Original Article

https://doi.org/10.1590/2317-6431-2021-2549

Audiology Communication Research
ISSN 2317-6431

Stimulation program in an educational setting for improvement of skills underlying reading

Programa de estimulação no ambiente educacional para aprimoramento de habilidades subjacentes à leitura

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ABSTRACT

Purpose: To develop and investigate the effect of a program that stimulates cognitive-linguistic skills predictive of phonological decoding skills aimed at improving of skills underlying reading. **Methods**: The research design was a prospective cohort study with quantitative analysis. A total of 124 1st – 3rd grade children from a public Ensino Fundamental I school in São Paulo, participated in the study, divided into: Research Group - 62 students who underwent intervention; Control Group: 62 students who did not receive stimulation. Reading fluency parameters (rate and accuracy) were individually evaluated (pre- and post-intervention) in a task with isolated words. The program had tasks designed to stimulate auditory discrimination, morphosyntactic knowledge, phonological access to the mental lexicon, phonological awareness, knowledge of the written code, reading fluency and the visual vocabulary of words. It was built to improve decoding and automatic word recognition skills in ten sessions of collective stimulation. **Results**: The Research Group showed greater differences in accuracy and score in word reading, when comparing the results of pre- and post-intervention assessments, than the Control Group. **Conclusion**: The program promoted the reading fluency of 1st and 2nd grade students. Significant increments were observed for auditory discrimination, phonological awareness and reading automaticity with variations depending on the grade.

Palavras-chave: Reading; Learning; Competency-based education; Speech therapy; Literacy

RESUMO

Objetivo: elaborar e investigar o efeito de um programa de estimulação de habilidades cognitivo-linguísticas preditoras da decodificação leitora, orientado para a melhora das habilidades subjacentes à leitura. **Métodos**: pesquisa prospectiva, de análise quantitativa. Participaram 124 crianças de 1º ano a 3º ano do Ensino Fundamental I de uma escola pública de São Paulo, distribuídas em: grupo pesquisa - 62 escolares que passaram por intervenção; grupo controle: 62 escolares que não receberam estimulação. Avaliaram-se individualmente (pré e pós-intervenção) parâmetros de fluência leitora (taxa e acurácia) em tarefa com palavras isoladas. O programa contou com tarefas destinadas a estimular a discriminação auditiva, conhecimento morfossintático, acesso fonológico ao léxico mental, consciência fonológica, conhecimento do código gráfico, fluência leitora e o vocabulário visual de palavras e foi construído para aprimorar, em dez sessões de estimulação coletiva, a decodificação e reconhecimento automático de palavras. **Resultados:** o grupo pesquisa apresentou maiores diferenças de acurácia e escore na leitura de palavras, quando comparados os resultados das avaliações pré e pós-intervenção com os do grupo controle. **Conclusão:** o programa promoveu a fluência leitora de escolares do 1º e 2º anos do Ensino Fundamental I. Incrementos significativos foram observados para a discriminação auditiva, consciência fonológica e automaticidade leitora, com variações em função do ano escolar.

Keywords: Leitura; Aprendizagem; Educação baseada em competências; Fonoaudiologia; Alfabetização

Study carried out at Universidade Federal de São Paulo – UNIFESP – São Paulo (SP), Brasil.
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Conflict of interest: No.
Authors' contribution: ESSD was responsible for the research project (master's program) drafting, bibliographic, and methodological study, data collection and analysis, drafting and final text revision; MS was responsible for drafting and final text revision; MOC participated in the project preparation, data statistical analysis, preparation of research data discussion, and text drafting; ASBK was the co-supervisor to the research project that originated this paper and participated in the methodological study, data analysis, drafting and final text revision; CRBA was the supervisor to the research project that originated this paper and participated in the methodological study, data analysis, drafting, and final text revision.
Funding: Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) - Projeto Universal 459953/2014-1 and Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) - master's scholarships.
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Received: July 28, 2021; **Accepted:** November 01, 2021

INTRODUCTION

The results of Basic Education Evaluation System[1] revealed that 39% of the students in the 5th grade of elementary education in Brazilian public schools demonstrated levels of Portuguese language proficiency below expected, underperforming in literacy indicators since the early education grades. Such a condition places school children at risk of failing at some point of their school trajectory. Twelve Brazilian states have a higher concentration of students in the 3rd grade of elementary school at levels 2 or 3 in the Portuguese language proficiency scale, therefore, are below expected. Besides, 42% of the students in the 9th grade of elementary education in Brazilian public schools have low mastery of basic skills related to Portuguese language proficiency[1] and are also at risk of not developing higher levels of reading proficiency.

In fact, the Programme for International Student Assessment[2] showed that approximately 50% of Brazilian students achieved scores below level 2, defined by the United Nations Organization (UNO) as "minimum proficiency level" all children should reach by the end of high school[2].

The current scenario of Brazilian education imposes the need to create new stimulation strategies that should be available to teachers and easily applied in the classroom environment. This is among the characteristics of the Response to Intervention (RTI) Model.

Similar to other approaches, this model is aimed at detecting and monitoring school children at risk of acquiring learning disorders[3]. It proposes an action guided by the teacher in the school environment to stimulate, at primary and universal intervention layers, the development of cognitive and linguistic skills in all students with activities that foster a more precise prevention and detection of risks of learning disorders[3]. Both detecting and monitoring allow to overcome the difficulties in time and to alleviate the manifestations of disorders through a supportive conduct[4-6].

The prospect of implementing a program based on this intervention model has proved to be relevant especially for proposing a collective application in the school environment – thus implying low cost – and for focusing on a favorable developmental stage. The age of higher brain plasticity is during the early education stage and can be maximized through the application of strategies highlighting skills related to phonological processing (known as optimum performance predictors of decoding and recognition of written words)[4]. It represents, thus, a good quality intervention, constituted of procedures and strategies grounded in scientific research and targeting the development of skills and competencies associated with academic demands, as well as accelerating the speed of school learning[3,6].

Such an intervention may facilitate the development of reading skills, providing those that experience some delays with a chance to overcome their difficulties[3,6]. The significant improvement of low frequency actual words reading and regular writing resulting from a phonological remediation program reinforces the efficiency of this type of action in an educational environment[3,6,7].

Other studies based on the training of phonological awareness and fluency have also demonstrated significant effects on reading decoding[6,8]. Progress in performance, especially regarding phonological skills, proved being capable to promote reading both by improving accuracy indicators and by increasing oral reading speed.

The intervention model of universal educational promotes the acquisition of skills in due course and decreases the number of learning damages and consequent referral for interventions in related health areas[3].

Early detection is crucial in the context of Brazilian school as well, since Brazilian school children have a high level of damage comparing with the prevalence of disorders in other countries, whose educational systems are better structured and foster great stimulation to students. Much of this failure does not originate from neurobiological problems, but from external factors, especially from restrictions in the school environment[2].

Such evidence has motivated our research and the design of a stimulation program in cognitive-linguistic skills predictors of reading decoding and respective effects aimed at enhancing underlying reading skills and reading itself.

METHOD

This a quantitative and prospective (follow-up) study approved by the Research Ethics Committee – CEP/Unifesp (CAAE: 47579715,9,0000,5505, Decision 1,309,571).

Sample

143 children (74 girls and 69 boys), aged 6 to 9 years and 6 months of age were recruited to perform the test. They were regularly enrolled in the first three grades of elementary school of a public school in the city of São Paulo (Table 1). School children were included in the sample upon meeting the following criteria: signing the Free and Informed Consent Form (TCLE – parents and/or caregivers) Free and Informed Consent Form (TALE – children); minimum frequency of 80% in the stimulation sections (minimum of eight sections); presence at all stages of tracking sections at pre- and post-intervention moments. Sampling loss while executing the research procedures was observed in 19 school children.

This research was based on the following experimental conditions: Research Group (RG), formed by 62 school children subjected to the intervention; Control Group (CG), with 62 school children who received only regular school stimulation while RG received the intervention (Table 1). This experimental design sought to control the recognized effect of education on reading decoding variables, allowing to better understand the effect of the proposed program.

As desired for the experimental design, the groups did not differ regarding the measured control variables at pre-intervention (reading accuracy: $F=0.106$, $p=0.901$, and reading time: $F=0.213$, $p=0.813$). Such equivalence is a basic condition for ensuring that possible differences are a direct effect of the program employed.

The study was performed in three stages: 1) pre-intervention tracking (pre-int), 2) application of stimulation procedure for underlying skills and competencies of reading decoding, and 3) post-intervention tracking (post-int). Tracking stages were aimed at investigating the performance of school children in

Table 1. Percentage distribution of the participants according to group and education (n=124)

Education	Control Group		Research Group		Total	
	No.	%	No.	%	No.	%
1st grade	23	18.6%	22	17.7%	45	36.3%
2nd grade	19	15.3%	20	16.1%	39	31.5%
3rd grade	20	16.1%	20	16.1%	40	32.2%
Total	62	50.0%	62	50.0%	124	100.0%

Subtitle: No. = number of participants; % = percentage

phonological processing and reading tasks. Gains from the stimulation program were monitored by comparing pre- and post-intervention stages[9]. Tracking consisted of the following tasks:

- Exam of oral reading of isolated words list: psychometrically validated, composed by 24 words (extension: 58.3% with 4-6 letters; 41.7%, 7-8 letters; correspondence letter: 52.1% regular, and 47.9% irregular)[10]. School children were instructed to read outloud in a fast and accurately manner the isolated words list (written in arial font, size 12). Reading rate and accuracy were calculated[11] and the hits from reading of 24 words were summed up[10].
- Picture auditory discrimination test: 40 word pairs represented in pictures and differing from each other by only one phoneme (minimum pairs)[12]. Each minimum pair contained three cards with two drawings each. The children heard the pronunciation of two words in a pair, which could be either similar or different, and pointed to the card containing the pictures corresponding to the words heard. Performance above 80% was considered adequate.
- Task of rapid object naming: psychometrically validated to stimulate the phonological access to mental lexicon[13], constituted of a card containing six pictures (egg, bread, ball, sun, key, fork) that were repeat randomly six times, summing 36 occurrences per card. Children were instructed to name each picture as fast as possible. Each hit corresponded to 1 point and the total performance time was recorded in seconds. Omissions and repetitions were considered errors.
- Task of phonemic exclusion – CONFIAS (Phonological Awareness Instrument of Sequential Assessment): psychometrically analyzed subtest[14], constituted of two items of practice and six items of test. Phonological awareness tasks were chosen for representing optimum predictors and contributing to reading accuracy and fluency[8]. The examiner requested that the child suppressed a particular phoneme from a given word. Each hit was attributed with 1 point and the score was calculated from the sum of the hits.

Tracking was performed individually in a room properly organized provided by the school. All tests were preceded by practicing stages. Both RG and CG participants were subjected to tracking simultaneously at pre- and post-intervention stages for the possible effect of school progression to be controlled. It is worth pointing out that CG school children participated in the Stimulation Program after data collection at post-intervention stages, according to related ethical procedures.

Stimulation Program

Activities addressing the skills of auditory word distinction, phonological awareness, phonological access to mental lexicon, stimulation of word and text reading. The activity was offered by a speech therapist twice a week, in the classroom, during ten 50-minute sections. Systematic and intensive instruction (frequency and duration) was chosen based on recommendations of scientific evidence[6,7,9]

The program was structured as follows: the first five sections stimulated auditory discrimination, phonological awareness, knowledge of graphic code (letter recognition), combined oral reading, visual vocabulary, phonological access to lexicon. Sections from six to ten stimulated phonological awareness, knowledge of graphic code (sound value of letters), combined oral reading, visual vocabulary, and phonological access to lexicon. These tasks are briefly outlined as follows:

- Auditory word discrimination: aimed at improving the detection of phonemic contrasts in the scope of words. It contained four-word sequences constituted of a target word and other two similar words differing from each other by only one phoneme, thus featuring either a minimum or a maximum opposition[12,15,16]. The oppositions were selected for the children to identify phonemic contrasts from the acoustic cues of frequency and duration.
- Phonological awareness: tasks focused on stimulating meta-phonological awareness at syllabic and phonemic levels. Priority to phonemic activities and tasks based on skills of detection, suppression, or synthesis[17]. Each stimulation item planned along the sections included choosing a target word (correct response) and two competitive options (high competition, characterized by minimum or maximum opposition to the phoneme or target syllable, stimulus of low competition without phonological similarity).
- Phonological access to mental lexicon: tasks aimed at stimulating speed and accuracy in the phonological access to mental lexicon[18-20]. The boards of rapid naming in the early sections contained two stimuli pairs representing words featured as maximum or minimum oppositions, and one stimulus phonologically different from the others. The boards presented in the final sections favored the naming utterance from a phonological track provided in advance (Ex: all pictures in the sheet started with /f/).
- Letter recognition: consisted of naming letters, assigning their sound values, and letter recognition based on their sound value[20-23].
- Word and text reading: combined reading out loud stories from books of the Collection "*Estrelinha*", by Ática

publisher, known for controlling spelling complexity (Originally in Portuguese, as applied: *O pato e o sapo, O galo maluco, O peru de peruca, A onça e a anta, O caracol viajante, A arara cantora, O mistério da lua, O barulho fantasma, O susto do periquito, Um palhaço diferente* –, corresponding in English to: The duck and the frog, The crazy rooster, The turkey in a wig, The jaguar and the tapir, The traveling snail, The singing macaw, The mystery of the moon, The phantom noise, The parakeet's fright, A different clown). The texts were arranged to progressively enhance the degree of difficulty along the spelling sections from transparent to opaque. To create a visual vocabulary of words, 96 words were selected in the texts (9.6 words per text) and introduced after the book was read. Those were high-frequency words with different extension (two-, three-, and multiple sylables) and spelling correctness to ensure the desired exposure frequency for automatic recognition of the visual form of words. The words were applied cumulatively along the sections for the exposure frequency to ensure the desired effect. The application of the proposed tasks allowed to estimate the risk of changes in performance. For school children in the first grade, without analysis parameters provided by the Exam of Reading of Items, was considered risk the impossibility of reading the words via phonological route, regardless of the fluency observed. On the other hand, for school children in the second and third grade, performance was classified as either low or average low.

All activities proposed were presented in the classroom using datashow illustrating boards with pictures representing the stimuli. The students were verbally instructed, and each task was preceded by practicing stages. Answer sheets were distributed aiming to engage school children in the tasks.

Statistical analysis

Statistical analysis encompassed data normality – Kolmogorov-Smirnov test (K-S) –, comparison of the reading fluency variables between pre-intervention (pre-int) and post-intervention tracking (post-int) stages for each group – Wilcoxon Test, and comparison of the evolution between the groups – Mann-Whitney Test. All analyses were performed on the SPSS (Statistical Package for Social Sciences), version 22.0. Statistically significant results were indicated upon a value of $p < 0.05$.

RESULTS

The application of the stimulation program pointed to higher values of accuracy rate in both groups at the post-intervention tracking (post-int). However, only the research group showed to have improved in the reading task of the 24 psychometrically selected words (Table 2).

The Research Group (RG) demonstrated higher differences between the pre-intervention and post-intervention tracking stages for the reading accuracy variables. The greatest differences, always positive, indicated that after the intervention program, RG presented significantly higher accuracy indicators and more hits than the Control Group (CG) when reading the 24 isolated words. The comparative analysis of performance between the pre-intervention and post-intervention tracking stages for the studied groups aimed to explore the results from the stimulation of underlying skills and capacities of word decoding and recognition (Table 3).

RG showed a better performance at the post-intervention tracking in all factors analyzed, whereas CG did not progress significantly over the same period regarding their skills of auditory discrimination and phonological awareness.

RG showed significantly higher increase in the number of hits as a consequence of the program on the variables of auditory discrimination and phonological awareness in the 1st grade. For the 2nd grade, however, a significant increase of hits occurred only in RG if considering the phonological awareness variable. As for the 3rd grade, no significant differences in performance were found between RG and CG in relation to the differences in performance at pre-intervention and post-intervention tracking stages (Table 4).

The aim of the comparative analysis of results for the variables of reading decoding and fluency, as a function of education, provided by the school children in both RG and CG, was to analyze the effects of the stimulation program on school children at different school levels. The analysis of the 1st and 2nd grade shows a higher difference in performance for RG between the post-intervention and pre-intervention tracking stages in relation to CG for rate, accuracy, and hits variables for reading the 24 psychometrically selected words. No significant

Table 2. Comparative results of the variables of reading decoding and fluency at pre-intervention and post-intervention tracking reached by research and control groups

Variables		Tracking (Pre-int) Mean (sd)	Tracking (Post-int) Mean (sd)	Wilcoxon Test		Result
RG	Rate	21.6 (21.0)	27.8 (23.1)	Z=-2.548	0.000*	M2 > M1
	Accuracy	13.3 (18.4)	19.3 (22.6)	Z=-2.294	0.000*	M2 > M1
	Hits_24p	6 (7)	8 (9)	Z=-2.113	0.000*	M2 > M1
CG	Rate	21.1 (18.6)	24.9 (22.5)	Z=-3.663	0.000*	M2 > M1
	Accuracy	11.6 (16.2)	15.1 (20.1)	Z=-3.784	0.000*	M2 > M1
	Hits_24p	6 (7)	6(7)	Z=-0.750	0.161	M1 = M2

Test: Wilcoxon, statistical significance level: p=0.05 (*)

Subtitle: RG = research group; CG = control group; sd = standard deviation; Rate = total of words read per minute; Accuracy = total of words correctly read per minute; Hits_24p = total of hits in the reading of the 24 psychometrically selected words; pre-int = pre-intervention; post-int = post-intervention; Z = result of the Wilcoxon test; M = moment

Table 3. Comparative results of the variables of underlying skills and reading decoding and fluency hability at pre-intervention and post-intervention tracking reached by Research and Control Groups

Variables		Tracking		Wilcoxon Test	Result
		(pre-int)	(post-int)		
		Mean (sd)	Mean (sd)		
RG	Aud_Disc	27.3 (15.8)	28.5 (15.9)	0.004*	post-int > pre-int
	RN_temp	43.6 (14.4)	38.1 (12.6)	0.000*	post-int < pre-int
	RN_errors	7.3 (3.6)	6 (2.72)	0.001*	post-int < pre-int
	PA	3.1 (1.9)	4.4 (1.91)	0.000*	post-int > pre-int
CG	Aud_Disc	37.6 (2.7)	37.8 (2.3)	0.742	pre-int = post-int
	RN_temp	42.9 (12.9)	40.3 (13.7)	0.005*	post-int < pre-int
	RN_errors	7.6 (2.6)	6.68 (2.6)	0.004*	post-int< pre-int
	PA	3.56 (1.9)	3.82 (1.79)	0.059	pre-int = post-int

Wilcoxon Test, statistical significance level: p=0.05 (*)

Subtitle: RG = research group; CG = control group; Aud_Disc: total of hits in the auditory discrimination exam; RN_time = time spent in rapid naming in seconds; RN_errors = total of errors in the RN task; PA = performance in phonological awareness (phonemic exclusion task); pre-int = pre-intervention; post-int = post-intervention

Table 4. Comparative results between research and control groups regarding the difference in performance between post-intervention and pre-intervention tracking during tasks to analyze underlying skills and reading decoding and fluency ability per school grade

School Grade	Variables	Group		Mann-Whitney Test	Result
		GP	GC		
		Dif (pre-int)-(post-int) (sd)	Dif (pre-int)-(post-int) (sd)		
1st	Disc_Aud	2.04 (1.5)	0.13 (1.5)	0.000*	RG>CG
	NR_time	-4.50 (7.7)	5.54 (11.5)	0.953	RG=CG
	NR_errors	-0.91 (3.5)	0.59 (3.4)	0.846	RG=CG
	PA	1.08 (1.2)	0.61 (1.3)	0.015*	RG>CG
2nd	Disc_Aud	0.22 (1.4)	0.45 (2.2)	0.806	RG=CG
	NR_time	-6.72(16.5)	3.05 (10.9)	0.087	RG=CG
	NR_errors	-1.11 (3.2)	-0.05 (3.0)	0.239	RG=CG
	PA	1.72 (1.3)	0.40 (1.1)	0.004*	RG>CG
3rd	Disc_Aud	0.05 (1.3)	-0.09 (1.5)	0.688	RG=CG
	RN_time	-5.42(11.8)	-4.66 (6.1)	0.469	RG=CG
	RN_errors	-1.94 (2.5)	-1.85 (1.9)	0.789	RG=CG
	PA	0.89 (1.9)	-0.23 (0.8)	0.065	RG=CG

Test Mann-Whitney, statistical significance level: p=0.05(*)

Subtitle: RG = research group; CG = control group; Disc_Aud = total of hits in the auditory discrimination exam; RN_time = time spent during rapid naming in seconds; RN_errors = total of errors in the RN task; PA = performance in phonological awareness (phonemic exclusion task); Dif (pre-int)-(post-int): difference in performance between pre-intervention and post-intervention tracking stages; sd = standard deviation

effect of training on reading decoding variables was observed on the school children in the 3rd grade (Table 5).

When analyzing the risk for reading disorders in the research group (Chart 1) based on the performance of school children in the Exam of Reading of Isolated Items, we found a lower percentage of risk comparing with the values indicated at the pre-intervention and post-intervention tracking stages for all children.

DISCUSSION

Response to Intervention (RTI) programs have been used as learning stimulus, fostering early, accurate prevention and detection of risk of learning school disorders. For this purpose, the applied tasks stimulate phonological processing skills and knowledge of written code aimed at promoting reading fluency in school children at yearly education grades[24]. Thus, as constant, proper stimulation of underlying decoding skills should promote reading automaticity[23,24].

In this research, training generated in an increase in speed and accuracy for RG school children, as well as those in CG, demonstrated that education influences reading automaticity (Table 2). When comparing the performance of rate and accuracy between the pre-intervention and post-intervention stages, we found that RG presented higher index of hits for all the 24 psychometrically selected words following the activities. This reveals the effect of skill training since those are low frequency words, requiring a beginner reader to use the phonological route to them. Such results suggest the efficiency of the Response to Intervention Program on reading decoding and fluency.

Our search on the literature found no studies on stimulation programs addressing all the skills, competencies, and knowledge analyzed in our study, neither those including exclusively school children in the first three grades of elementary school. However, the literature highlights the efficiency of intervention action aimed at stimulating phonological processing or language skills with positive effects on reading decoding[8,20,21].

Programs designed based on multidimensional stimulation approaches generated more effective results for reading decoding

Table 5. Comparative results between research and control groups regarding the difference in performance between the pre-intervention and post-intervention tracking stages during reading decoding and fluency tasks per school grade

School Grade	Variables	Group		Mann-Whitney Test	Result
		GP	GC		
		Dif (pre-int)-(post-int) (sd)	Dif (pre-int)-(post-int) (sd)		
1st	Rate	5.91 (7.8)	1.57 (3.5)	0.020*	RG>CG
	Accuracy	1.96 (4.2)	0.72 (2.3)	0.023*	RG>CG
	Hits_24p	1.65 (2.7)	0.08 (0.7)	0.004*	RG>CG
2nd	Rate	7.24 (6.1)	3.20 (4.4)	0.028*	RG>CG
	Accuracy	8.65 (7.3)	1.94 (5.3)	0.002*	RG>CG
	Hits_24p	4.11 (3.7)	0.10 (3.5)	0.002*	RG>CG
3rd	Rate	5.29 (8.4)	7.07 (6.7)	0.215	RG=CG
	Accuracy	8.09 (7.1)	8.05 (8.0)	1	RG=CG
	Hits_24p	2.47 (2.8)	1.71 (4.0)	0.282	RG=CG

Test: Mann-Whitney, statistical significance level: p=0.05(*)

Subtitle: RG = research group; CG = control group; Rate = total of words read per minute; Accuracy = total of words correctly read per minute; Hits_24p = total of hits during the reading of the 24 psychometrically selected words; Dif (pre-int)-(post-int) = difference in performance between pre-intervention and post-intervention tracking stages; sd = standard deviation

Chart 1. Total of school children in the research group detected with potential risk of reading disorders at the second tracking using the Exam of Reading of Isolated Items as function of school grade

School Grade	Performance Levels**	Tracking Stage		Percentage of Risk	
		(pre-int)	(post-int)	(pre-int)	(post-int)
1st	**Does not read**	17	10	73%	43%
	Reads	6	13		
2nd	**Low**	9	5	68%	47%
	Low Average	4	4		
	Average	3	1		
	Higher Average	3	7		
	High	0	2		
3rd	**Low**	7	6	45%	35%
	Low Average	2	1		
	Average	2	5		
	Higher Average	6	1		
	High	3	7		
TOTAL	**At risk**	39	26	63%	41%
	No risk	23	36	37%	58%

**Data in bold point to school children at risk of reading disorders. For the school children in the first grade, without analysis parameters provided by the Exam of Reading of Isolated Items, risk was regarded as the impossibility of reading the words via phonological route, regardless of the fluency demonstrated. For the school children in the second and third grades, the performance was classified as low or average low.

Subtitle: pre-(int) = pre-intervention; post-(int) = post-intervention

than those based only on the training of underlying isolated skills or competencies[3,8,23,25]. The effects of the training of linguistic skills, competencies, and knowledge of graphic code related to decoding, as well as to the results of the reading training They also proved being positive in the fostering of decoding capacity and word recognition automaticity.

Other authors have analyzed a response to intervention program applied to school children with reading and writing difficulties in the 3rd and 4th grades of elementary school to investigate the efficiency of RTI program. These studies involved the stimulation of skills of phonological awareness, vocabulary, fluency, and comprehension. The students presented some improvement in reading and writing tasks, thus indicating the efficiency of RTI program for school children in many aspects, facilitating the development of reading and writing, as observed in our study[3].

Another intervention program used rapid automatic naming and reading tasks[19] and found an improvement in the detection of syllables and medial and final phonemes, addition and combination of syllables, repetition of non-words, reading of actual words, and pseudowords.

Other studies have showed the efficiency of underlying skills combined training on phonological awareness and the knowledge of alphabet letters and respective sound values in fostering reading and writing acquisition, especially in school children in early education grades[8,23]. Phonological awareness and vocabulary skills influence children in the early education grade more than intelligence level when learning to read and write[8].

The training of underlying decoding skills in all the scientific studies that we detected was able to promote the capacity of reading words accurately and automatically[26]. Thus, our results corroborate with literature reports, allowing us to conclude that stimulation programs based on improving the training of underlying skills, competencies, and/or knowledge of reading decoding may have positive outcomes, especially regarding reading accuracy. Besides, literature confirms maximized benefits

by associating training of various skills and/or knowledge implied in decoding[7,8,23,24,26].

The analysis of results of the effects of training on the components of phonological information and language processing (Table 3) indicated RG with an improved auditory discrimination, accuracy, and speed of lexical access and phonological awareness. When comparing the response profile between the groups, however, we found that education level also enhanced CG performance, except for auditory discrimination and phonological awareness. Comparatively, phonological awareness provided RG with significantly higher profits. The proposed auditory discrimination based on strategies to develop contrastive of phonemes (maximum and minimum oppositions) in the word context proved efficient at enhancing auditory and speech perception skills after ten stimulation sections for RG. Such stimulation is efficient to foster the learning of phonological system properties[16], which support the phonological information processing required for reading decoding[7]. Phonemic discrimination training for school children at early reading instruction, or even those with learning difficulties regarding the alphabetic code facilitates auditory and reading decoding skills[26].

Difficulties in the perception of lower speech segments may compromise the learning of reading since the grapheme-phoneme association enables the child to read any word[24]. Both our results and the consulted literature allow to assume that the combined instruction of auditory skills and phonological awareness, which proved to be effective in our research, caused RG school children to enhance their capacity to detect speech units (syllables and phonemes) required for understanding and learning the graphic code, as well as being essential to the development of reading phonological route.

The analysis of training efficiency results on the performance of reading decoding and fluency in school children in different education grades showed that RG participants in the 1st and 2nd grades have benefited from the intervention. These children had an expressively greater increase in the values of rate, accuracy, and total of hits for reading the 24 psychometrically selected words than CG participants (Table 4).

The early education grades focused on teaching to read (school children in the 1st and 2nd grades) require the students to increase their phonological awareness and progressive skill of letter knowledge. In turn, such a learning process allows school children to detect connections between the written word and its phonological form by progressively building hypothesis on the rules of the written code[8,24]. These associations lead the reading via phonological route to arise, highly depending on the phonological information processing. In more advanced levels, school children start to appeal less and less to this reading route since the experience of reading itself allows to enlarge their visual vocabulary and achieve progressive mastery of morphemic unit recognition, leading the reading via lexical route to emerge and fostering reading automaticity[27,28]. Such hypothesis is confirmed in studies indicating that the factors related to phonological information processing, especially phonological awareness, are excellent predictors and benefit reading accuracy and fluency. However, its role proved more relevant in the early grades with related contributions decreasing as the educational level increased[27]. In contrast, morphological awareness, which benefits the progressive increase in the use of reading via lexical route, becomes necessary to understand and detect patterns of the language orthographic system and is further required in the 2nd and 3rd grades of elementary school[24].

Our results are in line with the literature, allowing us to assume the positive influence of the multidimensional training proposed in fostering automatic decoding and recognition of words. However, such an efficiency proved to be limited to the early education grade, which involve instruction on the written code, suggesting that the program acted more specifically on the skills and competencies required for phonological information processing, supporting the reading development via phonological route. Thus, its lower relevance with time, due to the more frequent use of recognition via lexical route, would justify the results found.

Despite the promising results, it is worth regarding a limitation of this research: school children with reading skills difficulties may take time to increase the use of the lexical route, even upon greater educational level and reading experience. Scientific evidence has demonstrated that, in the absence of reading accuracy, the improvement of visual vocabulary is more restricted[24]. Therefore, prospective studies should address exclusively school children at risk of reading disorders.

The assessment of the program effect on reading performance will allow to detect a potential improvement of phonological information processing and resulting reading accuracy, consequently promoting automatic word recognition, in line with some researchers' assumptions[8].

The results of the training of phonological information and language processing components, as function of the school grade, demonstrate that RG school children in the 1st grade benefited from the program significantly more than CG participants in the scope of the tasks of auditory discrimination and phonological awareness. In turn, RG school children in the 2nd grade also had higher gains in phonological awareness than those in CG. School children in the 3rd grade, in turn, presented the same gain in performance for tasks of phonological information and language processing, thus demonstrating, unexpectedly, the absence of a superiority effect of the program on school education per se (Table 5). This analysis was associated with the previously discussed findings, which proved the efficiency of the training of auditory discrimination and phonological awareness for school children in the early grades of elementary school. These children started to detect the basic characteristics of phonemes more accurately and knowingly, thus improving their phonological representation system organization[5,6,18]. However, education itself also facilitated these skills and competencies, which lost relevance as education progressed[20,27].

The longitudinal results from many of the analyses on response to intervention models have been presented from data showing lower risks of learning disorders as a result of the educational intervention. It is known, however, that experimental studies based on "clinical assays" alone, using controlled variables, would produce evidence that the changes observed derived exclusively from the stimulation program proposed.

As for the quantitative results of lower risk for reading disorders as function of the school grade, the analysis of all school children detected with potential risk for reading disorders revealed lower percentage of risk for all grades investigated in RG (Chart 1). In a general perspective, we found that the rate of reading disorders risk was already high at the pre-intervention tracking, even considering the criteria analysis applied to a large, randomized sample, representing the school system in the city of São Paulo[13]. Such performance indications, although excessively

high, are in line with the data obtained from assessment exams of Brazilian school children reading skills[2,29].

The comparison of the risk percentage at the pre-intervention and post-intervention tracking stages demonstrated that the program was important to reduce the risk of reading disorders. Such a reduction, however, proved more effective for the 1st grade of elementary school, having further decreased progressively as function of education. This finding is in line with the perception that the program is able to stimulate the skills and competencies involved in the phonological information processing, which are more relevant in the early stage of written code skill[8,27]. The high-risk indices at the post-intervention tracking suggest the need to design more specific intervention programs with greater duration and intensity for an even more significant reduction of these percentages.

Response to intervention programs are designed as multilayer methods aimed at progressively decreasing the indices of school education alteration[3,5]. Despite proving its efficiency, the program did not reach the desired percentages of reduction according to the Education Department Institute of Education Sciences[9]. It is expected that approximately 15% of the population at risk of learning disorders remain so after the first collective intervention. It is worth highlighting that the proposed indices are applied to the American educational system, where the changes in the early education stage are significantly lower than those found in the Brazilian scenario, as demonstrated in our research.

It is necessary to further study the design of a full educational intervention program on a universal layer (layer 1) and specific level with school children who still demonstrated to be at risk of developing reading disorders (layer 2) for a more efficient reading and alleviation of risks of damages to the graphic code skill. The results are linked to the intensity of stimulation, teacher's instruction, and the intervention being applied in both groups simultaneously[3,30].

CONCLUSION

The stimulation program was comprised of activities aimed at stimulating components of phonological information and language processing proved effective for facilitating reading decoding performance. The following components of phonological information and language processing responded positively to the proposed stimulation, regardless of the effect of educational level: auditory discrimination of words and phonological awareness. Therefore, it is possible to infer that the facilitation of these skills proved efficient and the process of learning to read benefited from their stimulation in the general context of the program.

Phonological awareness had the best response among all phonological processing skills when observing school children performance in the early grades of education (1st and 2nd grades of elementary school). The positive results of the training of auditory discrimination skills may have been related to the auditory contrasts between phonemes in the activities, based on the detection of differences in frequency and duration in the oppositions, which may have enhanced the attention to language phonology.

Finally, the methodological attention when establishing CG, whose participation in the intervention was effective only after the end of RG stimulation, allowed to precisely detect the isolated efficiency of the stimulation program, counteracting the effects of education per se. It is relevant to highlight that the analyses demonstrated that education alone was able to foster skills (phonological access to lexicon), knowledge (morphosyntactic awareness, knowledge of letters and mastery of grapho-phonemic relation) and reading.

ACKNOWLEDGEMENTS

We thank the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) - Projeto Universal 459953/2014-1, and the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES). Both Foundations supported this research.

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