

RESPONSE TO INTERVENTION (RTI) PROGRAM FOR THE DEVELOPMENT OF EXECUTIVE FUNCTIONS IN FIRST-YEAR ELEMENTARY SCHOOL

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Abstract

Objectives: To develop a second-tier Response to Intervention (RTI) program for the development of executive functions in first-year elementary school students and to analyze the clinical significance of the program via a pilot study. *Method:* The work was carried out in two phases: elaboration and application of the RTI program; followed by a clinical significance analysis of the children’s performance in pre and post-test situations. *Participants:* The initial sample comprised 71 children (age from 6 years to 6 years and 11 months, of both sexes) from two public schools (groups GI and GII). These were submitted to a pre-assessment protocol: Attention Screening Test by digit cancellation; Five Digit Test; Digit Span subtest, Track Testing, and Protocol for Early Identification of Reading Problems. Risk for difficulty in executive function was presented by 18/37 of the participants that completed the pre-assessment protocol and these were selected for the intervention program. *Results:* There was a reliable improvement in the components of executive function inhibition, working memory and alternation, for some children and in rhyme identification tasks, phoneme production, and phonological working memory, although the program does not focus on its development. *Conclusion:* The program we elaborated demonstrated applicability and can be used by educational speech therapists, school psychologists and educators as a scientific evidence-based intervention tool to support the development of executive functions in second-tier RTI programs.

Keywords: *Executive function, intervention studies, learning.*

1. Introduction

Executive functions (EF) are considered higher-order cognitive resources that command low-er-level processes. They are directly related to the ability to learn, since for the student to be able to acquire reading and writing skills, it is essential that there is planning, attention, behavior regulation and motivation (Diamond & Lee, 2011).

Studies showed that there is a difference between the development of its different components, that is, some would consolidate before others (Dawson & Guare, 2012; Diamond & Lee, 2011; Miyake, Friedman, Emerson, Witzki, Howerter, & Wager, 2000).

This model, proposed by Miyake et al. (2000), which received acceptance in the literature (Diamond & Lee, 2011; Diamond, 2013, Sullivan, Davis, & Koh, 2022), considers three components essential related to executive functions: inhibition, working memory and shifting demonstrating that, from their integration, they allow other skills to emerge, such as planning, decision making, problem solving, among others. Studies have been published both nationally (Seabra, & Dias, 2012; Gonçalves et al., 2017) and internationally (Van der Ven, Kroesbergen, Boom, & Leseman, 2012; Rudasill, Acar, & Xu, 2022), on the use of early interventions for the development of executive functions and problems of learning, as well as the performance of skills involved, however, there are still few studies that focus on the development of executive functions in students at risk for learning difficulties through the Response to Intervention (RTI) (Grosche & Volpe, 2013; Reynolds & Shaywitz, 2009; Rodríguez, Areces, García, Cueli, Gonzalez-Castro, 2021).

The Response to Intervention (RTI) is a multi-level educational and behavioral model where the activities developed seek the identification and early intervention in schoolchildren at risk for learning and behavioral difficulties, as well as diagnostic models of learning and behavior disorders (Andrade, Andrade, & Capellini, 2014; Fuchs & Fuchs, 2006; Fletcher & Vaughn, 2009), widely used in

international and national literature (Andrade, Andrade, & Capellini, 2014; Berkeley et al., 2020; Fuchs & Fuchs, 2006)

The RTI Model is composed of three tier: (1) universal screening of academic and behavioral problems in all schoolchildren through collective content and strategies, scientifically proven to be the most effective, and their progress systematically monitored by teachers; (2) application of specific and progressive interventions in smaller groups, based on the response to progress monitoring assessments (Fletcher & Vaughn, 2009); (3) evaluation and specific intervention with the objective of excluding the possibilities of learning and/or behavior disorders in schoolchildren who do not make progress in the previous stages (Fletcher & Vaughn, 2009; Fuchs & Fuchs, 2006). The term ‘responsiveness’ refers to the responsiveness to preventive interventions.

Based on the hypothesis that an RTI tier 2 intervention program with executive functions in schoolchildren can help to identify students at risk for executive function and learning difficulties, the study aimed to develop and to analyze the clinical significance of a RTI Tier 2 executive function program for 1st grade level Brazilian schoolchildren in a pilot study.

2. Methods

This study was carried out after approval by the Research Ethics Committee (81064117.5.000.5406). This is a quasi-experimental study developed in two phases, Phase 1 being the elaboration of the RTI Tier 2 executive functions program for Brazilian schoolchildren and Phase 2 the analysis the significance clinical of program.

The theoretical bases for the elaboration of the RTI Tier 2 intervention program, called RTI-FEx were based on the theoretical model proposed by Miyake et al. (2000), considering the three main components of executive functions: ‘inhibition’; ‘working memory’ and ‘shifting’.

Each of the components was considered as an objective of the program, developed for application in a school environment, in the group modality. In this way, RTI-FEx was composed of 10 strategies, distributed over 9 sessions with an average duration of 40 minutes each, to be carried out weekly over 2 months and 1 week.

Phase 2 of this study was the realization of the applicability of the program developed in phase 1 of this study through the pilot study.

The initial sample comprised 71 children (age from 6 years to 6 years and 11 months, of both sexes) from two public schools (groups GI and GII). These were submitted to a pre-assessment protocol: Attention Screening Test by digit cancellation; Five Digit Test; Digit Span subtest, Track Testing, and Protocol for Early Identification of Reading Problems. Risk for difficulty in executive function was presented by 18/37 of the participants that completed the pre-assessment protocol and these were selected for the intervention program.

3. Results

The results of this study were analyzed using the JT Method (Jacobson, & Truax, 1991) for single-case analysis. This method provides a comparative analysis between pre- and post-intervention scores and aims to decide whether the differences between them represent reliable changes and whether they are clinically relevant.

To analyze the results of the clinical significance of the performance of schoolchildren in pre- and post-testing situations after application of the intervention response program RTI -FEx, they were named S1 to S8. Table 1 and Table 2 show the reliable change index (RCI) of each student in this study based on their performance based on the instruments used in pre- and post-testing situations.

Table 1. Performance of schoolchildren in pré- and post-testing situations.

Instruments used in the pre- and post-assessment protocol						
Schoolchildren	FDT	TAC1	TAC2	TAC3	DIG	TTB
1	RPC	RPC	-	RPC	RPC	RPC
2	RPC	RPC	-	RPC	-	-
3	-	RPC	-	RPC	-	-
4	RPC	RPC	-	RPC	-	RPC
5	RPC	RPC	-	-	-	-
6	-	RPC	-	-	-	-
7	RPC	RPC	-	RPC	-	-
8	-	RNC	-	-	-	-

Subtitles: RPC= reliable positive change; RNC= reliable negative change; FDT= five digit test; TAC1= attention test cancellation part 1; TAC2= attention test cancellation part 2; TAC3= cancellation attention test part 3; DIG= digits subtest; and TTB= trail test part B.

Table 2. Performance of schoolchildren in the tests of the Early Identification Protocol for Reading Problems used in pre- and post-testing situations.

Evidence of the Protocol for Early Identification of Reading Problems – PEIRP													
Schoolchildren	AK	RP	RI	SS	PWF	PS	PA	IPI	PWM	FAN	SR	WPWR	LCP
1	-	-	-	-		-	-	-	RPC	-	-	-	-
2	-	-	-	-	RPC	-	-	-	-	RNC	-	-	-
3	-	-	-	-		-	-	-	-	-	-	-	-
4	-	-	-	-		-	-	-	-	-	-	-	-
5	-	-	-	-		-	-	-	-	-	-	-	-
6	RNC	-	RPC	-		-	-	-	-	-	RNC	-	-
7	-	-	-	-		-	-	-	-	-	-	-	-
8	-	-	-	-	RNC	-	-	-	RNC	-	-	-	-

Subtitles: RPC= reliable positive change; RNC= reliable negative change; AK= alphabet knowledge; RP= rhyme production; RI= rhyme identification; SS= syllabic segmentation; PWF= production of words from the given phoneme; PS= phonemic synthesis; PA= phonemic analysis; IPI= initial phoneme identification; PWM= phonological working memory; FAN= fast automatic naming; SR= silent reading; WPWR= words and pseudowords reading; and LCP= listening comprehension of sentences from pictures.

4. Discussion

The inhibition component was evaluated using the Five-Digit Test (FDT) and the Attention Cancellation Test (TAC). During the application of the FDT, all students were unable to perform the task in the pre-test situation, presenting difficulty in understanding the instructions for the procedure necessary to carry out the task. The same task was proposed in a post-assessment situation, where S1, S2, S4, S5 and S7 were able to perform it despite presenting a performance suggestive of clinical deficit.

Although it is not possible to state that the inhibition gains can be attributed to the intervention from the application of the FDT, since the students were not able to perform the task in the pre-test, there is a second test used to evaluate the inhibition component, the inhibition test. cancellation attention, an instrument that evaluates selective attention, which according to the literature is one of the skills involved in executive functions (Friedman, & Miyake, 2017). In this task, an improvement in performance was observed in part 1 of the test designed to assess selective attention (S1, S2, S3, S4, S5, S6 and S7) and in part 3 of the test, also designed to assess selective attention, but with alternation demand (S1, S2, S3, S4 and S7), being necessary to change the focus of attention in each line (Seabra & Dias, 2012).

Being the preliminary data, although it cannot be said that the gains in this component are due to the intervention and not just to the schooling process to which the students in this study continued to be exposed during the school year, it is important to mention, according to the literature, that, in addition to the ontogenetic development of executive functions, from around 12 months of age to early adulthood (Romine & Reynolds, 2005), there is a difference between the development of its different components, that is, some would consolidate before others (Miyake et al., 2000; Dawson & Guare, 2012; Diamond & Lee, 2011). Based on the theory proposed by Miyake et al. (2000), inhibition is the first component to be consolidated.

The working memory component was assessed using the digits subtest, which is an integral part of the Weschlers Assessment Scale (Wechsler, 2012).

Although the results presented, from the comparison between pre and post-test through the described subtest, have revealed a reliable indication of change for an S1 student, it is important to emphasize that the student was not able to perform the second part of the task during the pre-test situation. test, thus presenting a raw score for only the first part of the subtest. In the post-test situation, the same student had a better score in the first part of the test and a performance classified as preserved from the score and classification of the instrument itself, suggesting a gain in the test. performance on tasks involving working memory.

The alternation component was assessed using the path test: parts A and B (Seabra & Dias, 2012). Regarding the indicator of reliable change, there was a reliable change for two students, S1 and S4, and regarding S4, it is not possible to state that the gains in alternation can be attributed to the intervention from the application of the test, since the school he was unable to perform the task in the pre-test, as he did not master the alphabetical order evaluated in part A of the test, making it impossible to

measure his performance in alternation. In the post-test, the same student was able to perform both parts of the test (A and B), which, in turn, may reflect a gain with schooling.

According to literature, studies carried out on early identification of schoolchildren at risk for reading difficulties, using the phonological basis and the grapheme-phoneme mechanism (Fadini & Capellini, 2011), revealing, however, that metaphonological skills, phonological working memory, rapid automatic naming and reading are predictive skills for reading development, which must be taught in an instructional in the first two years of literacy, justifying the absence of indications of gains from the pre and post-test in the tests knowledge of the alphabet, rhyme production, syllabic segmentation, phonemic synthesis, phonemic analysis, identification of the initial phoneme, rapid automatic naming, silent reading, reading words and pseudowords, as well as listening comprehension of diseases from figures, since the intervention program did not focus on specific instruction aimed at these skills.

In the rhyme identification test, there was an indicative of reliable change for the student S6, an indication of reliable change, as well as in the test of word production from given phoneme, presenting an indication of reliable change for the student S2. Knowledge of major phonological units such as onset-rhyme develops independently of reading instruction, and can be observed in children aged between three and five years (Capellini, César, & Germano, 2017), when developing skill categorizing words, involving the act of attending to their constituent sounds, can have a considerable effect on their future success in learning to read and write (Bradley & Bryant, 1983). Thus, considering selective attention as the ability to select only what will be important for a given task at a given moment, focusing attention and not being distracted by various stimuli in the environment (Van Moorselaar, & Slagter, 2020), we can relate this finding to the gains shown.

In the phonological working memory test, there was an indication of reliable change for the student from S1, the same student who showed an indication of reliable change in the comparison of pre- and post-testing from an instrument that aims to assess working memory from of verbal stimulus. The phonological working memory system is considered responsible for the temporary storage of information (Baddeley, 2017), occurring through working memory the storage and manipulation of information for a short period, a skill necessary for the cognitive and effective functioning of activities. everyday activities, such as school performance. Thus, the results suggest a relationship between the development of executive functions, promoting reading skills, according to the literature (Diamond, 2013; Diamond & Lee, 2011), which has emphasized the importance of promotion of early development of executive functions and its relationship with school readiness, as well as its important predictive power on reading performance during the schooling process.

Although it cannot be said, from the preliminary data, that the gains presented are due to the intervention, since the improvement evidenced may be related to the neurodevelopment and schooling of the schoolchildren, as it is a pilot study, there was no comparison of the group studied with a control group. Therefore, an effectiveness analysis study will be carried out.

As for the hypothesis of this study, that an RTI tier 2 intervention program for the development of executive functions in schoolchildren from the 1st grade level of Elementary School I can help in the identification and early intervention in schoolchildren at risk for learning difficulties was partially confirmed, because in the pilot study there was an indication of improvement in the performance of rhyme identification skills, word production from given phoneme and phonological working memory. However, the limitation in the sample size of the pilot study did not allow us to attribute clinical significance only to the effects generated by the program, as there is still the educational and neurodevelopmental effect. Thus, future studies will be conducted to expand the sample in order to verify the effectiveness of this intervention.

The results showed that there was a reliable improvement in the components of executive function inhibition, working memory and cognitive flexibility for some schoolchildren in this study. In tasks of rhyme identification, production from the phoneme, phonological working memory, the results also showed that there was a reliable improvement, although the program did not focus on its development.

5. Conclusion

The program in this study proved to be applicable and, can be used as an intervention instrument based on scientific evidence that helps the development of executive functions and learning in RTI tier 2.

It was also possible to conclude that from the analysis of the clinical significance carried out to analyze the results of the program developed for this study, it showed an indication of improvement in the components of executive functions and in the predictive skills for reading acquisition, as there were positive changes in the response of the schoolchildren. when comparing the performance in pre- and post-testing situations.

References

- Andrade, O. V. C., Andrade, P. E., & Capellini, S. A. (2014). Cognitive-Linguistic Profile in Students with Reading and Writing Difficulties. *Psicologia, Reflexão e Crítica*, 27(2), 358. doi:10.1590/1678-7153.201427217
- Baddeley, A. (2017). *Exploring working memory: Selected works of Alan Baddeley*. Routledge.
- Berkeley, S., Scanlon, D., Bailey, T. R., Sutton, J. C., & Sacco, D. M. (2020). A Snapshot of RTI Implementation a Decade Later: New Picture, Same Story. *Journal of Learning Disabilities*, 53(5), 332-342. doi:10.1177/0022219420915867
- Bradley, L., & Bryant, P. E. (1983). Categorizing sounds and learning to read – a causal connection. *Nature*, 301(5899), 419-421.
- Capellini, S. A., César, A. B. P. C., & Germano, G. D. (2017). *Protocolo de identificação precoce dos problemas de leitura – IPPL*. 1ª. Ribeirão Preto, SP: Booktoy.
- Dawson, P., & Guare, R. (2012). *Coaching students with executive skills deficits*. Guilford Press.
- Diamond, A. (2013). Executive functions. *Annual review of psychology*, 64, 135. doi:10.1146/annurev-psych-113011-143750
- Diamond, A., & Lee, K. (2011). Interventions shown to aid executive function development in children 4 to 12 years old. *Science*, 333(6045), 959-964. doi.org/10.1126/science.1204529
- Fadini, C. C., & Capellini, S. A. (2011). Treinamento de habilidades fonológicas em escolares de risco para dislexia. *Revista Psicopedagogia*, 28(85), 3-13.
- Fletcher, J. M., & Vaughn, S. (2009). Response to intervention: Preventing and remediating academic difficulties. *Child development perspectives*, 3(1), 30-37. https://doi.org/10.1111/j.1750-8606.2008.00072.x
- Friedman, N. P., & Miyake, A. (2017). Unity and diversity of executive functions: Individual differences as a window on cognitive structure. *Cortex*, 86, 186-204. https://doi.org/10.1016/j.cortex.2016.04.023
- Fuchs, D., & Fuchs, L. S. (2006). Introduction to Response to Intervention: What, Why and How Valid is It? *Reading Research Quarterly*, 41(1), 93-99. http://www.jstor.org/stable/4151803
- Gonçalves, H. A., Viapiana, V. F., Sartori, M. S., Giacomoni, C. H., Stein, L. M., & Fonseca, R. P. (2017). Funções executivas predizem o processamento de habilidades básicas de leitura, escrita e matemática?. *Neuropsicologia Latinoamericana*, 9(3).
- Jacobson, N. S., & Truax, P. (1992). Clinical significance: a statistical approach to defining meaningful change in psychotherapy research. In A. E. Kazdin (Ed.), *Methodological issues & strategies in clinical research* (pp. 631–648). American Psychological Association. https://psycnet.apa.org/doi/10.1037/10109-042
- Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex “frontal lobe” tasks: A latent variable analysis. *Cognitive psychology*, 41(1), 49-100. https://doi.org/10.1006/cogp.1999.0734
- Reynolds, C. R., & Shaywitz, S. E. (2009). Response to intervention: Prevention and remediation, perhaps. Diagnosis, no. *Child development perspectives*, 3(1), 44-47. https://doi.org/10.1111/j.1750-8606.2008.00075.x
- Rodríguez, C., Areces, D., García, T., Cueli, M., & Gonzalez-Castro, P. (2021). Neurodevelopmental disorders: An innovative perspective via the response to intervention model. *World Journal of Psychiatry*, 11(11), 1017. doi:10.5498/wjp.v11.i11.1017
- Rudasill, K. M., Acar, I., & Xu, Y. (2022). Early Teacher-Child Relationships Promote Self-Regulation Development in Prekindergarten. *International Journal of Environmental Research and Public Health*, 19(14), 8802. doi:10.3390/ijerph19148802.
- Seabra, A. G., & Dias, N. M. (2012). *Avaliação neuropsicológica cognitiva: Atenção e funções executivas* (Vol. 1). São Paulo, Brasil: Memnon.
- Sullivan, Y. W., Davis, F. D., & Koh, C. E. (2022). Executive functions and information systems learning. *MIS Quarterly*, 46(2).
- Van der Ven, S. H., Kroesbergen, E. H., Boom, J., & Leseman, P. P. (2012). The development of executive functions and early mathematics: a dynamic relationship. *British Journal of Educational Psychology*, 82(Pt 1), 100-119. doi:10.1111/j.2044-8279.2011.02035.x.
- Van Moorselaar, D., & Slagter, H. A. (2020). Inhibition in selective attention. *Annals of the New York Academy of Sciences*, 1464(1), 204-221. doi:10.1111/nyas.14304
- Wechsler, D. (2012). *Wechsler Preschool and Primary Scale of Intelligence* (4th edition). San Antonio, TX.: The Psychological Corporation.