (aged from 8 years to 11 years and 11 months) from third to fifth grades of an elementary school in Marília (SP). All students who participated in this study had the informed consent term signed by parents or guardians. These students were divided into the following two groups:

- Group I (GI): It comprised 10 students with interdisciplinary diagnosis of dyslexia, enrolled in a regular school in Marília (SP), and waiting in line for an appointment in the Center for Studies of Education and Health at the School of Philosophy and Sciences, Marília (SP), submitted to the intervention program.

The students with interdisciplinary diagnosis of dyslexia in this study were diagnosed by the same team of professionals from the Laboratory of Investigation of Learning Deviations of the Center for Studies of Education and Health at the School of Philosophy and Sciences, UNESP, Marília (SP), and from the Clinic of Learning Disabilities at the Hospital of the School of Medicine, UNESP, Botucatu (SP), composed of a pediatric neurologist, neuropsychologist, educational psychologist, and speech-language pathologist and/or audiologist.

- Group II (GII): It comprised 10 students with good academic performance, regularly enrolled in a regular school in Marília (SP), who were paired by gender and age with the students of GI and subjected to the intervention program elaborated for this study.

The students in this group were suggested by teachers based on the achievement of a record higher than 5.0 in evaluations of Portuguese and Mathematics in two consecutive 2-month

periods. These criteria are based on the teacher's report, referred to in SARESP Pedagogical Reports<sup>(15)</sup>.

We excluded from this study students with history of hearing, visual, cognitive, or motor impairment informed in school records or teachers' reports; who were submitted to intervention programs such as visual-motor perception and/or phonological skills; presence of other genetic syndromes and intellectual disabilities, presence of comorbidity with attention deficit hyperactivity disorders, and other comorbidities; and who did not presented the informed consent term signed by parents or guardians.

The decision to choose the participation of students from the third grade of elementary school was based on the fact that, at this stage of education, the students should already be literate and writing in cursive letters and there is an exposure to training in written expression for at least three years, according to the document of the Ministry of Education — Department of Basic Education "Catalogue of the National Network for Continuing Education of Primary Education Teachers — Literacy and Language"<sup>(16)</sup>. Therefore, students from the third grade are able to write, make copy, write or copy a verse in a legible and understandable manner, according to the standards required by the culture in which they live.

However, we emphasize that, for the selection of the students, we asked teachers to choose them only by the criteria of evaluation grades, and not by the quality of the handwriting.

The choice of a control group of students with good academic performance was based on the literature<sup>(17,18)</sup>, which shows that even students without learning disabilities may have deficits in the quality of handwriting, and this may be due to the lack of educational investment in visual-motor perception strategies to develop rapid and legible handwriting. Thus, as this is a program designed to intervene in the impact of the perceptual-motor disorders in students with dyslexia for better control of its efficacy, it has been implemented to students that, supposedly, by having a good academic performance, with no neuropsychological deficits that could justify their poor letter drawing.

The following procedures were used for evaluation in pre- and post-testing situations: Test of Visual-Perceptual Skills (TVPS-3)<sup>(19)</sup>, comprising the following skill set: visual discrimination, visual memory, visual-spatial relationship, form constancy, visual sequential memory, visual figure-ground, and visual closure.

The quality of the handwriting was analyzed through the analysis criteria of the Dysgraphia Scale<sup>(20)</sup>. This scale comprised 10 items of evaluation that assess the presence of floating lines; ascending/descending lines; irregular space between words; retouched letters; curvature and angles of arches of M, N, U, V; junction points; collisions and adhesions; sudden movements; dimension irregularity; and poor forms. The scoring criteria used for the analysis of the quality of the handwriting ranged from 0 to 17 points, being considered as having a dysgraphia pattern in writing of the student that obtained a grade equal to or greater than eight and a half points — the equivalent to 50% of the total grade of the scale.

As part of the intervention participants were submitted to the "Intervention program with visual-motor perception skills", elaborated as part of a research project funded by the National

Council for Scientific and Technological Development (CNPq)<sup>(21)</sup>, based on the description of the literature<sup>(22,23)</sup> regarding both the selected exercises and the recommended intervention period.

Therefore, the exercises present in this intervention program with the visual-motor perception skills have as a priority to create the basis for the identification, preparation, and understanding of the visual messages, as well as the establishment of codes to improve general coding and decoding of the visual image of letter, word, and image for a possible representation in a motor act, such as writing and reading<sup>(22,23)</sup>.

This program comprised eight exercises, with one visual-motor coordination exercise and seven exercises of visual perception (visual discrimination, visual-spatial relationship, form constancy, visual memory and sequential memory, visual figure-ground coordination, and visual closure), designed to be practiced in 12 sessions of the intervention program. The exercises of the intervention program were created to be performed in two blocks, described as follows:

1. Visual-motor coordination exercises: vertical dashed line; horizontal dashed line; diagonal dashed line; zigzag dashed line; dashed line in vertical/horizontal; dashing in the shape of a semicircle; dashing in a circle; wavy dashed line; "U"-shaped dashed line; "le"-shaped dashed line.
2. Exercises of visual perception: visual discrimination of the stimulus; visual-spatial-objective relationship; shape-objective constancy; sequential-objective visual memory; visual-objective figure-ground coordination; visual-objective closure.

The exercises of the intervention program involving linguistic stimuli for representation of figures and words were taken from the word database of the Laboratory of Investigation of Learning Deviations of the School of Philosophy and Science, UNESP, which was prepared from Portuguese language textbooks used by teachers of the Public Education Network in the city of Marília, São Paulo.

The intervention program was applied individually in 12 sessions, 50 minutes each, twice a week. The data from the students of GI and GII were collected at the Laboratory for Research of the Learning Disabilities on the shift opposite to the classes.

The statistical analysis was done using the Statistical Package for Social Sciences (SPSS) software, version 20.0. The statistical results were analyzed at the level of significance of 5% (0.05) marked with an asterisk in the tables regarding the results. The tests used for statistical analysis were the Wilcoxon signed-rank test and the McNemar test.

## RESULTS

The tables show the performance of GI and GII, in pre- and post-testing situations in the Dysgraphia Scale<sup>(20)</sup>, analyzed with the application of the Wilcoxon signed-rank test.

The following scale analysis criteria were considered: presence of floating lines (FL); ascending/descending lines (ADL); irregular space between words (IS); retouched letters (RL); curvatures and angles of the arches of M, N, U, V (CAA); junction

points (JP); collisions and adhesion (CA); sudden movements (SM); dimension irregularity (DI); and poor forms (PF).

It can be noted that there was a difference in the comparison between the pre- and post-testing situations for the criteria of floating lines, retouched letters, collisions and adhesion, and sudden movements, suggesting improvement in the tracing of writing in the students of GI after being submitted to visual-motor intervention (Table 1).

Regarding the students of GII, it was possible to observe that there were differences when comparing the pre- and post-testing situations for the criteria of floating lines and retouched up letters (Table 2).

According to the results described in Tables 1 and 2, it was possible to make a comparison between the classification of the students from GI and GII, concerning the presence or absence of dysgraphia in pre- and post-testing situations of the Dysgraphia Scale by applying the McNemar test (Table 3).

It was possible to verify differences regarding the classification of students from GI and GII concerning the Dysgraphia Scale, indicating that students, after being subjected to the visual-motor intervention program, showed improvement in the quality of handwriting.

To analyze the performance of the students from GI and GII in TVPS-3<sup>(19)</sup>, we applied the Wilcoxon signed-rank test.

Comparing the means between the pre- and post-testing situations of students from GI, differences were observed in visual discrimination skills, visual memory, visual-spatial relationship,

**Table 2.** Distribution of mean, standard deviation, and p-value regarding the performance of students from Group II in pre- and post-testing on the Dysgraphia Scale

Variables	n	Mean	Standard deviation	p-value
FLpre	10	1.00	0.67	0.046*
FLpost	10	0.60	0.52	
ADLpre	10	0.75	0.42	0.257
ADLpost	10	0.60	0.46	
ISpre	10	0.20	0.35	0.317
ISpost	10	0.10	0.21	
RLpre	10	1.40	0.70	0.008*
RLpost	10	0.70	0.48	
CAApr	10	1.00	0.47	0.317
CAApost	10	0.90	0.32	
JPpre	10	1.50	0.85	0.086
JPpost	10	1.05	0.50	
CApr	10	0.45	0.76	0.109
CApost	10	0.00	0.00	
SMpre	10	1.20	0.63	0.206
SMpost	10	0.80	0.63	
Dlpre	10	0.30	0.48	0.317
Dlpost	10	0.20	0.42	
PFpre	10	1.00	0.00	>0.999
PFpost	10	1.00	0.00	

\*Significant values (p≤0.05) – Wilcoxon signed-rank test

**Caption:** FL = presence of floating lines; ADL = ascending/descending lines; IS = irregular space between words; RL = retouched letters; CAA = curvatures and angles of the arches of M, N, U, V; JP = junction points; CA = collisions and adhesions; SM = sudden movements; DI = dimension irregularity; PF = poor forms

**Table 1.** Distribution of mean, standard deviation, and p-value regarding the performance of students from Group I in pre- and post-testing on the Dysgraphia Scale

Variables	n	Mean	Standard deviation	p-value
FLpre	10	1.30	0.67	0.034*
FLpost	10	0.70	0.67	
ADLpre	10	0.90	0.52	0.052
ADLpost	10	0.50	0.53	
ISpre	10	0.80	0.42	0.067
ISpost	10	0.30	0.42	
RLpre	10	1.70	0.67	0.023*
RLpost	10	0.70	0.82	
CAApr	10	1.00	0.00	>0.999
CAApost	10	1.00	0.00	
JPpre	10	1.30	0.67	>0.999
JPpost	10	1.30	0.82	
CApr	10	1.05	1.01	0.020*
CApost	10	0.00	0.00	
SMpre	10	1.60	0.70	0.008*
SMpost	10	0.75	0.72	
Dlpre	10	0.70	0.48	0.180
Dlpost	10	0.40	0.52	
PFpre	10	0.90	0.32	0.157
PFpost	10	1.10	0.32	

\*Significant values (p≤0.05) – Wilcoxon signed-rank test

**Caption:** FL = presence of floating lines; ADL = ascending/descending lines; IS = irregular space between words; RL = retouched letters; CAA = curvatures and angles of the arches of M, N, U, V; JP = junction points; CA = collisions and adhesions; SM = sudden movements; DI = dimension irregularity; PF = poor forms

form constancy, visual sequential memory, visual figure-ground and visual closure (Table 4).

It can be noted that the mean of correct responses in the post-testing situation was higher than that in pretesting situation, showing that students with developmental dyslexia benefited from the visual-motor perception intervention program.

Comparing the means between the pre- and post-testing situations of students from GII, differences were observed in visual memory skills, form constancy, visual figure-ground and visual closure (Table 5).

**Table 3.** Comparison of the classification of the students in Groups I and II regarding the presence and absence of dysgraphia in the pre- and post-testing

Group	Dpre		Dpost		Total	p-value
	1	2	1	2		
GI	8	2	4	6	10	0.219
	80.00%	20.00%	40.00%	60.00%	100.00%	
GII	3	7	0	10	10	0.083
	30.00%	70.00%	0.00%	100.00%	100.00%	
Total	11	9	4	16	20	0.039*
	55.00%	45.00%	20.00%	80.00%	100.00%	

\*Significant values (p≤0.05) – McNemar test

**Caption:** Dpre = dysgraphia pretesting; Dpost = dysgraphia post-testing; 1 = presence of dysgraphia; 2 = non dysgraphia; GI = Group I; GII = Group II

The mean of correct responses in post-testing situation was observed to be higher than that in the pretesting situation, showing that students with good academic performance showed improvement in visual skills after being submitted to the visual-motor intervention program (Table 5).

**DISCUSSION**

The results achieved by the students with dyslexia in this study showed a higher number of alterations in handwriting in relation to the students with good academic performance in subitems of the Dysgraphia Scale<sup>(20)</sup>, which corroborates the literature<sup>(13,14)</sup>.

The presence of dysgraphia in students with dyslexia has been reported in the literature, and generally the authors refer that, among these students, alterations in the drawing of letters can be found in copying tasks<sup>(25)</sup> and manual dexterity tasks<sup>(26)</sup>. According to the literature<sup>(23)</sup>, problems with fine motor control and/or low perceptual ability can impair the performance on reading, writing, and arithmetic tasks, affecting the child's

**Table 4.** Distribution of mean, standard deviation, and p-value regarding the school performance of students from Group I in pre- and post-testing of the Test of Visual-Perceptual Skills (TVPS-3)

Variables	n	Mean	Standard deviation	p-value
VDpre	10	5.90	3.07	0.008*
VDpost	10	10.40	3.44	
VMpre	10	6.60	3.50	0.007*
VMpost	10	9.70	2.98	
SRpre	10	8.70	4.55	0.007*
SRpost	10	14.40	2.59	
SCpre	10	7.80	4.26	0.005*
SCpost	10	11.20	4.26	
SMpre	10	8.00	3.40	0.020*
SMpost	10	10.40	1.90	
FGpre	10	6.30	3.09	0.043*
FGpost	10	9.40	3.78	
VCpre	10	5.60	3.75	0.005*
VCpost	10	10.80	2.82	

\*Significant values (p≤0.05) – Wilcoxon signed-rank test

**Caption:** VD = visual discrimination; pre = pretesting; post = post-testing; VM = visual memory; SR = visual-spatial relationship; SC = shape constancy; SM = visual sequential memory; FG = visual figure-ground coordination; VC = visual closure

learning process in the classroom, besides interfering in his or her achievements, motivation, and self-esteem.

The described data lead us to think that the dysgraphia in handwriting is not a unique characteristic of students with developmental dyslexia because the alterations in the tracing of writing are present in both groups. Those data are in accordance with the national<sup>(13,27)</sup> and international<sup>(28)</sup> literature, which indicated that 10 to 34% of children in school age fail to develop efficiently the handwriting and academic development,

**Table 5.** Results of the performance of Group II students in situations of pre- and post-testing regarding the Test of Visual-Perceptual Skills (TVPS-3)

Variables	n	Mean	Standard deviation	p-value
VDpre	10	8.20	3.39	0.137
VDpost	10	10.40	2.80	
VMpre	10	7.80	4.32	0.042*
VMpost	10	11.60	3.84	
SRpre	10	11.90	4.23	0.765
SRpost	10	12.30	5.25	
SCpre	10	7.40	3.06	0.024*
SCpost	10	11.30	4.64	
SMpre	10	9.80	2.44	0.106
SMpost	10	11.00	3.02	
FGpre	10	8.30	2.98	0.007*
FGpost	10	12.30	4.08	
VCpre	10	9.80	3.97	0.049*
VCpost	10	12.70	1.83	

\*Significant values (p≤0.05) – Wilcoxon signed-rank test

**Caption:** VD = visual discrimination; pre = pretesting; post = post-testing; VM = visual memory; SR = visual-spatial relationship; SC = shape constancy; SM = visual sequential memory; FG = visual figure-ground coordination; VC = visual closure

which may be justified by the lack of investment of the school in activities involving fine and global motor experiences<sup>(29)</sup>.

When analyzing the performance of students in both situations of the evaluation, there was an increase in the number of students that did not have dysgraphia in the post-testing situation, indicating that a program specifically designed to intervene in the visual-motor perception skills has provided a favorable situation, rich in written materials and with interactions with the writing practices, which seemed to positively influence the development of handwriting.

Regarding the subitems evaluated in the Dysgraphia Scale<sup>(20)</sup>, students with dyslexia showed difficulties on the following criteria: ascending/descending lines; irregular space between words, curvatures, and angles of the arches of M, N, U, V; junction points; collisions and adhesions; dimensional irregularity; and poor forms. It corroborates the study by Caraciki<sup>(30)</sup>, who describes these features as the main manifestations of dysgraphia.

In the evaluation of visual perceptual skills through the application of TVPS-3<sup>(19)</sup>, we identified, in this study, that students with good academic performance achieved superior performance compared to students with dyslexia, which corroborates the current literature<sup>(13)</sup>. According to the literature<sup>(11,14)</sup>, the presence of motor and visual-motor disorders in students with dyslexia is justified because of the increased vulnerability of neural work, responsible for sensorimotor integration of the information. This justification can be used to explain the lower performance of students with dyslexia in relation to the group with good academic performance<sup>(13)</sup>.

Regarding the comparison of pre- and post-testing situations of the performance in visual skills, it was observed that students with dyslexia showed better performance in post-testing situation, in all skills assessed in the TVPS-3<sup>(25)</sup>, whereas students with good academic performance showed improvement only in visual memory skills, form constancy, visual

figure-ground and visual closure. This shows the importance of intervention programs designed specifically to practice perceptual and visual-motor skills, as these can be used to improve the visual abilities of this population in the clinical and educational environments<sup>(16)</sup>.

We also concluded that the lack of research about this theme was a limitation of this study because it was not possible to perform a more thorough and complete comparison of the obtained results with other studies. Thus, we find the continuity of studies using an intervention program to develop visual-motor perception skills to be relevant, so that new findings may be disclosed, discussed, and compared with the results found on the dyslexic population of this study.

In addition, there is a limitation in this research common to studies conducted in students with dyslexia in the Brazilian reality, which is the difficulty to conduct studies with a sample population with near chronological ages, because this population take longer to seek for a diagnosis and intervention in public services.

## CONCLUSION

On the basis of the aspects stated earlier, this study aimed to verify the effectiveness of an intervention program with visual-motor perception skills for students with dyslexia.

We conclude that the use of the intervention program with the visual-motor perception skills had positive effects because it promoted relevant qualitative changes in the tracing of the writing of students that participated in this study.

For students with dyslexia, better performance was seen in the post-testing situation of all visual discrimination; memory; visual-spatial relationship; form constancy; visual sequential memory; visual figure-ground and visual closure skills. They also had better performance in the quality of the handwriting, because the occurrence of floating lines; retouched letters; collision and adhesion and sudden movements decreased. For students with good academic performance, there was a superior performance after the completion of the intervention program in just four visual skills, visual memory, form constancy, visual figure-ground and visual closure. Regarding quality of handwriting, these students showed improvement in aspects of floating lines and retouched letters.

Therefore, both the students with dyslexia and those with good academic performance submitted to the intervention program showed superior performance in the post-testing situation compared to the pretesting situation. For students with dyslexia, the impact of the intervention program occurred in all the visual skills and in the improvement of the tracing of writing.

The fact that students with good academic performance have shown improvement in visual and letter tracing skills only reinforces the need for implementation of the use of strategies to stimulate visual-motor perception in the classroom context. This is one of the most important guidelines that must be suggested by speech language pathologists to professionals that work directly with students with dyslexia or those with learning difficulties in clinical intervention.

## ACKNOWLEDGMENTS

We thank the Pro-rectory for Research at UNESP for granting a Mastering scholarship to the first author and the National Council for Scientific and Technological Development (CNPq) for the research-aid granted to the last author.

*\*NF foi responsável pela realização do projeto, coleta, tabulação dos dados, análise, interpretação e elaboração do manuscrito; GDG foi responsável pela análise e interpretação dos dados, colaborou com a orientação das etapas de execução e revisão do manuscrito; SAC foi responsável pela orientação do projeto e acompanhou as etapas de execução, elaboração e revisão do manuscrito.*

## REFERENCES

1. Goldstand S, Koslowe KC, Parush S. Vision, visual-information processing, and academic performance among seventh-grade school children: A more significant relationship than we thought? *Am J Occup Ther.* 2005;59(4):377-89.
2. Gvion A, Friedmann N. Letter position dysgraphia. *Cortex.* 2010;46:1100-13.
3. Volman MJM, Schendel BMV, Jongmans MJ. Handwriting difficulties in primary school children: a search for underlying mechanisms. *Am J Occup Ther.* 2006;60(4):451-60.
4. McCutchen D. Knowledge acquisition, processing efficiency, and working memory: Implications for a theory of writing. *Educ Psychol.* 2000;35(1):13-23.
5. Berninger VW, Nielsen KH, Abbott RD, Wijsman E, Raskind W. Gender differences in severity of writing and reading disabilities. *J Sch Psychol.* 2008;46(2):151-72.
6. Hakvoorta B, van der Leija A, Mauritsb N, Maassenc B, van Zuijen TL. Basic auditory processing is related to familial risk, not to reading fluency: an ERP study. *Cortex.* 2014;63C:90-103.
7. Franceschini S, Gori S, Ruffino M, Pedrolli K, Facoetti A. A causal link between visual spatial attention and reading acquisition. *Curr Biol.* 2012;22(9):814-9.
8. Kohnen S, Nickels L, Castles A, Friedmann N, McArthur G. When 'slime' becomes 'smile': developmental letter position dyslexia in English. *Neuropsychologia.* 2012;50(14):3681-92.
9. Salgado CAS, Pinheiro A, Sassi AG, Tabaquim MLM, Ciasca SM, Capellini SA. Avaliação fonoaudiológica e neuropsicológica na dislexia do desenvolvimento do tipo mista: relato de caso. *Revista Salusvita.* 2006;25:91-103.
10. Gomes ZG. Neurofisiologia da linguagem oral e escrita. In: Zorzo J, Capellini, AS. *Dislexia do desenvolvimento e outros distúrbios de leitura-escrita.* São José dos Campos (SP): Pulso; 2009. p. 35-42.
11. Crawford SG, Dewey D. Co-occurring disorders: a possible key to visual perceptual deficits in children with developmental coordination disorder? *Hum Mov Sci.* 2008;27:154-69.
12. Nicolson RI, Fawcett AJ. Dyslexia, dysgraphia, procedural learning and the cerebellum. *Cortex.* 2011;47:117-27.
13. Wang YP, Su CY. Rasch analysis of the Developmental Test of Visual-Motor Integration in children with intellectual disabilities. *Res Dev Disabil.* 2009;30(5):1044-53.
14. Fusco N. *Elaboração de programa de intervenção com as habilidades percepto-viso-motoras em escolares com dislexia do desenvolvimento [dissertação].* Marília (SP): Universidade Estadual Paulista "Júlio de Mesquita Filho"; 2013.
15. São Paulo. Secretaria da Educação do Estado de São Paulo [Internet]. *Relatório Pedagógico 2011 - Saresp Língua Portuguesa.* São Paulo (SP): Secretaria da Educação do Estado de São; 2011 [cited 2011 Dec 12]. Available from: [http://saresp.fde.sp.gov.br/2011/Pdf/Relat%C3%B3rio\\_Pedag%C3%B3gico\\_L%C3%ADngua\\_Portuguesa\\_2011.pdf](http://saresp.fde.sp.gov.br/2011/Pdf/Relat%C3%B3rio_Pedag%C3%B3gico_L%C3%ADngua_Portuguesa_2011.pdf)

16. Batista AA, Silva CS, Frade IC, Bregunci MG, Castanheira ML, Mourão S. Pró letramento: Programa de formação continuada de professores dos anos/séries iniciais do ensino fundamental: Alfabetização e linguagem. Capacidades linguísticas: alfabetização e letramento (fascículo 1). Unidade II: Capacidades linguísticas da alfabetização. Brasília: Ministério da Educação; 2008.
17. Sumner E, Connelly V, Barnett A. Children with dyslexia are slow writers because they pause more often and not because they are slow at handwriting execution. *Read Writ.* 2012;26(6):991-1008.
18. Rosenblum S, Aloni T, Josman EN. Relationships between handwriting performance and organizational abilities among children with and without dysgraphia: a preliminary study. *Res Dev Disabil.* 2010;31:502-9.
19. Martin NA. Test of visual perception skills. 3<sup>rd</sup> edition. Novato, CA: Academic Therapy Publications; 2006.
20. Lorenzini MV. Uma escala para detectar a disgrafia baseada na escala de Ajuriaguerra [dissertação]. São Carlos (SP): Universidade Federal de São Carlos; 2003.
21. Capellini SA. Avaliação e intervenção percepto-viso-motora na dislexia e no TDAH: estudo comparativo. Conselho Nacional de Desenvolvimento Científico e Tecnológico. Relatório de pesquisa; 2012.
22. Capellini SA, Fusco N. PTF para Intervenção com as Habilidades percepto-viso-motoras. In: Pró Fono, organizadores. Planos Terapêuticos Fonoaudiológicos (PTFs). Barueri (SP): Pró-Fono; 2012. p. 143-8.
23. Lane KA. Developing ocular motor and visual perceptual skills: an activity workbook. New Jersey: Slack Incorporated; 2005.
24. Hammil DD, Pearson NA, Voreess JK. Teste evolutivo de percepção visual. 2<sup>a</sup> edição. Rio de Janeiro: Entreletras; 2001.
25. Fawcett A, Nicolson R. Dyslexia: the role of the cerebellum. *Rev Electron Investig Psicoeduc Psicopedag.* 2011;2(2):35-58.
26. Capellini SA, Souza AV. Avaliação da função motora fina, sensorial e perceptiva em escolares com dislexia do desenvolvimento. In: Sennyey AL, Capovilla FC, Montiel JM. Transtornos da aprendizagem: da avaliação à reabilitação. São Paulo: Artes Médicas; 2008. p. 55-64.
27. Toniolo CS, Santos LCA, Lourenceti MD, Padula NAMR, Capellini SA. Caracterização do desempenho motor em escolares com transtorno de déficit de atenção e hiperatividade. *Psicopedagogia.* 2009;26(79):33-40.
28. Rosenblum S, Dvorkin AY, Weiss PL. Automatic segmentation as a tool for examining the handwriting process of children with dysgraphic and proficient handwriting. *Hum Mov Sci.* 2006;25(4-5):608-21.
29. Conlon E, Sanders M, Wright C. Relationships between global motion and global form processing, practice, cognitive and visual processing in adults with dyslexia or visual discomfort. *Neuropsychologia.* 2009;47(1):907-915.
30. Caraciki AM. Distúrbios da palavra. Criciúma (SC): Editora Mario; 1980