Reading of Students with Developmental Dyslexia: Impacts of an Intervention with Phonic Method Associated with the Executive Functions Stimuli[1]

Leitura de Estudantes com Dislexia do Desenvolvimento: Impactos de uma Intervenção com Método Fônico Associado à Estimulação de Funções Executivas

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ABSTRACT: The aim of this study was to verify the impact of an intervention program involving the phonic method associated with executive functions (EF) in the performance of seven students with dyslexia with the mean age of 10.7 years (experimental group - EG), in tasks of executive functions (EF), phonemic awareness and reading. The performance of the EG was compared to three control groups: dyslexics (DCG) of the same age range of the EG; by age group (ACG) composed of seven boys of the same age group as the EG, and another group of skilled but younger readers (RCG) with four participants. The EG received the intervention in 28 sessions. The four groups were evaluated in phonemic awareness, reading, comprehension and the EF before and after the intervention received by the EG. As a result, the EG presented significantly higher performance than DCG in reading of isolated words (frequent, non-frequent and pseudowords). In reading comprehension, the two groups of dyslexics progressed in their performance, but not significantly. The intervention did not affect the performance of the EF of cognitive flexibility and working memory. The EG improved in orthographic verbal fluency and inhibitory control as measured by Go/No Go. The performance of the ACG and RCG did not change significantly in phonemic awareness, word reading, sentence and text comprehension, and most of the EF. These results allow to conclude that the participation of dyslexics in an intervention focusing on the development of phonemic awareness, reading and executive functions was efficient to promote their performance in reading, especially the reading of isolated words.

KEYWORDS: Dyslexia. Executive Function. Intervention. Special Education.

RESUMO: O objetivo deste estudo foi verificar o impacto de uma intervenção envolvendo o método fônico associado à estimulação de FE no desempenho de sete estudantes com dislexia com idade média de 10,7 anos (grupo experimental – GE), em tarefas de funções executivas (FE), consciência fonêmica e leitura. O desempenho do GE foi comparado com três grupos de controle: de disléxicos (GCD) da mesma faixa etária do GE; por idade (GCI) composto por 7 meninos da mesma faixa etária que o GE, e outro grupo de leitores hábeis, porém mais jovens (GCL) com quatro participantes. O GE recebeu a intervenção em 28 sessões. Os quatro grupos foram avaliados em consciência fonêmica, leitura, compreensão e FE antes e após a intervenção recebida pelo GE. Como resultado, o GE apresentou desempenho significativamente maior que o GCD na leitura de palavras isoladas (frequentes, não-frequentes e pseudopalavras). Em compreensão leitora, os dois grupos de disléxicos progrediram em seu desempenho, porém não significativamente. A intervenção não afetou o desempenho das FE de flexibilidade cognitiva e memória de trabalho. O GE melhorou em fluência verbal ortográfica e controle inibitório medido pelo *Go/No Go*. O desempenho dos GCI e GCL não tiveram mudança significativa em consciência fonêmica, leitura de palavras, compreensão de sentenças e textos, e na maioria das FE. Esses resultados permitem concluir que a participação dos disléxicos em uma intervenção focalizando o desenvolvimento da consciência fonêmica, da leitura e das funções executivas foi eficiente para promover seu desempenho em leitura, notadamente a leitura de palavras isoladas.

PALAVRAS-CHAVE: Dislexia. Funções Executivas. Intervenção. Educação Especial.

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1 Introduction

Developmental dyslexia refers to the impoverished ability of reading, on a neurobiological basis that affects literacy at the level of word recognition, resulting in the difficulty of reading and spelling regular words, decoding and spelling nonwords, which will unfortunately result in poor comprehension of reading and impoverished vocabulary (Vellutino & Fletcher, 2013).

According to Rotta and Pedroso (2016), reading difficulties in developmental dyslexia result from deficiencies in phonological processing, most notably in phonological awareness, that is, in the ability to pay conscious attention to the sounds that make up the speech. Understood in this way, phonological awareness refers to the awareness of suprasyllabic, syllabic and intra-syllabic segments (such as phonemic awareness) (Moojen & França, 2016).

Literature is unanimous about the importance of phonological awareness stimulation in the interventions for teaching reading in dyslexics (R. Cardoso & Capellini, 2009; Capellini & Conrado 2009; Mello, 2015). These interventions have important results for reading learning and are based on the phonological deficit theory as the main party responsible for the pattern of cognitive processing of dyslexics. However, because reading is a complex activity in which several cognitive processes are simultaneously involved, such as: working memory, attention, executive functions (EF), rapid automatic naming, among others, that the possibility of interventions is considered, which involve, in addition to phonological awareness, the stimulation of other linguistic-cognitive abilities, such as EF.

To Gilbert and Burgess (2008), the EF involves the highest-level cognitive processes that allow the individual to decide what to do when they need to make a decision and adapt to unfamiliar circumstances. Lezak (1982) describes EF as the center of personal development that is wholly or partly involved in everything that is done by the individual. It is the ability to build objectives, plan how to execute them, and follow them so they are developed efficiently.

In a more recent conceptualization, Diamond (2013) describes EF as a group of top down cognitive processing evoked during concentration, or intuitive or automatic behavior. It is a cognitive process that involves effort because it depends on the need or the will of the individual. Often doubts are found about the EF, since they are also nominated as: executive control, cognitive control, executive processes and executive skills. However, some works define them as central executive, relating to working memory (Miyake et al., 2000; Corso, Sperb, Jou, & Salles, 2013; Cartwright, 2015). It is, therefore, an umbrella term used to refer to higher-level cognitive and metacognitive processes of control and management of other mental, emotional, and behavioral processes (Diamond, 2013; Gilbert & Burgess, 2008; Seabra, Laros, Macedo, & Abreu, 2014; Corso et al., 2013).

The executive functions required to solve problems are considered to be high-functioning, performing complex activities. However, these functions are only possible due to the performance of the basic EFs named by Miyake et al. (2000) as: flexibility (alternation between objectives or mental tasks), inhibition (of responses) and working memory (updating and monitoring).

Given the complexity present in dyslexia, there is no consensus among researchers about the predictive effect of EF in isolation. There is a relegation of some EFs in dyslexics, such as working memory and inhibitory control, but this relegation is not homogeneous in all

the individuals surveyed and cannot therefore be pointed out as predictors (Medina, Minetto, & Guimarães, 2017)

Few studies addressing intervention in EFs in dyslexics have been found in the literature (Luo, Wang, Wu, Zhu, & Zhang 2013; Lima, Alves, Silva, Azoni, & Ciasca, 2015; Medina et al., 2017). Luo et al. (2013) conducted two months of computerized training in working memory in children with dyslexia, which demonstrated improvement in reading skills. The training had a positive effect on rhyme tasks and reading fluency. The training tasks involved visuospatial, phonological and executive central working memory. This result confirms what Swanson and Sachse-Lee (2001) point out: intervention focusing on working memory in both typical and dyslexic readers results in an improvement in this type of memory.

The intervention conducted by Lima et al. (2015) was performed through a neuropsychological rehabilitation program focused on EF in six students with developmental dyslexia. In addition to improving EF, students improved performance in reading comprehension and in the use of learning and reading strategies. One of the forms of interventions carried out by Lima et al. (2015) was explicit teaching, also indicated by Berninger, Raskind, Richards, Abbott, and Stock (2008), Altemeier, Abbott and Berninger (2008) and Sesma, Mahone, Levine, Eason, and Cutting (2009) as a strategy that involves the EF and that can contribute to the learning of reading. Dyslexics benefit from explicit teaching insofar as it enables them to become aware of the shape of words and their parts. Through exemplification, explicit teaching helps students reflect on what they are learning, and thus supports the development of self-regulation strategies, directing students to read and write independently. Even students who do not have reading problems can benefit from interventions for the development of executive skills, given that they provide better reading conditions and also training in the use of reading strategies, such as monitoring, which enables better reading comprehension conditions (Sesma et al., 2009).

Horowitz-Kraus, Toro-Serey and Difrancesco (2015) performed an intervention using a computerized reading acceleration program that led to improvements in all EF and reading. The results were verified by means of cerebral activation measured by EEG (electroencephalogram). Before the intervention, the dyslexics were slower in EF, and after they improved in attention (time and accuracy), inhibition, processing speed, flexibility and EF generally evaluated by the Wisconsin Sort Card Test (WSCT). The EEG results also showed a positive effect of the intervention for the reconstruction of neural circuits related to visual processing, EF, memory and language areas in children with reading difficulties.

The longitudinal study conducted by Walda, van Weerdenburg, Wijnants and Bosman (2014) aimed to investigate whether progress in reading for dyslexic children is affected by EF, i.e. whether EFs contribute to proficiency in dyslexic literacy. The results showed that EFs are implicated in dyslexia, but do not predict progress in reading and spelling during the remediation process. Considering their results, the authors hypothesized that deficits in EF and reading are caused by the same problems (cognitive and phonological deficit).

However, in a recent systematic literature review, Medina et al. (2017) point out that several studies suggest the inclusion of EF stimulation to improve reading performance, considering that multiple dyslexia deficits require broader intervention, not only in phonological

awareness and reading. EF affects "reading strategies involving manipulation of information, response time, the capacity to inhibit distracting stimuli, as well as the alternation between different elements with different meanings" (Medina et al., 2017, p. 450), so the stimulation of EF may also bring benefits to the reading.

Considering the cognitive aspects of developmental dyslexia and the role of executive functions in reading, the purpose of this study was to find elements of response to the following question: what is the impact on performance in tasks of executive and reading functions of students with developmental dyslexia participants of an intervention program involving the phonic method associated to the stimulation of executive functions? In order to answer this question, we compared the performance of dyslexic students in the experimental group (intervention participants) in tasks that evaluate phonemic awareness, executive functions and reading (word recognition, reading and understanding of sentences and short texts) with the performance of participants from three control groups (dyslexics not participating in the intervention, readers of the same age group as of the dyslexics and younger readers) before and after the interventions implemented with the experimental group.

2 Method

This study was submitted to the Ethics Committee of the Federal University of Paraná and obtained authorization under the number CAAE 56442416.0.0000.102. Its accomplishment took place in a Municipal Center of Specialized Educational Service (called CMAEE) and in Municipal Schools of the city of Curitiba, Paraná, Brazil.

2.1 Participants

The 37 participants with dyslexia indicated by the Department of Inclusion and Specialized Educational Service (known as DIAEE) had been evaluated in CMAEEs of the city and had a diagnosis of dyslexia attested by a multiprofessional team. After careful review of the documentation, 23 individuals agreed to participate and completed the pre-test. After the application of exclusion criteria (non-confirmation of dyslexia and unavailability to participate in the intervention), 14 boys with dyslexia with a mean age of 10.7 years were selected, who were divided into two groups: experimental and control with dyslexia. The criterion for organizing the groups was the willingness to participate in interventions in pairs or trios once a week. For the age control group, seven boys who were enrolled in the same schools as the participants with dyslexia were selected. Four boys comprised the control group of younger, skilled readers who attended two grades below schooling than the dyslexics, with a mean age of 8.67 years (Table 1).

Group	N	Mean	CI	Median	SD
Experimental Group - Dyslexics - EG	7	10.65	9.54 a 11.77	10.54	1.20
Dyslexic Control Group - DCG	7	10.66	9.53 – 11.79	10.23	1.21
Age Control Group - ACG	7	10.35	9.61 – 11.08	10.18	0.79
Control Group of Younger Readers - RCG	4	8.67	8.23 – 9.11	8.77	0.27

Table 1. Number of participants and age
Source: Elaborated by the authors.
Legend: N: number of subjects; SD: Standard deviation; CI: Confidence Interval.

2.2 Procedure

The control groups were formed by pairing (matching). Firstly, students with dyslexia were evaluated in the reading tests and executive functions, in order to confirm the diagnosis of dyslexia and also to form the experimental and control groups with dyslexia. After surveying the characteristics of these students - age, school year and reading level -, we selected students from the control groups, of the same age and younger, from the schools where the students in the experimental group studied.

The pre and post-test in the experimental group was applied in the Municipal Center of Specialized Service (CMAEE), where the selected subjects received psychopedagogical assistance, being evaluated on the same days and times that they already received assistance. Between 4 and 5 sessions were held for the initial evaluation, approximately 45 minutes each, according to the degree of difficulty and the execution time of each participant.

The evaluation of the participants of the control groups without reading difficulties was carried out at the school where they studied, during class hours, according to the pedagogical team's release, in any room that was available. Three to four sessions were conducted, from 45 to 60 minutes each.

The experimental group was subdivided into two pairs and three trios, who received an intervention beginning in May 2017 and ending in December of the same year, totaling 28 weekly meetings. The three subgroups received the same intervention applied from a previously prepared work script. At the end, the participants, the family and the CMAEE team received feedback.

In order to stimulate executive functions (working memory, inhibitory control, cognitive flexibility, organization, planning, monitoring and evaluation), combined with phonemic awareness, reading and the development of reading comprehension, work modules were organized. The estimated time devoted to working each function is described in Table 2. In total, approximately 32 hours and 55 minutes were allocated for the stimulation of executive functions and 15 hours and 40 minutes for the stimulation of phonemic awareness, reading, and development of reading comprehension. The number of hours is only an estimate for the purpose of organizing and planning activities, since the same activity could stimulate more than one function concomitantly.

Modules (Worked Area)		**Number of sessions**	**Total amount of hours**
Executive Functions	Specific work memory activities	9	4h
	Specific inhibitory control activities	9	4h
	Specific cognitive flexibility activities	9	4h
	Organization, planning, monitoring and evaluation	28	20h55
Phonemic awareness and reading		22	9h05
Reading and reading comprehension		13	6h35
Total amount of hours			48h35

Table 2. Workload dedicated to the functions worked.
Source: Elaborated by the authors.

The activities chosen and elaborated for this program are based on activities and playful games that already exist and are publicly available for consultation and application in the field of education and cognitive stimulation used in research, Cognitive Psychology, Psychopedagogy and Neuropsychology. The authors consulted were: Adams, Foorman, Lundberg and Beeler (2006); Gear (2006); Meltzer (2010); Kaufman (2010); Fisher and Price (2012); Cooper-Kahn and Foster (2013); Dias and Seabra (2013); Spinillo and Mota (2013); Lima et al. (2015); Rocha (2015); Sampaio (2016a; 2016b); C. Cardoso and Fonseca (2016) and Tarrant and Holt (2016).

2.3 Instruments

Table 3 shows the instruments used in the pre and post-intervention phase of this study.

Instruments	Purpose of the application
PROLEC – Test of evaluation of reading processes (Capellini, Oliveira, & Cuetos, 2014)	Evaluate the reading of frequent, non-frequent words, pseudowords and comprehension of short texts.
Tasks of Phonemic Consciousness (Godoy & Cogo-Moreira, 2015)	Evaluate phonemic awareness.
TELCS – Reading test: Sentence comprehension (Vilhena, Sucena, Castro, & Pinheiro, 2016)	Evaluate reading comprehension of sentences.
Trail test part A and B (Seabra & Dias, 2012)	Evaluate cognitive flexibility.
Task of repetition of digits in inverse and direct order (Salles et al., 2016)	Evaluate the central executive component of working memory.
Span task of pseudowords (Salles et al., 2016)	Evaluate the phonological component of working memory.
Visuospatial working memory task (Salles et al., 2016)	Evaluate the visuospatial component of the working memory.
Audible Go/No Go Task (Salles et al., 2016)	Evaluate inhibitory control.
Attention Cancellation Test (Montiel & Seabra, 2012a)	Evaluate inhibitory control/selective attention.
Verbal Fluency Task (Salles et al., 2016)	Evaluate verbal fluency/executive functioning.

Table 3. Instruments applied in the study
Source: Elaborated by the authors.

3 Results

Non-parametric analysis were performed using the Mann-Whitney (U) statistical test to compare if there was a difference in inter-group (experimental and control) performance before and after the intervention, and the Wilcoxon (Z) statistical test for related samples to verify if there was a difference in the intra-group performance measured in the two moments of the research (pre and post-intervention), in the four groups of the research.

The absence of a significant difference ($p \leq 0.05$) between the ages of EG, DCG and ACG is confirmed by the Mann-Whitney test, as presented in Table 3. It is also possible to observe the significant difference in RCG age with the group of dyslexics.

	Md 1	Md 2	U	*p*
EG x DCG		DCG – 10.23	16.000	.277
EG x ACG	EG – 10.54	ACG – 10.18	21.000	.655
EG x RCG		RCG – 8.77	0.000	.008

Table 4. Age difference between groups.
Source: Elaborated by the authors.
Legend: Md: Median; U of Mann-Whitney; *p*: significance; EG: Experimental Group; DCG: Dyslexic Control Group; ACG: Age Control Group; RCG: Younger Readers Control Group.

As it can be seen in Table 4, the two groups of dyslexics (EG and DCG) did not differ significantly (U = 17.00, *p* = .335) in the phonemic awareness score at the initial evaluation, although the EG presented a higher median. In the comparison after the intervention, the EG showed to have progressed more significantly than the control group (U = 3.50, *p* = .007).

When comparing the evaluations of the reading of frequent, non-frequent words and pseudowords made with the PROLEC test, there was no significant difference between the groups in the pre-test, even with the EG medians being higher. After the intervention, the EG presented a significantly better performance than the DCG in the frequent (U = 7.00, *p* = .024) and non-frequent (U = 7.00, *p* = .023) reading evaluation, although this difference was not confirmed by the reading of pseudowords (U = 9.50, *p* = .052).

Instruments	Pre-intervention				Post intervention			
	Md EG	Md DCG	U	p	Md EG	Md DCG	U	P
Phonemic awareness	11.00	4.00	17.00	.335	32.00	22.00	3.50	**.007****
PROLEC - Reading of frequent words	17.00	4.00	10.50	.067	19.00	12.00	7.00	**.024***
PROLEC - Reading of non-frequent words	11.00	6.00	16.00	.274	18.00	9.00	7.00	**.023***
PROLEC - Pseudoword reading	8.00	2.00	13.00	.138	18.00	10.00	9.50	.052
PROLEC - Reading of frequent, non-frequent words, pseudowords	39.00	13.00	15.50	.250	56.00	31.00	7.00	**.025***
TELCS – Sentence comprehension	1.00	0.00	19.50	.479	6.00	6.00	18.50	.437
PROLEC - Text comprehension	0.00	0.00	23.50	.881	10.00	9.00	23.00	.846

Table 5. Mann-Whitney test results for dyslexic inter-group comparisons of pre and post-intervention in the evaluation of phonemic awareness and reading
Source: Elaborated by the authors.
Legend: EG: Experimental group; DCG: Dyslexic Control Group; Md: Median; U: Mann-Whitney; *p*: significance. Significance: * p <0.05.

In the evaluation of reading and comprehension of sentences and short texts, the two groups progressed over time and maintained similar performance in these two comprehension measures in the post-test (TELCS - *U* = 18.50, *p* = .437 / PROLEC - *U* = 23.00, *p* = .846).

As it can be seen in Table 5, when comparing participants' initial performance with their own performance in the final phase of the study, there was significant progress of the two

groups of dyslexics in phonemic awareness over time (EG: Z = -2.371, p = .018; DCG: Z = -1.997, p = .046).

Regarding the evaluation made by PROLEC, although the two groups improved their performance, only the EG increased their score significantly, when reading frequent words (Z = -2.207, p = .027), non-frequent words (Z = -2.384, p = .017) e pseudowords (Z = -2.371, p = .018).

Regarding the reading comprehension, the two groups, which showed similar performance in the pre-test, progressed significantly in reading and sentence comprehension (EG p = .016; DCG p = .042). In the reading and comprehension of short texts, evaluated by PROLEC, the two groups had their medians increased, but only the EG showed a significant difference in comparison to their own performance in the pre-test (Z = -2.032, p = .042).

To verify the effect of age, the performance of proficient readers of the same age group (ACG) than the dyslexic groups was compared before and after the intervention period suffered by the EG, demonstrating that there was no significant change in phonemic awareness, reading words, comprehension of sentences and texts, as a result of time or development in the period between the two evaluations. The same happened in the intra-group comparison of skilled readers with a younger age group (RCG), allowing to affirm that the changes identified in the groups of dyslexics may be due to the intervention they received.

Evaluations	Group	Pre Md	Post Md	Z	P
Phonemic awareness	EG	11.00	32.00	-2.371	**.018***
	DCG	4.00	22.00	-1.997	**.046***
	RCG	44.00	49.50	-1.841	.066
	ACG	52.50	54.00	-0.534	.600
PROLEC - Reading of frequent words	EG	17.00	19.00	-2.207	**.027***
	DCG	4.00	12.00	-1.581	.114
	RCG	20.00	20.00	-1.000	.317
	ACG	20.00	20.00	-1.134	.257
PROLEC - Reading of non-frequent words	EG	11.00	18.00	-2.384	**.017***
	DCG	6.00	9.00	-1.826	.068
	RCG	18.00	19.50	1.000	.000
	ACG	19.00	19.00	-.137	.891
PROLEC - Reading of pseudowords	EG	8.00	18.00	-2.371	**.018***
	DCG	2.00	10.00	-1.625	.104
	RCG	16.00	19.50	-1.414	.157
	ACG	19.00	18.00	-.105	.916
PROLEC - Reading of frequent and non-frequent words and pseudowords	EG	39.00	56.00	-2.375	**.018***
	DCG	13.00	31.00	-1.572	.116
	RCG	53.00	59.00	-1.342	.180
	ACG	58.00	57.00	-.256	.798
TELCS – Sentence comprehension	EG	1.00	6.00	-2.414	**.016***
	DCG	0.00	6.00	-2.032	**.042***
	RCG	10.00	18.00	-1.604	.109
	ACG	19.00	24.00	-1.897	.058

PROLEC - Text comprehension	EG	0.00	10.00	-2.032	**.042***
	DCG	0.00	9.00	-1.841	.066
	RCG	10.00	12.00	-.271	.786
	ACG	12.00	12.00	-.368	.713

Table 6. Wilcoxon test results for intra-group comparison of performance in the evaluation of phonemic awareness, reading and comprehension before and after intervention
Source: Elaborated by the authors.
Legend: EG: Experimental Group; DCG: Dyslexic Control Group; RCG: Reader Control Group; ACG: Age Control Group. Md: Median; Z: Wilcoxon; *p*: significance. Significance: * p < 0,05.

Regarding the executive functions (Table 6), it is possible to observe that the groups did not differ in the assessment of cognitive flexibility before the intervention. Despite the difference between the pre and post-test medians in both groups, this difference was not significant, and in the post-test the two groups continued to perform similarly (Trails A - U = 17.50, p = .336 / Trails B - U = 17.00, p = .336).

In the evaluation of working memory, the performance of the dyslexic groups, which in the pre-test was similar in the Direct, Inverse Digit Test and Pseudoword Span, did not change significantly in the post-test. The EG showed inferior performance to the DCG in the post-test in the Inverse Digit test, but this difference was not significant (U = 24.50, p = 1.000). Thus, in relation to the general working memory, both groups maintained similar performance in the two moments of the research, not denoting a significant difference (U = 17.00, p = .335). In the evaluation of verbal fluency, it was observed that, after the intervention, the median performance of the two groups of dyslexics increased, both in verbal orthographic and semantic fluency, but, in the same way as in memory, this difference was not significant. In the Go/No Go test the EG, which initially had DCG-like performance (U = 21.50, p = .699), differed significantly in the post-test (U = 5.50, p = .013).

Instruments	Pre-intervention				Post intervention			
	Md EG	Md DCG	U	P	Md EG	Md DCG	U	p
Trails A	19.00	19.00	20.50	.593	24.00	18.00	17.50	.336
Cognitive Flexibility - Trails B	8.00	6.00	22.00	.746	9.00	5.00	17.00	.336
Working memory - Direct digits	17.00	21.00	18.50	.441	19.00	17.00	24.50	1.000
Working memory - Inverse digits	11.00	15.00	19.00	.481	10.00	14.00	24.50	1.000
Working memory – Pseudoword span	11.00	9.00	16.50	.300	9.00	8.00	17.50	.364
Working Memory - Visuospatial	18.00	17.00	14.00	.176	25.00	24.00	17.00	.331
Working memory - Total score	60.00	52.00	18.50	.443	64.00	59.00	17.00	.335
Orthographic verbal fluency	3.00	3.00	22.00	.741	6.00	4.00	13.00	.136
Semantic verbal fluency	13.00	12.00	21.00	.654	14.00	14.00	18.50	.442
Inhibitory Control – Go/NoGO	52.00	50.00	21.50	.699	56.00	53.00	5.50	**.013***
Inhibitory Control – Go/ NoGO – errors	4.00	4.00	21.50	.697	3.00	3.00	17.50	.350

Inhibitory Control – Go/ NoGO – Omissions	2.00	3.00	22.00	.745	1.00	4.00	11.00	.078
Cancellation - Total Score	78.00	80.00	23.00	.848	85.00	81.00	18.50	.443
Cancellation - Total errors	0.00	0.00	22.50	.748	0.00	0.00	14.00	.061
Cancellation - Total Omissions	30.00	28.00	23.00	.848	23.00	29.00	14.00	.179

Table 7. Mann-Whitney test result for dyslexic inter-group comparisons in executive functions
Source: Elaborated by the authors.
Legend: EG: Experimental Group; DCG: Dyslexic Control Group; Md: Median; U: Mann-Whitney; *p*: significance. Significance: * p <0.05.

In the results of the comparison of the final performance with the initial performance of the cognitive flexibility, it was observed that the EG progressed its performance in the two subtests; whereas the DCG scored lower than its own performance in the post-test of the two instruments, but these differences were not significant, as indicated in Table 8.

In the evaluation of working memory, the performance of the dyslexic groups, which in the pre-test showed to be similar in the Direct, Inverse Digit Tests and Pseudoword Span, did not change significantly in the post-test. In the evaluation of visuospatial memory, only the DCG progressed in its performance when compared to the pre-test (Z = -2.371, p = .018).

The two groups of dyslexics progressed in the orthographic verbal fluency, but only the EG showed a significant difference when compared to the pre-test (Z = -2.207, p = .027). In the evaluation of semantic verbal fluency, none of the groups showed significant difference before and after intervention. In the Go/No Go test, the EG progressed significantly in its performance (Z = -2.201, p = .028), as well as the number of omissions made at the beginning of the research decreased (Z = -2.232, p = .026).

Evaluation	Group	Pre Md	Post Md	Z	P
Cognitive flexibility - Trails A	EG	19.00	24.00	-.962	.336
	DCG	19.00	18.00	-1.472	.141
	RCG	24.00	24.00	-1.000	.317
	ACG	24.00	24.00	-1.342	.180
Cognitive Flexibility – Trails B	EG	8.00	9.00	-.848	.396
	DCG	6.00	5.00	-.085	.932
	RCG	7.00	12.00	-.447	.655
	ACG	15.00	16.00	-.681	.496
Working memory - Direct digits	EG	17.00	19.00	-.816	.414
	DCG	21.00	17.00	-.425[a]	.671
	RCG	18.00	19.00	-1.633	.102
	ACG	22.00	22.00	-.552	.581
Working memory - Inverse digits	EG	11.00	10.00	-1.873[a]	.061
	DCG	15.00	14.00	-.254[a]	.799
	RCG	15.00	18.00	-.730	.465
	ACG	20.00	18.00	-1.261[a]	.207
Working memory - Pseudowords span	EG	11.00	9.00	-1.018[a]	.309
	DCG	9.00	8.00	-.170[a]	.865
	RCG	12.00	11.00	-1.461[a]	.144
	ACG	12.00	11.00	-1.109[a]	.268

Working Memory - Visuospatial	EG	18.00	25.00	-1.378	.168
	DCG	17.00	24.00	-2.371	**.018***
	RCG	24.00	24.00	-.552	.581
	ACG	28.00	23.00	-1.051	.293
Working memory - Total score	EG	60.00	64.00	-1.947	.051
	DCG	52.00	59.00	-1.690	.091
	RCG	67.00	73.00	-.730	.465
	ACG	79.00	71.00	-.170[a]	.865
Orthographic verbal fluency	EG	3.00	6.00	-2.207	**.027***
	DCG	3.00	4.00	-1.552	.121
	RCG	5.00	6.00	.000	1.000
	ACG	7.00	7.00	-.954	.340
Semantic verbal fluency	EG	13.00	14.00	-1.725	.084
	DCG	12.00	14.00	-.105	.916
	RCG	9.00	14.50	-1.841	.066
	ACG	16.00	18.00	-1.101	.271
Inhibitory Control – Go/NoGo – Total score	EG	52.00	56.00	-2.201	**.028***
	DCG	50.00	53.00	-1.275	.202
	RCG	54.00	54.50	-1.416[a]	.144
	ACG	54.00	59.00	-2.214	**.027***
Inhibitory Control – Go/NoGo – Errors	EG	4.00	3.00	-1.802[a]	.072
	DCG	4.00	3.00	-1.370[a]	.171
	RCG	2.00	3.00	-.271	-1.633
	ACG	3.00	1.00	-2.023	**.043***
Inhibitory Control – Go/NoGo – Omissions	EG	2.00	1.00	-2.232[a]	**.026***
	DCG	3.00	4.00	-.271	.786
	RCG	4.00	2.50	-1.633	.102
	ACG	2.00	0.00	-1.841	.066
Selective attention - Cancellation – Total score	EG	78.00	85.00	-1.439	.150
	DCG	80.00	81.00	-.931	.352
	RCG	66.00	76.50	-1.826	.068
	ACG	88.00	91.00	-1.859	.063
Selective attention - Cancellation - Total errors	EG	0.00	0.00	-1.414[a]	.157
	DCG	0.00	0.00	-1.604	.109
	RCG	0.00	0.00	-1.000	.317
	ACG	0.00	0.00	.000	1.000
Selective attention - Cancellation - Total omissions	EG	30.00	23.00	-1.693[a]	.090
	DCG	28.00	29.00	-.593[a]	.553
	RCG	42.00	31.50	-1.826	.068
	ACG	17.00	17.00	-1.859	.063

Table 8. Wilcoxon test results for intra-group comparison of performance in the evaluation of executive functions before and after intervention

Source: Elaborated by the authors.

Legend: EG: Experimental Group; DCG: Dyslexic Control Group; RCG: Reader Control Group; ACG: Age Control Group. Md: Median; Z: Wilcoxon; *p*: significance. [a]: based on the negative ranks. Significance: * p <0.05.

In the Cancellation test, both groups of dyslexics showed similar performance at the beginning and at the end of the study. Although the EG has advanced (pre md: 78.00, post md: 85.00) in its performance and performed fewer omissions in the post-test (pre md: 30.00, post md: 23.00), this difference was not significant (Z = -1.693, p = .090). The number of errors made in both Go/No Go and Cancellation tests showed no significant difference for the two groups of dyslexics, either before or after the intervention.

As also observed in reading assessments, the two control groups of skillful readers (ACG and RCG) maintained initial performance in evaluations of executive functions of working memory, cognitive flexibility, verbal fluency, and selective attention/cancellation. Only in the evaluation of the inhibitory control with the Go/No Go test there was a significant difference in intra-group ACG performance, obtaining a greater number of correct answers (Z = -2.214, p = .027) and a smaller number of errors (Z = -2.023, p = .043) in the post-test.

4 Discussion

Initially, both groups of dyslexics showed similar performance in phonemic awareness, and, after the intervention, both groups progressed significantly, but the EG in the post-test performed significantly better than the DCG. Phonemic awareness is one of the components of metalinguistics most closely related to reading, especially with the ability to detect phonemes (Goswamy & Bryant, 1990). As Snowling (2004, p. 55) reports, "phonemic awareness is not a prerequisite for reading, but a consequence of literary aptitude", which is developed simultaneously.

The most commonly used intervention for the remediation of reading difficulties in dyslexics involves the stimulation of phonological awareness (Capellini, Martins, Fadini, Refundini, & Fukuda, 2011). This type of intervention, when properly applied, meets the needs of children with dyslexia. There are few studies that show the advantages of an intervention program also involving EF in dyslexics, especially with Brazilian participants. There is already evidence of the positive effect of interventions involving EF in young children with no learning difficulties (Dias & Seabra, 2015a, 2015b) and in children with ADHD (Menezes, Dias, Trevisan, Carreiro, & Seabra, 2015). To this day, the only program found in the Brazilian literature used in dyslexics is the one conducted by Lima (2015).

It is complex to compare intervention programs, since each one has its particularities and intervening variables that can affect the presented result, although the same program is applied by different professionals. In any case, it can be seen that the programs that focused on the executive functions in its scope of intervention have brought progress to its participants, as is the example of the program of 30 sessions of neuropsychological rehabilitation in executive functions for students with dyslexia developed by Lima (2015) and applied to six students with a mean age of 14.67 (± 1.03) years. The results of this study showed that, after the intervention, the group of dyslexics advanced in reading comprehension, and especially in the functions of attention, memory, inhibitory control, cognitive flexibility and semantic verbal fluency. In addition, participants began to use more reading and learning strategies, particularly metacognitive strategies.

The ability to read frequently, non-frequent words and pseudowords evaluated by PROLEC, when comparing intra-groups, showed that only the EG progressed significantly

in the post-test. And when comparing inter-groups, in evaluations of frequent, non-frequent and general word reading, the EG showed a performance significantly superior to DCG. In the evaluation of pseudowords reading, the two groups presented equivalent performance at the beginning of the research. At the end, when compared in the post-test, both still had no significant difference between them, showing that both groups of dyslexics evolved in this evaluation. These results indicate that both groups progressed in reading throughout the year; the EG, however, has made further progress. We can then hypothesize that the intervention program used is an efficient method for dyslexics because it showed results in reading learning, in the same way as programs that do not include executive functions and the use of metacognitive strategies (Cirino et al., 2017).

There are several studies that show the low performance of dyslexics in word and pseudoword reading (Capovilla, Trevisan, Capovilla, & Rezende, 2007; Salles & Parente, 2002; Guimarães, 2005). According to Coltheart, Masterson, Byng, Prior and Riddoch (2007), Ellis (1995), Coltheart (1996) and Snowling and Hulme (2013), better performance in reading words than pseudowords in dyslexics denotes the use of the lexical route for reading (direct), that is, it is easier for the reader to read words that he/she already knows and are stored in his/her mental lexicon. However, when he/she needs to read aloud non-words or unknown words, he/she performs decoding, but, if he/she does not find in the repertoire of phonological and orthographic lexicon the representation of the proper pronunciation of the word, he/she fails the reading (Manis, Seidenberg, Doi, McBride-Chang, & Petersen, 1996; Manning, 2008).

With the advances in reading performance of isolated words obtained by dyslexics, we believe that it is possible to affirm that the intervention was effective and that the learning of these dyslexic students needs to continue to be monitored so that they can recognize words more and more automatically and therefore "free" cognitive resources for reading comprehension. Corroborating this hypothesis, Alégria, Leybaert and Mousty (1997) argue that when there is no automatism in reading, the reader dispenses so much cognitive effort to decipher each of the words that make up the text, that is, for decoding, which ends up leaving little or nothing left to invest in understanding.

In the evaluation of sentence comprehension (TELCS), the two groups showed progress in an equivalent way throughout the research, as indicated by their medians; therefore, both groups of dyslexics showed compatibility in the ability to read and understand sentences that evolved throughout the intervention they received. Reading and sentence comprehension are less complex activities than reading and understanding texts. In a process of progressive learning, the child first learns to read words, which progresses to reading of sentences and, consequently, to texts (Morais, 2013). It can be said that the advancement in decoding in both groups transferred effects to the sentence comprehension. As in these groups there were advances in word reading, these advances influenced the reading and the comprehension of sentences.

In relation to the comprehension capacity of short texts (PROLEC), the two groups improved their performances, maintaining the similarity before the intervention, in the inter-group comparison after the intervention. In the intra-group comparison, only the EG significantly improved its ability, when compared to its own performance after the intervention.

The intervention did not affect the performance of the executive functions of cognitive flexibility and working memory in the EG, when compared to the other dyslexics who did not receive the intervention, neither in comparison to the pre-test. As justification for this result, it is considered that the instruments may not have been sensitive to capture the advances in work memory and cognitive flexibility, or that the amount of stimulation focused on working memory and on cognitive flexibility was not sufficient and efficient to cause cognitive changes that would impact the performance of the tests that evaluate these functions.

Two meta-analyzes aimed at verifying the effects of work-memory training (Shipstead, Redick, & Engle, 2012; Melby-Lervag & Hulme, 2013) show that, although the literature demonstrates that working memory stimulation yields results, there are still controversies, since there are several factors that can influence its performance, such as: age of the participants, characteristics of the samples, amount of training, types of tasks used for training and type of evaluations performed. Melby-Lervag and Hume (2013) report that work memory training yields results in tasks similar to those that have been trained, but there is no evidence that work memory training produces gains in other areas, such as verbal ability, decoding, or arithmetic, even when assessed immediately after training.

Working memory is important for learning, but it is not easy to intervene in this deficit, especially when it is also related to reading, as is the case with dyslexics. The stimulation of executive functions in activities that also involved phonemic awareness and reading brought advances to reading, but did not evidence specific advances in working memory.

The EG performance also improved, after the intervention, in orthographic verbal fluency and inhibitory control as measured by Go/No Go, both in intra-group and inter-group comparisons. Berninger, Abbott, Cook and Nagy (2016) applied the FAS test in order to relate their results to oral language, reading and writing in dyslexics. They used the word repetition index during the two subtests to provide self-monitoring capability measures (remember the words already spoken and do not repeat them). From the study, it is concluded that verbal fluency and inhibition are significantly correlated to auditory and verbal language, that is, they are correlated to the cognitive measures involved in the linguistic translation process. These findings allow the interpretation that, during academic learning, students are constantly making translations through the domains of cognition and language, and that such translation may be difficult in children with learning difficulties, but that it is possible to overcome them with adequate remediation.

The results of the study conducted by Cirino et al. (2017) suggest some reflections on this and that need to be considered. The authors applied an intervention involving EF and the teaching of self-regulation strategies for the reading comprehension in 24 students of the fourth year of Elementary School without learning difficulties. The performance of this group was compared to the performance of 27 students from the same school level who did not receive any stimulation, and 24 students who participated in a reading comprehension stimulation based only on reading the text, both from the same school level. At the end of the study, comparison of the groups showed little difference in performance in reading comprehension, regardless of the intervention received. In addition, the groups that received intervention improved performance in what was specifically taught to them. In view of these results, the researchers raised three hypotheses: (a) the academic knowledge base and the motivated attitude

to learn that the students brought with them may have affected the results; (b) the time of the sessions in the two groups was the same, however the group that received EF stimulation together with self-regulation strategies for reading comprehension should have been larger; (c) the instrument used to assess reading comprehension did not verify whether students used the strategies they were taught when undergoing reading comprehension assessment.

The study conducted by Cirino et al. (2017) shows the complexity of developing an experimental research, and how important it is to choose well the samples and instruments to be used. Thus, when the results of the cited research (Cirino et al., 2017) as well as this research are analyzed, it is possible to highlight, also based on Diamond and Ling (2016), that performance in EF does not depend exclusively on an intervention; on the contrary, EF is a group of cognitive abilities that manifests itself at all times in which an individual is performing some task. In this perspective, it should be pointed out that the participants of this research were involved in academic activities, in full youth development, experiencing formal, informal, playful, emotional, and learning experiences that undoubtedly affected their training and may have affected the results of this research.

5 Conclusion

The comparison of inter-group performance of dyslexics showed that in the post-test the experimental group presented significantly higher performance than the dyslexic control group in reading isolated words (frequent, non-frequent and pseudowords). These results allow us to conclude that the participation of dyslexics in an intervention focusing on the development of phonemic awareness, reading, and executive functions was efficient to promote their performance in reading, especially the reading of isolated words.

In addition, it is important to note that one of the limitations of this study is the size of the sample, although it is known of the difficulties of finding participants with the profile needed for research of this nature. Thus, it is suggested that new studies such as the one presented here are performed, since, as previously mentioned, there are still few studies that focus on executive functions in dyslexics, especially in the context of the Portuguese language of Brazil.

Another limitation of the study is related to the instruments for evaluating executive functions. In this sense, it is recommended to analyze and evaluate the adequacy of the instruments used to capture performance in cognitive flexibility and verbal fluency. This is because the Trail test (A and B), used to assess cognitive flexibility, uses the alphabet, and dyslexics may have difficulty in alphabetical ordering, being at a disadvantage when compared to other participants. Moreover, the FAS test, used to evaluate verbal fluency, because a reduced version was used, may limit the capture of participants' performance.

Finally, the scientific contribution of this study, which aims to increase the knowledge about the cognitive functioning of dyslexics, especially the EF, has to be emphasized. In addition, the work offers an intervention option for professionals that work with students with developmental dyslexia, who aim to learn reading. Thus, it is believed to be possible to say that this work increases the reflections on the linguistic-cognitive abilities of students with dyslexia, in order to seek new answers for their remediation.

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