Chapter #7

RTI TIER 2 EXECUTIVE FUNCTION PROGRAM FOR 1ST GRADE BRAZILIAN SCHOOLCHILDREN

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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 schoolchildren and to analyze the clinical significance of the program via a pilot study. **Method:** This study was developed in two phases: elaboration and application of the RTI program for Brazilian schoolchildren; and a clinical significance analysis of the children's performance in pre- and post-test situations. The initial sample comprised 71 children (age from 6 years to 6 years and 11 months of both sexes) from two Brazilian public schools. These were submitted to a pre-assessment protocol. 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 functions, intervention studies, learning, response to intervention.

1. INTRODUCTION

Studies have been published both in Brazil (Cardoso, Dias, Seabra, & Fonseca, 2017; Gonçalves et al., 2017) and internationally (Catts & Tomblin, 2001; Shuai et al., 2017; Rudasill, Acar, & Xu, 2022; Van der Ven, Kroesbergen, Boom, & Leseman, 2012), on the use of early interventions for the development of executive functions and for learning problems, as well as the performance of those skills involved.

However, there are still few studies that focus on the development of executive functions among at-risk students for learning difficulties using the Response to Intervention (RTI) model (Dvorsky, Becker, Tamm, & Willoughby, 2021; Kuhn, Willoughby, Vernon-Feagans, & Blair, 2016; Rodríguez, Areces, García, Cueli, & Gonzalez-Castro, 2021).

2. BACKGROUND

Executive functions (EF) are considered higher-order cognitive resources that command lower-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).

Executive functions have been studied from perspectives that aim to define their components for classification and evaluation purposes, and the term executive functions is used to designate a wide variety of cognitive functions (Hamdan & Pereira, 2009).

The course of neurobiological development is progressive, through which its components are consolidated at different stages, with environmental factors acting in conjunction (Dawson & Guare, 2010; Dias & Seabra, 2013). Thus, in addition to the ontogenetic development of executive functions, from around 12 months of age to early adulthood (Romine & Reynolds, 2005), studies have shown that there is a variation between the development of its individual components, or that is, some components consolidate before others (Dawson & Guare, 2010; Diamond & Lee, 2011; Miyake et al., 2000).

This model, proposed by Miyake et al. (2000), which has recently received acceptance in the literature (Diamond, 2013; Diamond & Lee, 2011; Sullivan, Davis, & Koh, 2022), considers three essential components related to executive functions: inhibition, working memory and shifting, thereby demonstrating that, via their integration, they allow other skills to emerge, such as planning, decision making and problem solving, among others.

Knowing the milestones of ontogenetic development, as well as the evolutionary course of the components of executive functions, allows us not only to evaluate, but also to develop strategies for early interventions for their development. Studies have shown that executive functions can be used as an important predictor of school readiness, because they exert a great influence on academic performance since they are associated with adjustment and cognitive, emotional, behavioral and social development (Blair & Ursache, 2011; Diamond, 2013).

Thus, the literature has advocated a combined approach that includes assessment and intervention addressing the areas of cognitive processing, which may underlie learning processes in the various areas of reading, writing and mathematics (Howard, Johnson, & Pascual-Leone, 2014, Kerges-Alcantara & Capellini, 2020). Studies have defended the relationship between executive functions and academic skills in assessment and intervention situations (Willoughby, Hudson, Hong, & Wylie, 2021) contributing to individualized instruction projects that are fundamental to special education (Rodríguez et al., 2021).
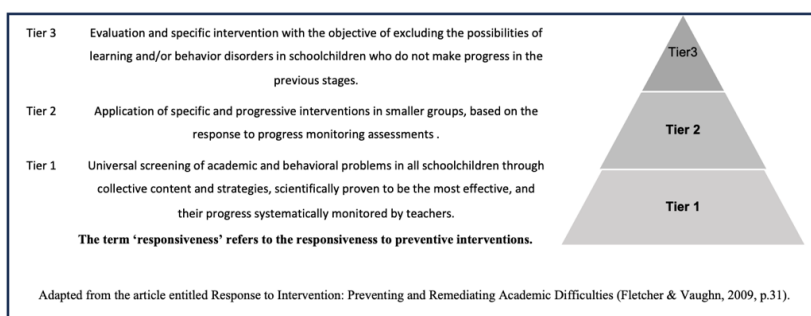
RTI is a multi-tier educational and behavioral model where the activities developed seek the identification and early intervention in at-risk schoolchildren for learning and behavioral difficulties, as well as diagnostic models of learning and behavior disorders (Andrade, Andrade, & Capellini, 2014; Fletcher & Vaughn, 2009; Fuchs & Fuchs, 2006).

The RTI model is designed to offer resources that allow more efficient care programs to provide a faster response to the needs of schoolchildren with learning and behavioral problems (Andrade et al., 2014; Fox, Carta, Strain, Dunlap, & Hemmeter, 2010; Jiménez, Gutiérrez, & de León, 2021), having been widely used in international and national literature (Andrade et al., 2014; Berkeley, Scanlon, Bailey & Sutton, 2020; Brito, Seabra, & Macedo, 2018; Mellard & Johnson 2007; Fuchs & Fuchs, 2006; Grosche & Volpe, 2013; Marino & Beecher, 2010; Miranda, et al., 2019; Vellutino et al., 1996).

The RTI model is composed of three tiers: (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), that is, the responsiveness to preventive interventions, of those schoolchildren who did not

respond positively to universal screening and therefore are identified as at-risk for learning problems and eligible to the second tier; and (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 (Al Otaiba et al., 2011; Fletcher & Vaughn, 2009; Fuchs & Fuchs, 2006). The RTI model's structure is shown in Figure 1.

Figure 1.
Three-tier structure of the RTI model.

Tier 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.
Tier 2	Application of specific and progressive interventions in smaller groups, based on the response to progress monitoring assessments .
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.

The term 'responsiveness' refers to the responsiveness to preventive interventions.

Adapted from the article entitled Response to Intervention: Preventing and Remediating Academic Difficulties (Fletcher & Vaughn, 2009, p.31).

The term 'responsiveness' refers to the response to preventive interventions. Therefore, the RTI is a model focused on prevention, carried out in tiers (several phases of model implementation), where the monitoring of a student's "responsiveness" or "non-responsiveness" to early intervention programs will determine whether he or she will be referred to specialists, who in turn will conduct the individualized remedial intervention and diagnosis (Andrade et al., 2014; Fuchs & Fuchs, 2006; Wixson & Valencia, 2011).

Corroborating this, the current edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5-TR) included in the diagnostic criteria for learning disorders a proposal for a response to intervention, based on the premise that existing environmental variables, as well as the time and mode of response to the intervention, can generate false positives for diagnosis of dyslexia. Consequently, this manual recommends that initially a diagnostic hypothesis is established, which will then be confirmed or refuted after a minimum period of six months of scientifically based intervention (American Psychiatric Association, 2023).

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

3. METHOD

This study was realized following approval by the Research Ethics Committee. This is a quasi-experimental study developed in two phases: Phase 1 the elaboration of the RTI Tier 2 executive functions program for schoolchildren; and Phase 2 an analysis of the program's clinical significance.

The theoretical basis for the elaboration of the RTI Tier 2 intervention program, called RTI-FEx was the theoretical model proposed by Miyake et al. (2000), considering the three main components of executive functions: inhibition of prepotent responses ''inhibition''; updating and monitoring of working memory representations "working memory"; and shifting between tasks or mental sets ''shifting''.

Each of the components of executive functions was considered as an objective of the program, developed for application in a school environment and in the group modality. For each objective, strategies were developed for this study, based on gold standard instruments described in the national and international literature, and intended for the assessment of executive functions (Strauss, Sherman, & Spreen, 2006; Zimmermann, Cardoso, Kristensen, & Fonseca, 2017), in addition to intervention programs in executive functions published in the national literature (Cardoso, et al., 2017; Dias & Seabra, 2013).

Thus, RTI-FEx was composed of 10 strategies, distributed over 9 sessions with an average duration of 40 minutes each, to be carried out on a weekly basis over a nine-week period, progressively considering the three main components of executive functions: inhibition; working memory; and shifting.

Phase 2 of this research was a pilot study to determine the applicability of the program developed in Phase 1. The pilot study sample initially comprised 71 schoolchildren that were authorized to participate in the research from the 1st grade level of Elementary School I, of both genders, aged between 6 years and 6 years and 11 months, from two public schools in the city of Marília, São Paulo, Brazil.

The 71 schoolchildren were submitted to an assessment to identify those at-risk for difficulties in executive function. The following instruments were used as evaluation procedures in pre- and post-testing situations: Assessment Attention Cancellation Test (TAC); Trail Making Test (Parts A and B); Protocol for Early Identification of Reading Problems – IPPL; Five Digits Test – FDT; and Wechsler Scale Digits Subtest – WISC IV. The criterion used to identify at-risk schoolchildren was performance levels classified as below average in all instruments applied in pre-testing situations.

Only 37 of the 71 schoolchildren completed the pre-assessment procedures and of these 18 were identified as being at-risk for difficulties in executive functions and learning and as such met the inclusion criteria for the second-tier intervention. Of the 18 schoolchildren who completed the pre-testing assessment and were referred to the intervention program developed in phase 1 of this study, only eight schoolchildren completed the program and underwent the application of post-assessment procedures.

Therefore, the sample for the pilot study of phase 2 in this research comprised eight schoolchildren from the 1st year of Elementary School I, aged between 6 years and 6 years and 11 months, of both sexes, from two public schools in the city of Marilia, Sao Paulo, Brazil.

3.1. 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 determine whether the differences between them represent reliable changes and whether they are clinically relevant.

The JT Method results in two complementary processes: calculation of the reliability of changes that occurred between the pre- and post-intervention assessment, described in terms of a Reliable Change Index (RCI), and analysis of the clinical significance of these changes. The difference is calculated based on the difference between pre- and post-test divided by the standard error of the difference. In this way, the change from pre- to

post-testing can be a reliable positive (when there is improvement); reliable negative (when there is worsening); with clinical significance (which makes or will make a difference in the clinical scope); and there may also be no change.

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 based on their performance in the instruments used in pre- and post-testing situations.

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

Instruments used in the pre- and post-assessment protocol

Student	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	-	-	-	-

RPC = reliable positive change; RNC = reliable negative change; FDT = five digit test; TAC1 = attention cancellation test part 1; TAC2 = attention cancellation test part 2; TAC3 = attention cancellation 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

Student	AK	RP	RI	SS	PWF	PS	PA	IPI	PWM	FAN	SR	WPWR	LCP
1	-	-	-	-		-	-	-	RPC	-	-	-	-
2	-	-	-	-	RPC	-	-	-	-	RNC	-	-	-
3	-	-	-	-		-	-	-	-	-	-	-	-
4	-	-	-	-		-	-	-	-	-	-	-	-
5	-	-	-	-		-	-	-	-	-	-	-	-

	AK	RP	RI	SS	PWF	PS	PA	IPI	PWM	FAN	SR	WPWR	LCP
6	RNC	-	RPC	-		-	-	-	-	-	RNC	-	-
7	-	-	-	-		-	-	-	-	-	-	-	-
8	-	-	-	-	RNC	-	-	-	RNC	-	-	-	-

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

3.2. 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 the schoolchildren were unable to perform the task in a pre-testing situation because they presented difficulty in understanding the instructions of the procedure required to perform the task. It is underscored that the instrument is intended for the evaluation of this component in the age group of this study (Sedó, Paula, & Malloy-Diniz, 2015). The same task was proposed in a post-assessment situation, where S1, S2, S4, S5 and S7 were able to perform the task, albeit presenting a performance suggestive of clinical deficit.

Although it is not possible to say that the gains in inhibition can be attributed to the intervention from the application of the FDT, as the schoolchildren were not able to perform the task in the pre-testing, there is a second test used to evaluate the inhibition component, the attention cancellation test, an instrument that assesses selective attention, which according to the literature is one of the skills involved in executive functions, fundamental to adaptive and purpose-oriented functioning (Friedman & Miyake, 2017). Also, according to the literature, the inhibition component includes the concept of selective attention, as it allows for the inhibition of overbearing responses and attention to irrelevant stimuli (Dawson & Guare, 2010).

In this task, which consists of three matrices printed with different stimuli, a performance improvement 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 intended for the evaluation of selective attention, but with a demand for alternation (S1, S2, S3, S4 and S7), since it is necessary to change the focus of attention in each line.

The second part of the test presents a greater degree of difficulty, through an activity similar to the first, but using a target stimulus composed of double figures. Here, the student must mark the target figures, for example, a cross and a star, which must necessarily be in that order, thus raising the task's level of complexity (Seabra & Dias, 2012).

This is a pilot study and as such the data are preliminary, therefore it cannot be said that the improvement in this component are due to the intervention alone or in part due to the schooling process to which the schoolchildren in this study continued to be exposed during the academic year. It is worth noting that, according to the literature 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 the various components, that is, some would consolidate before others (Miyake, et al.,

2000; Dawson & Guare, 2010; 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 evaluated using the Digits Subtest, which is an integral part of the Wechsler Assessment Scale (Wechsler, 2012). Although the results presented, from the comparison between pre- and post-testing through the described subtest, were indicative of reliable change for student S1, it is important to emphasize that the student was not able to perform the second part of the task during the pre-test situation, thus presenting a raw score for only the first part of the subtest. In the post-testing situation, the same student, in addition to presenting an improved score in the first part of the test, not only managed to perform the second part, but also presented a performance classified as preserved from the score and classification of the instrument itself, suggesting a gain in test performance for tasks involving working memory, information transformation, mental agility, and visual and spatial images.

The alternation component was evaluated through the Trail Making Test: parts A and B. Regarding the indicator of reliable change, there was a reliable change for two schoolchildren, S1 and S4, and in relation to S4, it is not possible to affirm that the gains in alternation can be attributed to the intervention from the application of the test, since the student was unable to perform the task in the pre-test, due to not mastering the alphabetical order evaluated in part A, this making it impossible to measure performance in alternation. During post-testing, the same student was able to perform both parts of the test (A and B), which in turn may reflect a gain from schooling.

According to national and international literature, studies carried out on early identification of at-risk schoolchildren for reading difficulties present the response to intervention (RTI) as a means to identify and intervene in an early manner, using the phonological basis and the grapheme-phoneme mechanism (Fadini & Capellini, 2011; Hulme & Snowling, 2014), revealing, however, that metaphonological skills, phonological working memory, rapid automatic naming and reading are predictive skills for reading development, which must be taught 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 sentences based on pictures, since the intervention program did not focus on specific instruction aimed at these skills.

In the Rhyme Identification Test, there was an indication of reliable change for the student S6, and also an indication of reliable change in the Word Production from a given Phoneme Test, presented by 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, Cesar, & Germano, 2017; Badian, 2001), when developing skill categorizing words, involving the act of attending to their constituent sounds, this 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 that which will be important for a given task at a given moment, thereby focusing attention and avoiding being distracted by the various stimuli present 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 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 verbal stimulus. According to the literature, the phonological working memory system is considered responsible for the temporary storage of information

(Baddeley, 2017), the storage and manipulation of information during a short period occurs through working memory, a necessary skill for the cognitive and effective functioning of everyday activities, such as performing tasks at school. Thus, the results suggest a relationship between the development of executive functions, promoting reading skills, according to the literature (Blair & Diamond, 2008; Meltzer, 2010), 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 for reading performance during the schooling process.

However, it cannot be affirmed from the preliminary data that the gains presented are entirely due to the intervention, since the improvement observed may also be related to the schoolchildren's neurodevelopment and schooling. Likewise, since it is a pilot study, there was no comparison of the study group with a control group. Therefore, future research will perform an effectiveness analysis study.

Regarding the analysis of the clinical significance of the program in a pilot study, there is an indication of improvement in the components of executive functions and in the predictive skills for reading acquisition; however again, without a control group, it was not possible to attribute the improvement exclusively to the intervention program.

Regarding the aim of elaborating a RTI tier 2 intervention program for the development of executive functions in schoolchildren from the 1st grade level of Elementary School I, it can be said that the objective was partially completed, since we demonstrated the need to include ecological tests to facilitate the generalization of cognitive gains in the performance of tasks by schoolchildren.

Regarding 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 to the effects generated by the program alone, since there are also educational and neurodevelopmental effects to be considered. 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, and phonological working memory, the results also showed that there was a reliable improvement, although the program did not focus on its development.

4. FUTURE RESEARCH

The limitation in the sample size of this pilot study did not allow us to attribute clinical significance to the effects generated by the program alone, since there is also the role of educational and neurodevelopmental effects to be considered. Thus, future studies need to be conducted with a larger sample size and control group to quantify the effectiveness of this intervention.

5. CONCLUSION

The program developed for this study proved to be applicable and can be used as an intervention instrument based on scientific evidence that promotes 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 designed for this study, there was an indication of improvement in the components of executive functions and in the predictive skills for reading acquisition, since there were positive changes in the schoolchildren's' responses, when comparing performance in pre- and post-testing situations.

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