



# Phonological awareness training in students with risk indicators for learning difficulties

Programa de remediação fonológica  
em escolares com sinais de risco para  
dificuldades de aprendizagem

Programa de remediación fonológica en los  
estudiantes con señales de riesgo para las  
dificultades de aprendizaje

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## Abstract

Introduction: Learning difficulties can provide obstacles to the literacy process of schoolchildren. The development of reading and writing depend on a broad set of skills, but the stimulation of phonological awareness appears as one of the most important factors in this process. Given the importance of this skill, intervention models called phonological remediation programs have been adopted. However, the literature has offered greater attention to the implementation of these programs in populations already diagnosed with learning disabilities, thus students whose academic deficits are already present. Objective: To investigate the cognitive-linguistic performance of children with risk indicators for learning difficulties after a phonological remediation program. Material and method: Ten children of both genders were selected, aged 6-7 years and 11 months, considered with signs of risk for learning difficulties. After the selection, they were subjected to a phonological remediation program (18 therapy sessions, individual

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sessions, lasting 50 minutes). Results: After the intervention, it was found that the students showed significant progress in cognitive-linguistic abilities, phonological awareness, auditory working memory, access to the mental lexicon, and reading and writing of real words. However, as control groups were not adopted in the methodology of the study cannot be said that the results derive exclusively from the remediation. Conclusion: The results reinforced the importance of early intervention in children with signs of risk for learning disabilities, as it offers better conditions for the development of reading and writing in this population.

**Keywords:** remediation; learning disorders; risk factors; child; reading.

### Resumo

*Introdução:* As dificuldades de aprendizagem podem oferecer barreiras ao processo de alfabetização de crianças em fase escolar. O desenvolvimento da leitura e escrita depende de um amplo conjunto de habilidades, entretanto a estimulação da consciência fonológica configura-se como um dos fatores mais relevantes a esse processo. Dada a importância dessa habilidade, surgem modelos de intervenção denominados de programas de remediação fonológica. Porém, a literatura tem oferecido maior atenção à aplicação desses programas em populações já diagnosticadas com transtornos de aprendizagem, cujos prejuízos acadêmicos já estão presentes. **Objetivo:** Verificar o desempenho cognitivo-linguístico de escolares com sinais de risco para dificuldades de aprendizagem, após a aplicação de um programa de remediação fonológica. **Material e método:** Foram selecionadas 10 crianças de ambos os gêneros, na faixa etária de 6 a 7 anos, consideradas com sinais de risco para as dificuldades de aprendizagem. Após a seleção foram submetidas ao programa de remediação (18 sessões de terapia, atendimentos individuais, com duração de 50 minutos). **Resultados:** Verificou-se que os escolares apresentaram evolução significativa nas habilidades cognitivo-linguísticas de consciência fonológica, memória de trabalho auditiva, acesso ao léxico mental, leitura e escrita de palavras reais após a intervenção. Entretanto, como não foram adotados grupos controles na metodologia do estudo, não se pode afirmar que os resultados decorrem exclusivamente da remediação. **Conclusão:** Os resultados reforçaram a importância da intervenção precoce em escolares com sinais de risco para dificuldades de aprendizagem, uma vez que oferece melhores condições para o desenvolvimento da leitura e escrita nessa população.

**Palavras-chave:** remediação; transtornos de aprendizagem; fatores de risco; criança; leitura.

### Resumen

*Introducción:* Las dificultades de aprendizaje pueden colocar barreras al proceso de alfabetización de niños en edad escolar. El desarrollo de la lectura y la escritura depende de un amplio conjunto de habilidades, no obstante el estímulo de la conciencia fonológica se revela como uno de los factores más relevantes en este proceso. Dada la importancia de esa habilidad, surgen modelos de intervención denominados programas de remediación fonológica. Sin embargo, la literatura ha dado mayor atención a la aplicación de esos programas en poblaciones ya diagnosticadas con trastornos de aprendizaje, cuyos perjuicios académicos ya están presentes. **Objetivo:** Verificar el desempeño cognitivo-lingüístico de escolares con señales de riesgo para las dificultades de aprendizaje después de haber pasado por un programa de remediación fonológica. **Material y método:** Fueron seleccionados 10 niños de ambos sexos, en una franja etaria de 6 a 7 años y 11 meses, considerados con señales de riesgo para las dificultades de aprendizaje. Tras la Selección fueron sometidas al programa de remediación fonológica (18 sesiones de terapia, consultas individuales, con duración de 50 minutos). **Resultados:** se verificó que los escolares presentaron una evolución significativa en las habilidades cognitivo-lingüísticas de conciencia fonológica, memoria de trabajo auditiva, acceso al léxico mental, lectura y escritura de palabras reales. Sin embargo, como grupos de control no fueron adoptados en la metodología del estudio, no se puede decir que los resultados se derivan exclusivamente de la remediación. **Conclusión:** Los resultados reforzaron la importancia de la intervención precoz en escolares con señales de riesgo para dificultades de aprendizaje ya que ofrecen mejores condiciones para el desarrollo de la lectura y escritura en esa población.

**Palabras clave:** remediación; trastornos de la aprendizaje; factores de riesgo; niño; lectura..

## Introduction

School failure is probably the most distressing problem of Brazilian education and is manifested by difficulties in academic learning, particularly with regard to literacy<sup>1</sup>.

Learning difficulties can occur due to pedagogical problems (failure in the school method or inadequacy to the educational system), psychosocial (influence of family factors, socio-economic deprivation, emotional or motivational problems faced by the scholar), cognitive (resulting from insufficient stimulation of neuropsychological functions), among others<sup>2</sup>. However, many children are pre-labeled with “disorders” and sent to specialized centers without actually having organic changes which justify such diagnosis<sup>3</sup>. The aforementioned authors also point out that frequently the reasons for learning difficulties are centered on the learner, when in reality they could be related to insufficient stimulation of skills considered essential for literacy.

Although reading and writing development depends on a wide range of skills, phonological awareness (PA) appears as one of the most relevant factors<sup>4,5</sup>.

Phonological awareness is the ability of the individual to realize that speech is made up of different sounds, which can be segmented into smaller units (phonemes). Still reflects the ability to manipulate speech sounds: addition, segmentation, implementation and replacement of syllables and phonemes, identification and production of rhymes and alliteration, among others. In reference to writing, (PA) will be prerequisite for establishing the phoneme-grapheme relationship, ability to perceive that speech sounds (phonemes) are represented by letters (graphemes).

PA is part of the so-called phonological processing which involves the auditory working memory skills and access to mental lexicon, which are also fundamental to literacy<sup>6</sup>. According to the authors, access to mental lexicon refers to the facility and speed access to information stored in long term memory. They explain that the rapid and efficient access to phonological information allows words decoding during reading and writing process. This process also depends on the auditory working memory which corresponds to temporary storage (short-term) of phonological information<sup>7</sup>. In addition to changes in phonological processing,

presence and / or history of speech and language disorders, difficulty in recognizing letters, memory impairment (visual and / or auditory), difficulties with writing his/her name, difficulties regarding spatial and temporal orientation and laterality, are commonly found in children with learning problems<sup>8,9</sup>. The familial history, difficulty in recognizing letters, the speed of access to mental lexicon and phonological awareness can be considered as the main risk factors for reading and writing alterations, for children. The authors also point out that alterations in the mentioned skills can be detected in children as young as 3.6 years 4. Therefore, deficits in one or more of the aspects mentioned above can be considered as risk factors for learning disabilities<sup>10</sup>.

Considering the impact of PA in reading and writing performance, more attention has been given to stimulation of this ability as a strategy of prevention or rehabilitation of learning disabilities<sup>11</sup>.

In order to promote PA training, there are interventions also known as remediation programs. These programs are structured in a number of pre-set sessions and involve phonemic, syllabic and supra-phonemic activities (rhyme and alliteration), which are performed cumulatively, session after session, for a short period of time (approximately 3 months)<sup>12</sup>.

Studies show that individuals with learning disabilities perform better in reading and writing activities after exposure to remediation programs, which provides academic progress, resulting into increased self-esteem of the scholar<sup>13-14</sup>.

Neuroimaging studies also show that intensive training of phonological abilities promotes increased pattern of brain activation in the upper left temporal gyrus area, responsible for processing the phonological code<sup>15</sup>. These results demonstrate the effectiveness of these procedures and reinforce their applicability. The educational/school speech therapist can provide guidance to teachers about the various forms of stimulating PA skills for children, contributing to the literacy process<sup>17</sup>.

Stimulation in early school years is critical, because it is the right time to promote the skills which will favor further acquisition and writing and reading development<sup>18</sup>.

In 2003, the Early Years Foundation Stage Profile Program (EYFSP), a tool used for monitoring school education of children with learning disabilities, was formally introduced in English

schools. The results of EYFSP revealed that early stimulation of cognitive-linguistic skills was effective to promote reading and writing acquisition, in populations at risk for learning disabilities. Applied to 3-5 year-old-children, the program also points out that the evaluation of teachers provides important information for the development of children, enabling the identification of the ones who present high risk of educational difficulties<sup>19</sup>. Ideally, the education systems should incorporate such procedures in their policies and promote training for teachers, in order to identify and encourage children even in preschool, who require differentiated educational resources<sup>20</sup>.

Despite the above, it can be observed that those initiatives are poorly adopted by Brazilian schools, especially public education, which comprises most of the scholar population.

Considering the importance of early intervention and possible benefits of including PA activities in classrooms, this study aims to verify the cognitive-linguistic performance of children

with signs of risk for difficulties, after exposure to a remediation program.

## Casuistry And Methods

### Casuistry

A total of 10 students, both genders, took part: 2 females and 8 males aged 6-7 years and 11 months, attending elementary education from public schools and considered at risk for manifestation of learning disabilities. At first, 15 children were invited to participate in the study, but 5 were excluded due to consecutive absence in attendance. The following risk signs were considered: presence and / or historical speech and language disorder, changes in phonological awareness, access to mental lexicon, difficulties concerning recognition of letters and for writing his/her name, visual memory and /or hearing impairment and difficulties regarding spatial and temporal orientation and laterality (Table 1).

**TABLE 1 - OCCURRENCE OF RISK SIGNS IN THE POPULATION STUDIED**

	Gender/ Age	Sinais de risco considerados						
		Histórico de alteração na fala e/ou linguagem	Changes in phonological awareness	Access to mental lexicon	Difficulties in recognition of letters	Difficulties in writing his/her own name	Impairment in auditory and / or visual memory	Difficulties in temporal spatial orientation and laterality
Child 1	M/7,3	+	+	+	+	+	-	+
Child 2	M/6,5	+	+	+	-	-	-	-
Child 3	F/7,6	-	-	-	+	+	-	+
Child 4	F/7,2	-	-	-	+	+	-	-
Child 5	F/6,6	+	+	+	+	+	-	-
Child 6	F/6,5	+	+	-	-	-	+	-
Child 7	F/6,4	+	+	-	-	-	+	-
Child 8	F/6,4	+	+	-	+	+	+	+
Child 9	F/6,1	+	+	-	-	-	-	-
Child 10	F/6,0	+	+	+	+	+	-	+
Incidência (%)	F/6,2	80%	80%	40%	60%	60%	30%	40%

The selected scholar waited for speech therapy on the waiting list of a higher education public institution. These children were referred to the institution by their respective schools, whose complaint of teachers related mainly to speech (speech disorder) and learning (slow literacy process). Initially, audiological sessions were performed, after observing the need for speech therapy, the students were referred to the waiting list, to the infantile language sector.

Following the sequence of patients on the waiting list, parents / guardians were contacted by phone, checking their interest in taking part of the study. During the speech evaluation, the following exclusion criteria were adopted: children with genetic, neurological or neuropsychiatric syndromes (including Attention Deficit Disorder and Hyperactivity Disorder), (hearing or visual), motor or cognitive impairments (IQ <80), previously submitted to speech or pedagogical intervention, more than 2 consecutive absences for attendance proposed by the remediation program, and scholars who took medications for attention difficulties.

### Procedures

The study was approved by the Research Ethics Committee for Humans, in the institution where it was conducted, nº 089/2012. The parents/guardians signed the Free Informed Consent, authorizing the completion and divulgation of the research. To compare the cognitive-linguistic performance of the scholars, assessments were realized before and after (pre and post-testing) the implementation of the remediation program. All procedures were performed in the public institution, providing individual care sessions, lasting 50 minutes each. A total of 2 sessions were required for pre-testing application, 18 sessions for completion of the remediation program and 2 sessions for post-testing.

It is noteworthy to emphasize that pre- and post-testing were performed by a second researcher, thus avoiding possible influences of the principal investigator (responsible for implementing the remediation program) on the results of the study. This methodology has been identified as paramount in intervention researches, aiming bias measurement control.

Despite the above methodological care, this study presents limitations concerning the control groups. The adoption of a control group

(individuals not subjected to the tested procedures) is critical to ensure that the results are inherent to the intervention and not to external factors. However, comparisons were made with similar studies,<sup>12</sup> in which control groups were adopted. The studies applied for such comparisons evaluated students with learning disabilities, employed the same intervention model (remediation) and the same assessment procedures (cognitive-linguistic performance test, collective and individual version), enabling the discussion of results.

The pre and post-testing procedures and the remediation program applied in the study will be described below.

### Pre-testing and post-testing procedures

The Cognitive Linguistic Performance Tests were applied (collective and individual version)<sup>21</sup>. These tests are important tools for investigating the cognitive-linguistic skills involved in learning how to read and write. Thus, they can be used for the assessment of children with risk signals for learning problems. Besides speech therapists, teachers, psychologists and psychologists can also apply the tests. The collective version, as the name suggests, can be applied to more than one child at the same time, enabling its utilization in the classrooms. The other version of the test requires individual application. Different skills are evaluated for each test justifying the utilization of both..

#### Cognitive Linguistic Performance Test - collective version<sup>21</sup>

The test is originally composed of 5 trials, as follows: 1) recognition of the alphabet; 2) copy of 4 geometric shapes (assessment of visual processing); 3) mathematical calculations; 4) written proof / test - dictation (30 real words and 10 made-up) and 5) repeating numbers in random order (auditory memory). The tests were applied: 1) recognition of the alphabet; 2) copy of 4 geometric shapes; 4) written dictation, and 5) repetition of numbers in random order. The proof/test of mathematical calculations was disregarded, because the study was to evaluate the effects of remediation program on specific reading and writing skills. The results were recorded in the protocol recommended by the test, and 1 point was scored for each correct answer of the scholar.



### Cognitive Linguistic Performance Test - individual version<sup>21</sup>

The individual version consists of 13 tests, as follows: 1) reading words; 2) reading pseudo-words (made-up words); 3) alliteration and 4) rhyme (phonological awareness); 5) repetition of words and 6) repetition of pseudo-words (auditory memory); 7) rhythm (auditory processing); 8) syllabic segmentation (syllabic awareness); 9) rapid picture naming and 10) rapid naming of digits (access speed to mental lexicon); 11) visual memory for forms (short-term memory and spatial orientation); 12) discrimination of sounds (auditory processing) and 13) repetition of numbers in reverse order (repetition of 14 sequence of digits / auditory memory). All tests were applied, except rhythm test, since this ability is not stimulated by the remediation program. The results were also recorded in the protocol recommended by the test, and 1 point was scored for each correct answer of the scholar.

### **Phonological remediation program**

Upon completion of the pre-test, the scholars were submitted to the remediation program proposed by Silva and Capellini (2011)<sup>12</sup>. It is important to observe that the remediation program is cumulative, that is, in each session a new activity is included, associated with the activities of the previous sessions, always adding new words and/or phrases, different from those applied in the previous sessions. The order of carrying out the activities followed by the program will be described below:

**1) Identification of sound and letter:** all the alphabet letters were presented in A4 paper sheet. Then, the scholar was requested to name and to identify the letters (graphemes) and sounds (phonemes) of the alphabet. When the scholar was not able to identify, the therapist vocalized the grapheme/phoneme and then asked the scholar to repeat it.

**2) Identification of words in a sentence:** the therapist said affirmative sentences and asked the scholar to identify the words, marking them by clapping. Every session comprised 7 phrases.

**3) Identification and handling syllables in the word:** two words were presented orally, so that the same syllables were identified, **and** then the scholar was requested to manipulate the syllables

into initial, medial and final position, to form new words. Each session comprised six new words.

**4) Phonemic synthesis:** the phonemes which form a word were provided orally, so that the scholar was requested to synthesize those phonemes, aiming to recognize the word formed. Phonemes were supplied slowly/in segments. Each session comprised seven words.

**5) Rhyme:** the scholar was asked to produce words which finished with the same sound presented. Each session comprised 6 words.

**6) Identification and discrimination of phonemes:** a phoneme was presented orally and the scholar was requested to produce a word with that phoneme. Afterwards, 7 words were presented orally and the scholar was requested to identify if the target phoneme was present in that word. The phonemes were presented following the order of speech and language development (/p, /t, /k, /b/, /d, /g, /m, /n, /ŋ/, /f, /s/, /ʃ/, /v, /z/, /ʒ/, /l, /r/, /R, /r).

**7) Phoneme segmentation:** A word was presented orally and the scholar was asked to identify the phonemes that formed the word. The scholar had to pronounce slowly all the phonemes which formed the word. In that phase of the program, colored papers/forms were used to assist the scholar in segmenting the sounds of the words presented. Each session comprised 7 words.

**8) Subtraction of phonemes:** the therapist presented (orally) 6 words to the scholar, so that he/she could remove the final phoneme of the word. Then, 6 additional words were provided, so that the initial phonemes could be removed.

**9) Phonemes replacement:** a word was presented orally, and the scholar was requested to remove the initial phoneme, replacing it by another one, thus forming a new word.

**10) Phonemes transposition:** the therapist presented (orally) a word and asked the scholar to make the same word in reverse order, thus forming a new word. Each session comprised 6 words.

When the scholar was not able, or had difficulty performing activities, the therapist provided an example different from those used in therapy, and performed the activity together with the scholar, until he/she had understood the requested task. After applying the remediation program, all the participants underwent post-testing. At that stage, the same pre-test instruments were utilized..

### Statistical analysis

To check any differences between the two moments, pre and post-testing, the Wilcoxon Signed Rank Test and the McNemar Test were employed. The significance level for statistical tests was ( $p < 0.05$ ). Data analysis was performed using SPSS (Statistical Package for Social Sciences), version 17.0. The statistically significant results were marked by an asterisk (\*).

### Results

Visando a melhor apresentação dos resultados, as diferentes provas do Teste Desempenho Cognitivo-Linguístico (versão coletiva e individual) foram agrupadas de acordo com as habilidades avaliadas, sendo estas: leitura, escrita, consciência fonológica, processamento auditivo, processamento visual e velocidade de processamento (tabela 2).

**TABELA 2**-DISTRIBUIÇÃO DAS MÉDIAS, DESVIOS-PADRÃO E SIGNIFICÂNCIA (P) DO DESEMPENHO DOS ESCOLARES NO TESTE DE DESEMPENHO COGNITIVO-LINGUÍSTICO VERSÃO COLETIVA E INDIVIDUAL, PRÉ E PÓS-TESTAGEM

Skills	Evidence	N	Maximum score possible in the test	Performance of scholars (Mean of right answers)	DP	Significance (p)
Reading	Pré Alf	10	26	<b>12,48</b>	<b>10,1</b>	<b>0,008*</b>
	Pós Alf	10	-	<b>24,66</b>	<b>1,3</b>	
	Pré Pal	10	40	<b>3,12</b>	<b>2,6</b>	<b>0,005*</b>
	Pós Pal	10	-	<b>11,70</b>	<b>2,5</b>	
	Pré Pseud	10	10	<b>0</b>	<b>0</b>	0,068
	Pós Pseud	10	-	<b>4</b>	<b>1,1</b>	
Writing	PréPal	10	30	3,6	1,1	<b>0,036*</b>
	Pós Pal	10	-	11,7	2,3	
	PréPseud	10	10	1,9	0,8	0,744
	Pós Pseud	10	-	4,2	2,9	
Phonological awareness	PréAlit	10	10	6,4	1,6	<b>0,008*</b>
	Pós Alit	10	-	8,7	1,2	
	Pré Rima	10	20	13.1	2.8	<b>0,009*</b>
	Pós Rima	10	-	17.2	3.8	
	PréSegm	10	20	10,2	2,6	<b>0,038*</b>
	Pós Segm	10	-	19,3	3,2	

Auditory Processing	PréDiscr	10	20	18,5	1,5	0,075
	Pós Discr	10	-	19,5	1,3	
	PréRpal	10	8	4,9	1,2	<b>0,018*</b>
	Pós Rpal	10	-	6,9	1,1	
	PréRpseud	10	8	3,5	2,6	0,144
	Pós Rpseud	10	-	5,0	0,4	
	PréRdig	10	-	3,2	0,8	<b>0,043*</b>
	Pós Rdig	10	-	3,5	1,5	
	PréRdiginv	10	10	3,0	0,5	<b>0,012*</b>
Pós Rdiginv	10	-	3,8	0,5		
Visual Processing	PréCop	10	4	2,6	0,4	<b>0,068</b>
	Pós Cop	10	-	3,1	0,7	
	PréMvi	10	30	20.2	7,9	<b>0,068</b>
	Pós Mvi	10	-	25.6	6.0	
Processing Speed	PréNfig	10	-	52,0s	7,6	<b>0,048*</b>
	Pós Nfig	10	-	48,2s	10,6	
	PréNd	10	-	82,3s	25,1	<b>0,011*</b>
	Pós Nd	10	-	69,1s	16,8	

\*Significant differences ( $p < 0.05$ ) - Wilcoxon test

Legend 2 N = number of subjects / scholars SD = standard deviation; Pre = pre-testing; Post = post-testing; Alf = alphabet recognition in sequence; Pal = read / write words; Pseud = read / write pseudo; Alit= alliteration; Segm = syllabic segmentation; Discr = discrimination of sounds; Rpal = repetition of words; Rpseud = repetition of pseudo-words; Rdig = repetition of digits in direct order); Rdiginv = repeating digits indirect order; Cop = 4 copy geometric shapes; Mvi = visual memory for shapes; Nfig = rapid picture naming and Nd = prompt appointment of digits; s = seconds

The performance of the scholars in pre and post-testing, on the cognitive-linguistic performance test (collective and individual version) shows that, after submission to the remediation program, there was significant improvement ( $p < 0.05$ ) in alphabet recognition skills, reading and writing real words, phonological awareness (rhyme, alliteration and syllable segmentation), auditory processing (repetition of words and digits in direct and reverse order) and processing speed (digit and figures naming).

In order to investigate the evolution among the different writing levels (pre-syllabic, syllabic, syllabic-alphabetical and alphabetical) writing

proof/test as dictation, was analyzed from a qualitative perspective. The results of post-testing showed that from a total of 8 students of pre-syllabic stage, only one remained on that level; 4 evolved to syllabic-alphabetic phase and 3 to alphabetical. From a total of 2 scholars of syllabic-alphabetical stage, 1 remained at the same stage and the other evolved to the alphabetical level. The application of the McNemar test demonstrated a statistically significant difference ( $p = 0.046$ ) between the two testing moments. These figures present improvements in writing skills performance, after applying the phonological remediation program (Table 3).



**TABLE 3-** RESULTS OBTAINED IN PRE AND POST-TESTING OF WRITING ACTIVITY WITH DICTATION OF THE COGNITIVE LINGUISTIC TEST – COLLECTIVE VERSION

PRE TEST	POS TEST			Total
	PS	SA	A	
OS	1	4	3	8
AS	0	1	1	2
<b>Total</b>	<b>1</b>	<b>5</b>	<b>4</b>	<b>10</b>

\* Significant Values ( $p=0,046* < 0,05$ ) – McNemar Test

**Legend 3** PS = pre-syllabic phase; SA = syllabic-alphabetic phase; e A = alphabetical phase.

### Discussão

This study aimed to highlight the effects of a phonological remediation program for children younger than the usually studied and considered at risk for learning disabilities. This program did not intend to assure the effectiveness of the remediation program, due to the small amount of subjects (10 scholars) and the absence of a control group did not allow such findings.

The results of this study showed that from the 17 evaluated cognitive-linguistic skills, 11 (65%) showed significant improvement after applying the remediation program.

The performance in the alphabet recognition test showed that, prior to the intervention, the scholars recognized, on average, only 12 letters of the alphabet, performance considered lower than expected for the age and/or education of those children, however, consistent with learning difficulties<sup>4</sup>. After the intervention, the scholars began to recognize about 24 of the 26 letters of the alphabet, significantly better performance. Difficulties remained in recognition mainly for grapheme <w> and <y>. Those graphemes were not broadly explored during the sessions, considering that their presence in the Portuguese language is not significant. That fact may explain the difficulties of the scholars in recognizing them, even after the intervention, results also found in the literature<sup>12</sup>. During pre-testing, the scholars showed difficulties in PA skills (rhyme, alliteration and segmentation of syllables). PA training, subsidized by the remediation program, promoted the development of those skills, which could be observed by the increased number of correct answers in post-testing. It was possible to observe that the results approached the maximum test score, as also noted in other studies<sup>13,22</sup>. Thus, among all stimulated skills, PA presented better

performance, which could be expected considering it as the focus of the remediation program. The phonological remediation program employed, also showed a significant improvement in reading ability of real words. These results are in agreement with studies which reported close relationship between PA and reading ability<sup>17,23</sup>.

Regarding the writing skills performance, the results showed that 80% of the scholars improved significantly in this aspect ( $p=0.046$ ), because only two children did not show progress in the writing phase. Most scholars were in the pre-syllabic level, which corresponds to the unsystematic use of letters and misunderstanding of the relationship between the number of letters and sounds in the composition of a word. After remediation, they developed to the syllabic-alphabetic or alphabetic level, previously going through the syllabic stage. Therefore, the scholars began to realize the correspondence between the written representation of words and sound properties of letters, using initially one letter for each noise emission (syllable), and then, realizing that the syllables are written by more than one letter.

Whereas writing skills has not performed directly during the intervention program, it becomes possible to notice that the stimulation of PA, provided by the remediation program, was the contributing factor for writing evolution of the participant scholars in this study. This finding is supported by research which demonstrates the effective use of standardized programs using PA activities such as promoters of writing development<sup>24</sup>. Therefore, the present study reinforces the interrelationship of PA and the acquisition of the written code, emphasizing that PA constitutes a skill of great importance in literacy acquisition.

In an international study<sup>25</sup>, it was observed that after stimulation of phonological processing skills, children considered at risk for learning disabilities, achieved the best performance in tests which assessed reading and writing. Those children were followed from 5 to 7 years old, and during that period, the “gains” of the intervention were maintained. The group of children who did not undergo the program showed greater difficulties in the literacy process. The authors also emphasize that the results show the effectiveness of an intervention, which is planned, designed and applied early.

Despite the progress in reading skills and writing words, similar results were not observed in the pseudo-words category, also observed in another study<sup>9</sup>. Analysis of Table 2 shows that progress has occurred in reading and writing of pseudo-words during post-testing, but they were not relevant when considering the statistical analysis. In that category, the scholars often committed lexical errors (performing reading of pseudo-words as real words, due to structural similarities) factor responsible for declines in score and consequently statistical insignificance. That finding reveals the possibility of lexical influence (lexical route) extending in parallel to phonological processing (phonological route), as also reported in the literature<sup>26</sup>.

In assessing the auditory discrimination, significant differences were not observed between the two testing moments. However, those data are related to the fact that scholars showed no difficulties in that aspect, approaching the highest test scores in both, pre- and post-testing, although considered standard deviations. The absence of auditory discrimination deficits in students with difficulties and / or learning disorders are also reported in the literature<sup>8,12</sup>.

The repetition of words, pseudo-words and digits, require auditory working memory ability and on the evaluation of those aspects, it was found that only the memory for pseudo-words did not present significant evolution. This activity is, in fact, the most complex, as there is more activation demand of the phonological loop of the auditory working memory. Memorization of real words is influenced by prior knowledge of the words which trigger semantic resources (access to the meaning of words) facilitating the storage of such information and its subsequent playback (repetition)<sup>7</sup>.

Stimulation of PA promotes the development of the skills underlying to phonological processing,

including working memory and speed of access to mental lexicon<sup>27</sup>. This statement justifies the findings of this study, reinforcing that PA training, through the phonological remediation program, promotes positive effects on auditory working memory of children with signs of risk for learning difficulties. Those results are opposed to those reported in similar studies<sup>9,12</sup>, in which no evolution could be observed, neither the auditory working memory for words, nor for pseudo-words. The remediation program, the strategies used and the amount of sessions were the same in both studies, discarding possible influences of those aspects upon the results. Whereas the only differentiating factor was the age of the subjects, it is inferred that early stimulation (realized in this study with 6-7 year-old-children) may be more effective than when realized with older children.

Regarding the performance in access speed to mental lexicon, there have been significant results during post testing for both evaluated categories (numbers and figures); results also observed in another study<sup>9</sup>. The speed at which the access occurs is critical, for example, in establishing an efficient grapheme-phoneme conversion mechanism, required for reading and writing of a written system based on the alphabet, like Portuguese<sup>28</sup>.

The phonological remediation program prioritizes the use of auditory strategies, so the visual processing skills were slightly stimulated, which could justify the insignificant development of visual memory skills and copy of geometric forms (visual-motor performance) including scholars with signs of risk for learning difficulties. Whereas the scholars from this study demonstrated difficulties in visual processing (detected in the pre-testing) and showed no spontaneous evolution, it becomes necessary to include stimulation strategies of visual processing skills into the classroom context.

Another remarkable fact in this study, suggests that the intervention directed to phonological aspects, has enabled children to greater analysis of their own speech production. Although the assessment of spoken language has not been the focus of the study, it was found that after the remediation some children were able to reduce the amount of phonological changes, and perform self-correction when committing such errors.

PA stimulation allows children to think about the sounds of the language, which in turn, leads to reorganizations in the phonological system

reflecting in speech production<sup>17</sup>. These findings reinforce the importance of stimulating PA for both, either for the development of oral as for written language, according to the literature<sup>5</sup>.

There are few studies associating phonological remediation and children at risk for learning disorders, especially in the national literature<sup>28-30</sup>. Studies have offered greater attention to the implementation of these programs for populations already diagnosed with learning disorders, whose ages and academic losses are greater.

It highlights the relevance of these studies concerning such aspects, because they emphasize early identification of possible learning disorders, taking into account that lack of the scholar response to intervention can provide criteria for diagnosing such disorders<sup>18</sup>.

Developing programs which enhance learning skills of children with learning disorders in the school environment still constitutes a challenge for our education system, which favors only the ones who can read and write according to conventional parameters. Therefore, communion among the health and education professionals is necessary, in order to perform not only early diagnosis, but also for applying strategies aiming to maximize skills and to decrease reading and writing impairments. Consequently, improvement opportunities will be offered in the academic performance of scholars, especially those with learning disabilities

## CONCLUSION

It was observed that students with signs of risk for learning disabilities showed significant improvement in cognitive-linguistic skills of phonological awareness, auditory working memory, processing speed (access to mental lexicon), reading and writing real words, after applying the phonological remediation program. However, it is not possible to affirm that the results are exclusively due to the remediation program, since there was no pairing with a control group. Such intervention generated positive effects for the development of reading and writing in that population, providing opportunities for better academic performance. This finding reinforces the importance of including phonological awareness stimulation activities since early childhood education; and considering the relevance of the topic, those aspects should be discussed in further studies..

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