

Full Length Research Paper

Teaching facts of addition to Brazilian children with attention-deficit/hyperactivity disorder

Adriana Corrêa Costa*, Luis Augusto Rohde and Beatriz Vargas Dorneles

Federal University of Rio Grande do Sul, Porto Alegre, Brazil.

Received 21 February, 2014; Accepted 9 March, 2015

Storage and/or automatic retrieval of the basic facts of addition from the long-term memory seems to be impaired in children with ADHD presenting arithmetical difficulties. The present study was carried out to evaluate the effectiveness of an educational intervention model designed to teach basic facts of addition as a means of advancing from counting procedures to memory-based processes in 7 children with ADHD, divided into two groups (control and intervention). The main hypothesis was that the explicit teaching of decomposition strategies would lead to an advanced use of a memory-based procedure. It is an experimental study involving the use of a blind, parallel, randomized, controlled clinical trial. The intervention group participated in 10 one-hour sessions over a 10-week period, while the control group received the same quantity and distribution of teaching time. They carried out the kind of activities generally carried out in the classroom. Although there was no apparent statistical difference between the groups, our findings suggest that the tested educational intervention model is effective at promoting the retrieval of memory-based facts, since the intervention group came to predominantly adopt a memory-based strategy. A carefully designed educational program enhances memory-based processes in students with ADHD. These findings have important implications for further research considering interventions for both students with ADHD and those who perform poorly in arithmetic.

Key words: Special education, attention-deficit/hyperactivity disorder (ADHD), educational model, arithmetical difficulties, educational intervention.

INTRODUCTION

Learning difficulties are often associated with Attention-Deficit/Hyperactivity Disorder (ADHD), which has a great impact upon the child's educational development. During school years, the disorder is often associated with poor academic performance, grade retention, suspension, expulsion (Barkley, 2014; Lahey et al., 2004; Rohde et al., 1999) and difficulties in relationships (Lahey et al.,

2004), resulting in a worse quality of life (Klassen et al., 2004). Some authors (Faraone et al., 2001; Mayes et al., 2000) have related this worse performance with the high prevalence of comorbidity between learning disability (LD) and ADHD. Although several theoretical models have been proposed to explain this comorbidity, three of them received greater attention (Biederman et al., 2004;

*Corresponding author. E-mail: adri_costa@terra.com.br. Tel: 0555133083434.

Martinussen et al., 2005; Rhee et al., 2005; Shanahan et al., 2006; Willcutt et al., 2005). The first one suggests that the two disorders share risk factors in common, that is, there is one (or more) cognitive deficit underlying both the disorders; for example, the working memory and the processing speed (Biederman et al., 2004; Martinussen et al., 2005; Shanahan et al., 2006; Willcutt et al., 2005). The second one proposes that the presence of one disorder increases the risk for the other, i.e., the three nuclear symptoms of ADHD, inattention, hyperactivity and impulsivity, have a strong impact upon learning (DuPaul and Stoner, 2003). The third model suggests that the comorbidity represents independent disorders (Rhee et al., 2005). Even though the causes of this comorbidity are not yet clear, there is evidence that, when the two disorders occur together, students have greater attention and academic deficits than when they occur separately (Barkley, 2014).

A set of investigations (Ackerman et al., 1986; Benedetto-Nasho and Tannock, 1999; Kaufmann and Nuerk, 2008; Lindsay et al., 2001; Casas et al., 2009) indicates that the main feature of the calculation problems associated with ADHD is the scarce representation and/or deficient inhibition in the access to the semantic memory of arithmetical facts. These mechanisms determine an overloaded process with interference effects, with a more generalized deficit when the ADHD appears associated with Mathematics Disorder (MD). Sella et al. (2012), comparing students with and without ADHD, concluded that ADHD students showed more difficulty than their peers in identifying the best counting procedure to use, choosing the easier one, which was the earliest one. Similar results were found by Costa et al. (2012a). Thus, difficulty in storing and/or accessing basic arithmetic facts is identified as a striking feature in students with ADHD. Therefore, it is necessary to teach such students' strategies that might facilitate access to basic facts from memory.

Recent research and reviews (Costa et al., 2012a; Costa et al., 2012b; Gersten et al., 2009; Hopkins and Lawson, 2006; Sella et al., 2012; Woodward, 2004) have shown that students with learning difficulties do not advance spontaneously to memory processes, requiring direct and explicit teaching situations that facilitate their acquisition. Moreover, practice, as the sole type of instruction, has proven to be ineffective (Baroody et al., 2009; National Mathematics Advisory Panel, 2008).

In recent years, one widely used method of teaching calculation in classrooms has been based upon the conceptual understanding of the facts, through manipulative materials, and on meaning-based teaching proposals. Miller and Hudson (2007) report that these practices are largely centered upon the student. Woodward (2004) noted that, within this teaching approach, the cognitive load of the curricular activities and materials is very challenging for students with learning difficulties, even more so for those with ADHD.

It is important to note that the characteristics of the students with ADHD, including memory deficits (Keeler and Swanson, 2001; Kroesbergen and Luit, 2003), difficulty in attending to the main aspects of tasks and a passive approach to concluding tasks (Greenwood et al., 2002; Junod et al., 2006) contribute to increasing the challenges that all students have to face.

A variety of interventions has been tested in order to reduce the academic and social difficulties that often accompany ADHD (Tirado et al., 2004). Consistently, studies (MTA COOPERATIVE GROUP, 1999; Chronis et al., 2006; DuPaul and Stoner, 2003; DuPaul et al., 2006; Raggi and Chronis, 2006) have indicated that the best treatment is based on a more comprehensive approach including the use of medication and behavioral and psychoeducational interventions. The two latter approaches are aimed at the student, the parents and the teachers. While, on one hand, there are many studies indicating the efficacy of medication and showing that productivity increases with its use; on the other hand, there are few studies which examine the long-term results of academic interventions (Pfiffner et al., 1998; Raggi and Chronis, 2006). Most of this research has concentrated on strategies related to handling social behavior and conduct in the classroom, but this is only one aspect of ADHD; another is related to strategies aimed at enhancing academic performance (DuPaul and Stoner, 2003; Iseman and Naglieri, 2011).

To the best of our knowledge, no investigations have attempted to assess efficient strategies for teaching basic arithmetic facts to students with ADHD, despite evidence that this group of students continues to use immature counting procedures up to more advanced grades (Benedetto-Nasho and Tannock, 1999; Costa et al., 2012a; Sella et al., 2012; Zentall, 2007). Thus, the present study is the first to investigate the efficacy of a pedagogical intervention model directed at teaching basic arithmetic facts, as a resource for advancing to memory-based processes.

METHODS

This is an experimental study using a blind, parallel, randomized, controlled clinical trial. The sample was enrolled from the ADHD Outpatient Clinic at the Child and Adolescent Psychiatric Division of Hospital de Clínicas de Porto Alegre (PRODAH). The research project was approved by the Research Ethics Committee of the *Hospital de Clínicas de Porto Alegre*, RS, Brazil (project number 07591). Written informed consent from parents or a legal guardian and assent from the child were obtained.

Subjects

Four boys and three girls from the ADHD Outpatient Program were randomly allocated, using a sequential allocation strategy balanced by prognostic factors (Fossaluzza et al., 2009), into 2 groups: 1) control group (CG) – two boys and 1 girl aged from 8 to 11 years ($M = 9.67$), within the average range of intelligence ($M = 98.34$, SD

= 13.87) based on the WISC-III (2002) vocabulary and cube subtests, and 2) intervention group (IG) – two boys and two girls aged from 8 to 10 years ($M = 9$), within the average range of intelligence ($M = 92.5$, $SD = 9.57$).

The inclusion criteria were: a) attendance at the second to the seventh grade of elementary school; b) diagnosis of inattentive or combined ADHD subtypes, confirmed by the clinical staff according to the DSM-IV criteria (APA, 1994); c) an estimated IQ (WISC-III, 1991) between 80 and 120; d) the use of counting-based procedures and e) not receiving special educational support. Subjects diagnosed as having any comorbid Mood Disorder and Anxiety Disorder were excluded, as they are psychiatric disorders that interfere greatly in scholastic performance.

Mathematical assessments

The participants were assessed in two mathematical measures by two qualified research assistants, both trained in Psychopedagogy and linked to the School of Education at the Federal University of Rio Grande do Sul (UFRGS). The senior investigator (BVD) duly trained the two assistants. The two instruments were always applied in the same session and the children were assessed individually. The tasks used were as follows:

a) Evaluation of the counting procedure and strategy: the sub-item Strategy Windows from the Numeracy Project Assessment (New Zealand, 2007a), which evaluates the strategy employed to resolve addition problems, was used. Strategy Windows consists of 9 tasks with an increasing degree of difficulty. The tasks, arranged one at a time on a sheet of paper, were presented as mathematical stories in which both the parts were greater than 0, and the second was smaller than the first. The investigator read the question, and the child was expected to reply orally as soon as he/she had the answer. The child was informed that he/she could resolve the question in the way he/she found easiest and that it was not permitted to use paper and pencil to avoid the child doing the calculation on paper. To avoid inducing their use, the term “fingers” was not used, but finger counting was allowed. Upon the conclusion of each task, the investigator determined the counting procedure (counting all; counting on the highest) or the memory process used (decomposition or retrieval), based upon the child’s answer and the investigator’s observation (Figure 1). If required, the student was asked if he or she had solved the calculation. At the end of the test, the investigator indicated the predominant memory process or counting procedure and the most advanced counting strategy (fingers, oral or silent) that had been accurately used.

b) Knowledge of basic facts (adapted from Hopkins and Lawson, 2006): the students were requested to answer 38 problems of addition, written in the form $a + b$ in which both the parts were greater than 0, and b , greater than or equal to a . Of the 65 (100%) problems proposed by Hopkins and Lawson (2006), 38 (59%) were chosen. It was decided to execute an abbreviated form of the original proposal, as the assessment was to occur in a single day and the subjects were tired at the end in the pilot study, which could interfere with the results. The problems were presented, one at a time, on a sheet of paper, and the investigator read the problem orally. The students were requested to solve the problems by trying to retrieve the answer from memory. They were told that they could not count on their fingers and should say the number that came to their mind. Memory was considered to have been used when the child answered immediately¹, upon being presented with the question.

Immediately after the intervention (post-test) and two months later (follow-up), the instruments were applied to assess the

¹ The relevant literature (Andersson, 2008; Russell & Ginsburg, 1984) has indicated that 3 seconds is a good average.)

counting procedure and memory-based processes, as well as the subject’s knowledge of the basic facts. It should be pointed out that 2 subjects failed to attend the second evaluation. Figure 2 illustrates the study design.

Diagnostic procedures

The procedure used to diagnose ADHD and comorbid disorders for children and adolescents in our unit has been extensively described (Rohde and Jellinek, 2002; Rohde et al., 2005). Briefly, the diagnosis of ADHD was obtained using a semi-structured interview, Schedule for Affective Disorders and Schizophrenia for School-Age Children, Epidemiological Version (K-SADS-E) (Orvachel, 1985) applied by trained research assistants, and clinical evaluation of ADHD and comorbid conditions using DSM-IV (APA, 1994) criteria used by child psychiatrists in interviews with the child and parents. For dimensional analyses of ADHD symptoms, we employed the Swanson, Nolan and Pelham – IV Questionnaire (SNAP-IV) (Swanson et al., 2001). Cognitive evaluation relied on the vocabulary and block design sub-tests of the Wechsler Intelligence Scale – Third Edition (WISC-III) (Wechsler, 1991) administered by a trained psychologist to estimate the children’s overall IQ.

Intervention

The intervention, regardless of the group, occurred over a three-month period (June, July and August). Ten sessions, lasting approximately 1 h, were organized, occurring once a week in the *Hospital de Clínicas de Porto Alegre*. The intervention was conducted in small groups, and the subjects in the intervention group participated in one individual meeting (the 5th session).

Instructional content. For the intervention group, in the pre-intervention assessment, two groups of basic facts were selected to be worked on: make 10 (cycle 1) and the doubles + 1/ - 1 (cycle 2). The principles for intervention were obtained from the Numeracy Developmental Project (New Zealand, 2007b,c), as that program complies with a set of theoretical and practical formulations in line with the most recent research in the area. Emphasis was given to the teaching of the part-all strategy as an alternative way of acquiring the basic facts (Hopkins and Lawson 2006; Hopkins and Egeberg, 2009). Hence, as activities were included to develop an understanding of the base 10 system (e.g., partitioning and grouping of tens; composing and decomposing numbers), to help students develop a conceptual understanding of addition facts and the mathematical properties that can be used to solve other arithmetical facts. Fluency in the use of the facts was also part of the intervention, since computational fluency includes efficiency, accuracy, and flexibility with strategies (Bay-Williams and Kling, 2014).

Care was also taken with the use of story problems. Van de Walle (2007) suggests that when students are involved in finding a new strategy, “raw” arithmetic problems (e.g. $8 + 5$) are more suitable; while when the goal is to practice a strategy, it is best to have the fact embedded in a simple context (e.g. John had 8 candies and bought 5 more. How many candies did he have then?). A new cycle only started if most of the group were using the taught procedure.

Instructional components. Each cycle involved four moments: 1) explicit teaching (for constructing the conceptual knowledge of each solving strategy to be taught); 2) practical (to encourage and automatize the procedure learned); 3) generalization (to expand the use of the procedure to other contexts not worked on) and 4) follow-up.

The general sequence of the moments constituting the

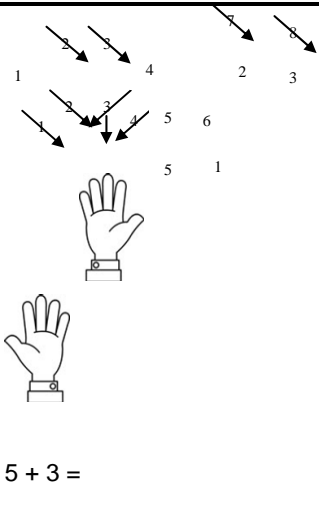
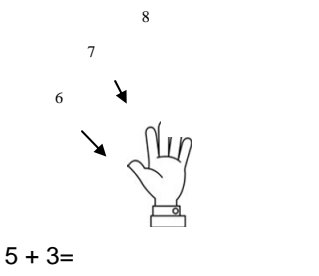
	<i>Procedures /processes</i>	<i>Definition</i>	<i>Example</i>
COUNTING PROCEDURES	<i>Counting all</i>	The student first represents each addend and after counts all.	 <p>5 + 3 =</p>
	<i>Counting on</i>	The student begins to count from one of the addends.	 <p>5 + 3 =</p>
MEMORY-BASED PROCESSES	Decomposition	The student applies a previously learned fact in order to arrive at an answer.	If $5 + 5 = 10$, then $6 + 5 = 5 + 5 + 1 = 11$
	Automatic retrieval	Simply knows the answer.	11

Figure 1. Counting procedures and memory-based processes. Source: Based on Hopkins and Egeberg (2009).

intervention is presented in Table 2.

Each lesson consisted of the following components: a Warm-Up (activating background knowledge by reviewing prerequisite concepts and skills and previously taught basic facts), Preview (providing an advance organizer), Modeled Practice (teaching the concepts and procedures while engaging students during instruction), Guided Practice (practicing as a group [choral and individual responding] with the interventionist), games designed to practice the taught procedure and Daily Check (Bryant et al., 2014; Cuillos et al., 2011), which assessed the content in each lesson. As can be seen, practice as a means of achieving automatization was greatly appreciated and, whenever possible, games were used for this purpose. Games provide opportunity for meaningful practice. The research about how students develop fact mastery indicates

that drill techniques and timed tests do not have the power that mathematical games and other experiences have. Appropriate mathematical activities are essential building blocks to develop mathematically proficient students who demonstrate computational fluency (Van de Walle, 2007).

Hence, the use of direct, explicit teaching, practice, constant feedback of the student’s performance, cumulative revision, and constant monitoring of his or her own progress (Fuchs et al., 2008) as practical principles.

The metacognition, i.e., the skills involving the understanding and control of cognitive processes, such as the monitoring and modifications of one’s own cognitive processes (Iseman and Naglieri, 2011) were emphasized. It is believed that in order to learn it is necessary to learn how to learn. Hence, the efficacy of the

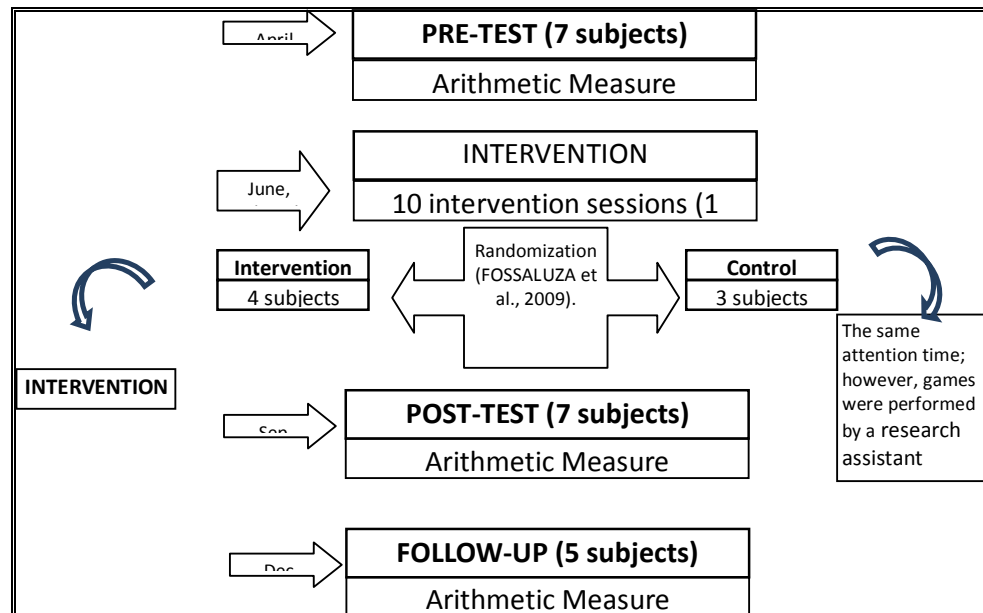


Figure 2. Representation of the study design.

learning is not dependent exclusively on conceptual knowledge, but also on the acquisition of metacognitive strategies that allow the student to plan and monitor his or her performance. Such strategies allow the student to consciously decide which processes he or she will use to learn and which learning strategy to adopt for each task, and furthermore, assess its efficacy, choosing an alternative when the desired results are not obtained.

In the fifth session, each child was seen individually for approximately 30 min. The main objective of this moment was to assess the child's progress. During the session, only those facts that would have to be solved using the make-10 strategy were selected (cycle1). The doubles were included with the purpose of introducing the new procedure (cycle 2). A calculation was shown to the child who was then expected to solve it in the manner he/she thought would be most efficient. They all used the make-10 procedure.

Control group

The control group received the same length of time of attention, although the games were supervised by a research assistant without pedagogical training. Reasoning games were chosen. In this group, the purpose was that, through the games, the subjects would have the opportunity to develop their emotional, cognitive, social and ethical skills. The emphasis was on the game as an instrument for mediating the relationship between the subjects. Thus, the proposed games were intended to help the subjects make decisions, find strategies for solving problems, learn how to deal with mistakes and develop awareness of their thought process. Some games were played in pairs, so that students could exercise the ability to cooperate with each other and work as a team, providing opportunities to cope better with emotions.

Thus, all the games involved rules, building relationships, developing strategies and negotiations between the participants. Some games were included deliberately to involve numbers (Prisoner – [original *El preso*] - marketed by Ruibal) and numerical sequence (Junior Profile [original *Perfil júnior*] - marketed by GROW and What's this? [original *Que bicho é esse?*] - marketed by Algarra). The card game, Uno (Mattel) was much appreciated by the group. All the games, with the exception of Prisoner [original *El*

preso], are made and easily found in Brazil.

RESULTS

The main objective of this study is to evaluate the effectiveness of a basic arithmetic facts education program as a means to advance the use of memory-based processes. The central hypothesis is that the explicit and direct teaching of the basic facts of addition would augment the repertoire of facts the student would be able to access, and that increase would be reflected in the use of a memory-based process.

In the statistical analysis, the variables were described in terms of the mean, median, minimum and maximum standard deviation, and compared within groups over time using the Friedman test and between groups using the Mann-Whitney test. The significance level for statistical tests was 5% (0.050).

The number of basic facts which each subject was capable of automatically retrieving at the three moments of the study (pre-intervention, post-intervention and in the follow-up) are presented in Table 1.

As can be seen, both the intervention group and the control group exhibited a gain in the number of basic facts they were capable of automatically retrieving from the long-term memory between the pre- and post-test. However, the difference was not significant.

It is important to note that the mean percent gain from pre to post-intervention was more than double in the intervention group compared to that of the control group. This improvement compared to the control group was maintained three months afterwards. The increase in the number of basic facts known allowed all the students

Table 1. Number of basic facts retrieved automatically at the three moments of the study.

		Pre-intervention	Post-intervention	Follow-up	P*
IG	Mean	20.50	33.00	26.67	0.050
	Median	20.00	33.00	24.00	
	Std. Deviation	2.52	3.37	5.51	
	Minimum	18.00	29.00	23.00	
	Maximum	24.00	37.00	33.00	
CG	Mean	24.00	29.33	21.00	0.223
	Median	26.00	26.00	21.00	
	Std. Deviation	5.29	5.77	11.31	
	Minimum	18.00	26.00	13.00	
	Maximum	28.00	36.00	29.00	
P**		0.400	0.400	0.800	

Significant values ($p < 0.05$) - *Friedman Test ** Mann-Whitney Test. Legend: IG = Intervention Group; CG= Control Group.

Table 2. General sequence.

Moments		Approximate time in min	Objective
	Warm-up	5-10	Explain which procedure will be taught and for what reason.
Explicit teaching	Teaching the new procedure	30 – 40	Seek to use solid materials in teaching a new procedure.
	Practicing the new procedure	10- 15	Suggest games in which the calculation can be resolved using the new procedure.
	Warm-down	5	Ask about what has been learned.
	Review	5-10	Remembering what was learned in the previous lesson.
Practice and generalization	Systematizing the new procedure	20 – 25	Performing paper and pencil-type activities using the new procedure.
	Practicing the new procedure	15 – 20	Suggest games in which the calculation can be resolved using the new procedure.
	Applying the new procedure in other contexts	10 – 15	Using the learned procedure in other, previously unworked, facts.
	Warm-down	5	Ask about what has been learned.
	Recalling	5-10	Remembering what was learned in the previous lesson.
Generalization and follow-up	Applying the new procedure	10 – 15	Using the learned procedure in other, previously unworked, facts
	Self-assessment	5 – 10	Checking whether I am using the learned taught/learned procedure. This self-assessment can be made by repeating the previous activities, or through arithmetic facts, where I should answer as quickly as possible.
	Warm-down	5	Ask about what has been learned.

Legend: In bold, most important steps, which may vary depending to the day.

from the intervention group to advance to using a memory-based counting strategy, a fact not observed in the control group, which continued using the same counting strategy. In the follow-up testing, all the subjects from the intervention group continued to use a procedure based upon memory.

Moreover, the Mann-Whitney test also showed there was no significant difference in the values of the automatically accessed basic facts within the groups.

DISCUSSION

To our knowledge, this is the first report investigating the efficacy of a pedagogical intervention model aimed at teaching basic facts to students with ADHD. The data from the present study indicate that direct teaching of decomposition added to a time of automation in this new procedure increases the number of basic arithmetic fact that the student is capable of accessing automatically.

This finding corroborates the findings of Hopkins and Lawson (2006), suggesting that confidence in automatic retrieval only occurs when the student has a significant number of basic facts in the long-term memory. Thus, the memory process requires the existence of at least some previously stored basic facts to assist the development of others. This would explain typical development, because the more facts the student is able to access automatically, the greater the incentive and satisfaction he/she will feel in engaging tasks and activities involving that skill. Consequently, most basic facts are stored in the memory, and so on successively.

For students with ADHD, the task is even more challenging because they have difficulty representing facts in the memory due to their attention and memory deficits (Kaufmann and Nuerk, 2008; Tannock, 1999). Thus, every time such a student attempts to solve a calculation, he/she needs to use a counting procedure, which is slow and often inaccurate. Consequently, the student is less inclined practice and, so is less capable of representing a larger number of arithmetic facts in the long-term memory. In addition to all this, ADHD students are known to have difficulty engaging in activities in general (Rogers et al., 2009). Thus, there is a real vicious circle of failure and frustration. Moreover, in such cases, practice becomes meaningless, making automatization slow. This is another of the important contributions provided by this study: highlighting the need of students with ADHD to practice the automatization of basic arithmetic facts. Therefore, it is important to find activities that engage such students (Rogers et al., 2009), an idea compatible with the findings of Zentall (1993) that students with ADHD require more instruction time and practice. Fletcher et al. (2009) suggest that an effective intervention program is one that substantially increases the student's exposure to situations that require mathematical thinking.

It should be noted that, at first glance, the control group showed an improvement, although it was inconsistent, since three months after, the results were lower than in the pre-test. The advance in the control group can be explained by the arithmetic tasks carried out, for example, the number line. Such activities, however, were unable to consolidate the taught knowledge, which was not the case in the intervention group. In the intervention group, there was also a decrease between the post-test and follow-up testing, but, compared with the pre-test, there was an advance. The decrease can be explained in two ways.

The first idea is to highlight the importance of practice. Possibly, after the intervention, the students did not practice anything other than what is commonly proposed in the classroom, which may have led to a diminished performance, as mentioned above.

The second explanation is related to the model of the response to the intervention (RtI) (Fletcher et al., 2009; Gersten et al., 2009). This model suggests that one

criterion for identifying learning disabilities (LD) should be the lack of a satisfactory response from the student to quality interventions. This criterion helps to distinguish a disorder from a difficulty, since, in the former case, studies (Dowker, 2004; Jordan et al., 2003) have indicated that the deficits are more persistent, which is not so in the case of difficulties. Thus, we may think that the students participating in this study presented a Learning Disorder (LD) as well as ADHD, which would make their response to the intervention even slower.

Research conducted in North America (Miller and Hudson, 2007; Powell et al., 2009) has indicated that in these countries the addition facts are part of the curriculum in preschools and in the first two years of elementary school. Probably then, students with typical typically development advance without any problems during those moments. However, studies in English (Baroody et al., 2009) and in Portuguese (Costa et al., 2012b) have demonstrated how difficult it is for students with difficulties in arithmetic to advance spontaneously from one procedure to another. To make matters worse, mathematics is characterized by a content hierarchy, in which new skills are built on those previously learned. Therefore, when students continue to use immature counting procedures, there is a need to develop teaching strategies suited to that level of knowledge, before moving on to new ones. The conclusion that this aspect is not considered in Brazilian schools provides an important contribution to the understanding of the subsequent arithmetic difficulties seen in this group of students. As they can be expected to have difficulty, for example, in understanding multiplication, a form of knowledge that implies an understanding the part-whole relation, which is not fully formed in this group of students. Furthermore, the lack of automatization in accessing simple addition facts also has an impact on the ability to solve multi-digit calculations, overloading working memory and favoring forgetfulness in the use of number grouping.

The data from the present study suggest decomposition/composition and commutativity are two difficult to understand principles, mainly for students with MD (Mathematical Disabilities). Similar findings were obtained by Baroody et al. (2009). Thus, understanding and explicitly teaching of these two principles can be crucial for the advance of a process based upon memory. Even so, this study suggests that this challenge can be overcome, depending on availability of suitable tools and opportunities.

While computer-based interventions may be more attractive to children, our main motives for using the present intervention model are twofold. The first is that some studies (Duhon et al., 2012; Ota and DuPaul, 2002) have shown there is no significant difference between computer-based and pencil and paper-based teaching. The second concerns the situation in the Brazilian education system, in which this study was conducted,

where using a computer as a teaching tool is not yet part of the educator's everyday life. Thus, the present teaching model has proven to be a promising path to be replicated in larger samples.

This finding confirms several intervention studies (Fuchs et al., 2005; Fuchs et al., 2006; Fuchs et al., 2008a; Fuchs et al., 2008b; Iseman and Naglieri, 2011; Tournaki, 2003; Woodward, 2006) showing that arithmetical skills are strongly susceptible to teaching. Iseman and Naglieri (2011) analyzed the efficacy of a ten days plan-based teaching with a group of ADHD students and concluded that there was an improvement in the students' performance, as assessed using math worksheets, and the students showed some knowledge transfer to standardized math tests.

The problem situations presented, being related to daily activities, may also have helped. Studies (Nunes and Bryant, 1997; Orrantia, 2006) have shown that linking mathematical problems to everyday life is capable of facilitating the learning of mathematical procedures and concepts by students. Orrantia (2006) reported that a large part of the arithmetical difficulties stems from the disconnection between the informal knowledge that students develop spontaneously and the formal knowledge that they learn in schools. Nunes and Bryant (1997) have postulated that this linking exerts a particularly strong influence in children with a low scholastic output. The effects of different teaching materials on students' performance, as well as the effects of pedagogical intervention time deserve a more detailed analysis in future research.

Conclusion

The main hypothesis is that subjects would advance from a procedure based upon counting to another relying on memory with both direct and explicit teaching of *decomposition* and moments of practice. This hypothesis was confirmed, indicating that the children in this study responded positively to explicit and direct teaching. The findings suggest two important pedagogical implications: 1) even interventions considered late may lead to changes, indicating that there is a delay in development and not a permanent deficit and 2) the need to pay greater attention to the teaching of basic arithmetic facts in order to facilitate the advance to memory-based processes.

The main methodological limitation of the present study was the sample size. Although the diagnostic criteria for ADHD were carefully controlled, the sample size was small, reducing the possibility of generalizing from the results obtained. Moreover, the small number of students with ADHD prevented comparison between subtypes of ADHD. Finally, the nonexistence of a group without ADHD meant that the comparison of the results found in children with ADHD with those described in children with

typical development could only be performed using data obtained from the relevant literature about the latter group (typical development). Another possible limitation is related to the control of the level of ADHD severity. It is likely that the most serious cases, and therefore the most difficult to remedy, were those who gave up or refused to take part in the study. However, it is important to emphasize an extremely innovative aspect of this study, which was to introduce the efficacy test model to the area of education. Further studies will be required to confirm the findings presented herein.

Due to the well-known clinical heterogeneity of ADHD, we cannot suggest that this teaching model would function for all children with ADHD. Nevertheless, a series of procedures can be described, which, as a whole, seem to be valid and should be taken into account in future studies:

1. Direct teaching in adding composition and decomposition using concrete materials, which should be gradually withdrawn.
2. Immediate feedback: during the intervention, students used an unsuitable procedure, because they did not know it was inefficacious.
3. Constant self-monitoring. Several studies (Biederman et al., 2004; Castellanos et al., 2006; Iseman and Naglieri, 2011; Shanahan et al., 2006) showed that students with ADHD use cognitive and metacognitive strategies less efficiently than their peers with typical development.
4. Time of practice in a determined procedure and not a mechanical practice, devoid of meaning. It should be borne in mind that, in order for the information to be transferred to the long-term memory and, consequently, to consolidate the knowledge, it is of paramount importance that the information be repeated (distributed practice) and organized.
5. The systematization and revision of what was studied, as well as the anticipation of what will be developed, are essential aspects, as students with ADHD have difficulty organizing, maintaining and using new knowledge.

Developing the strategy of quickly and accurately accessing the basic arithmetic facts of addition from the long-term memory is the result of a complex learning process. It should be pointed out that this is a cognitive construction process with different conceptual levels. The present study has shown that it is possible to develop teaching strategies that "destabilize" the student and make him or her advance more quickly to the next level.

In conclusion, it is important to point out that the progress shown by the intervention group suggests the importance and feasibility of executing short, easy-to-apply and low cost pedagogical interventions to improve learning. Moreover, it is important that educators, whether teachers or educational psychologists, pay more attention to the various moments of developing counting,

as each one involves different conceptual levels that should be respected.

Conflict of Interests

The author(s) have not declared any conflict of interests.

REFERENCES

- Ackerman PT, Anhalt JM, Dykman RA (1986). Arithmetic Automatization Failure in Children with Attention and Reading Disorders: Associations and Sequelae. *J. Learning Disability*. 19(4):222-232.
- American Psychiatric Association. (1994). Diagnostic and statistical manual of mental disorders, text revision (DSM-IV-TR). 4th ed. Washington, DC: American Psychiatric Association (APA).
- Barkley RA (Ed.). (2014). Attention-deficit hyperactivity disorder: A handbook for diagnosis and treatment. Guilford Publications.
- Baroody AJ, Bajwa NP, Eiland M (2009). Why can't Johnny remember the basic facts? *Developmental Disabilities Res. Rev.* 15(1):69-79.
- Bay-Williams JM, Kling G (2014). Enriching Addition and Subtraction Fact Mastery through Games. *Teach. Children Math.* 21(4):238-247.
- Benedetto-Nasho E, Tannock R (1999). Math computation, error patterns and stimulant effects in children with attention deficit hyperactivity disorder. *J. Attention Disorders.* 3(3):121-134.
- Biederman J, Monuteaux MC, Doyle AE, Seidman LJ, Wilens TE, Ferrero F, Morgan CL, Faraone SV (2004). Impact of executive function deficits and attention-deficit/hyperactivity disorder (ADHD) on academic outcomes in children. *J. consult. clinical psycho.* 72(5):757.
- Bryant BR, Bryant DP, Porterfield J, Dennis MS, Falcomata T, Valentine C, Brewer C, Bell K (2014). The Effects of a Tier 3 Intervention on the Mathematics Performance of Second Grade Students With Severe Mathematics Difficulties. *J. learning disabilities*, 0022219414538516.
- Casas AM, De Alba AM, Taverner RM (2009). Habilidades matemáticas y funcionamiento ejecutivo de niños con trastorno por déficit. *Psicothema*, 21(1):63-69.
- Castellanos FX, Sonuga-Barke EJ, Milham MP, Tannock R (2006). Characterizing cognition in ADHD: beyond executive dysfunction. *Trends in cognitive sci.* 10(3):117-123.
- Chronis AM, Jones HA, Raggi VL (2006). Evidence-based psychosocial treatments for children and adolescents with attention-deficit/hyperactivity disorder. *Clinical Psychol. Rev.* 26(4):486-502.
- Costa AC, Dorneles BV, Rohde LAP (2012a). Identification of counting procedures and memory processes predominantly used by children with ADHD. *Psicologia: Reflexão e Crítica*, 25(4):791-801.
- Costa AC, Rohde LA, Dorneles BV (2012b). Development of numerical facts by students with learning disorders. *Bolema: Boletim de Educação Matemática*, 26(44):1151-1170.
- Ciullo S, SoRelle D, Kim SA, Seo YJ, Bryant BR (2011). Monitoring student response to mathematics intervention: Using data to inform tier 3 intervention. *Intervention in School and Clinic*, 1053451211414188.
- Dowker AD (2004). What Works for Children with Mathematical Difficulties? London: Department for Education and Skills, 2004. (Research report, RR554). Retrieved may 30, 2014 from <<http://www.dfes.gov.uk/research/data/uploadfiles/RR554.pdf>>
- Duhon GJ, House SH, Stinnett TA (2012). Evaluating the generalization of math fact fluency gains across paper and computer performance modalities. *J. school psycho.* 50(3):335-345.
- DuPaul GJ, Jitendra AK, Volpe RJ, Tresco KE, Lutz JG, Junod REV, Cleary KS, Flammer LM, Mannella MC (2006). Consultation-based academic interventions for children with ADHD: Effects on reading and mathematics achievement. *J. Abnormal Child Psychol.* 34(5):633-646.
- DuPaul GJ, Stoner G (2003). ADHD in the schools: Assessment and Intervention strategies. 2nd ed. New York: Guilford.
- Faraone SV, Biederman J, Monuteaux M, Doyle AE, Seidman LJ (2001). A psychometric measure of learning disability predicts educational failure four years later in boys with attention-deficit/hyperactivity disorder. *J. Attention Disorders.* 4(4):220-230.
- Fletcher JM, Lyons GR, Fuchs LS, Barnes MA (2009). Transtornos de aprendizagem: da identificação à intervenção. *Artmed*.
- Fossaluza V, Diniz JB, Pereira BDB, Miguel EC, Pereira CADB (2009). Sequential allocation to balance prognostic factors in a psychiatric clinical trial. *Clinics.* 64(6):511-518.
- Fuchs LS, Compton DL, Fuchs D, Paulsen K, Bryant JD, Hamlett CL (2005). The prevention, identification, and cognitive determinants of math difficulty. *J. Educ. Psychol.* 97(3):493.
- Fuchs LS, Fuchs D, Hamlet CL, Powell SR, Capizzi AM, Seethaler PM (2006). The effects of computer-assisted instruction on number combination skill in at-risk first graders. *J. Learning Disabilities.* 39(5):467-475.
- Fuchs LS, Fuchs D, Powell SR, Seethaler PM, Cirino PT, Fletcher JM (2008a). Intensive intervention for students with mathematics disabilities: Seven principles of effective practice. *Learning Disability Q.* 31(2):79-92.
- Fuchs LS, Powell SR, Hamlett CL, Fuchs D, Cirino PT, Fletcher JM (2008b). Remediating computational deficits at third grade: A randomized field trial. *J. Res. Educ. Effectiveness.* 1(1):2-32.
- Gersten R, Beckmann S, Clarke B, Foegen A, Marsh L, Star JR, Witzel B (2009). Assisting Students Struggling with Mathematics: Response to Intervention (RtI) for Elementary and Middle Schools. NCEE 2009-4060. What Works Clearinghouse. Retrieved dec. 18, 2014 from <http://ies.ed.gov/ncee/wwc/publications/practiceguides/>.
- Greenwood CR, Horton BT, Utley CA (2002). Academic engagement: Current perspectives on research and practice. *School Psychol. Rev.* 31(3):328-349.
- Hopkins S, Egeberg H (2009). Retrieval of Simple Addition Facts Complexities Involved in Addressing a Commonly Identified Mathematical Learning Difficulty. *J. Learning Disabilities.* 42(3):215-229.
- Hopkins SL, Lawson MJ (2006). The effect counting speed has on developing a reliance on retrieval in basic addition. *Contemporary Educ. Psychol.* 31(2):208-227.
- Iseman JS, Naglieri JA (2011). A cognitive strategy instruction to improve math calculation for children with ADHD and LD: A randomized controlled study. *J. Learning Disabilities*, 44(2):184-195.
- Jordan NC, Hanich LB, Kaplan D (2003). Arithmetic fact mastery in young children: A longitudinal investigation. *J. experimental child psycho.* 85(2):103-119.
- Junod REV, DuPaul GJ, Jitendra AK, Volpe RJ, Cleary KS (2006). Classroom observations of students with and without ADHD: Differences across types of engagement. *J. School Psychol.* 44(2):87-104.
- Kaufmann L, Nuerk HC (2008). Basic number processing deficits in ADHD: A broad examination of elementary and complex number processing skills in 9-to 12-year-old children with ADHD-C. *Developmental science*, 11(5):692-699.
- Keeler ML, Swanson HL (2001). Does strategy knowledge influence working memory in children with mathematical disabilities?. *J. Learning disabilities.* 34(5):418-434.
- Klassen AF, Miller A, Fine S (2004). Health-related quality of life in children and adolescents who have a diagnosis of attention-deficit/hyperactivity disorder. *Pediatrics*, 114(5):e541-e547.
- Kroesbergen EH, Van Luit JE (2003). Mathematics interventions for children with special educational needs: a meta-analysis. *Remedial Special Educ.* 24(2):97-114.
- Lahey BB, Pelham WE, Loney J, Kipp H, Ehrhardt A, Lee SS, Willcutt EG, Hartung CM, Chronis A, Massetti G (2004). Three-year predictive validity of DSM-IV attention deficit hyperactivity disorder in children diagnosed at 4-6 years of age. *Am. J. Psychiatry.* 161(11):2014-2020.
- Lindsay RL, Tomazic T, Levine MD, Accardo PJ (2001). Attentional function as measured by a continuous performance task in children with dyscalculia. *J. Developmental Behavioral Pediatrics.* 22(5):287-292.
- Martinussen R, Hayden J, Hogg-Johnson S, Tannock R (2005). A meta-analysis of working memory impairments in children with attention-deficit/hyperactivity disorder. *J. Am. Acad. Child Adolescent*

- Psychiatry, 44(4):377-384.
- Mayes SD, Calhoun SL, Crowell EW (2000). Learning disabilities and ADHD overlapping spectrum disorders. *J. learning disabilities*, 33(5):417-424.
- Miller SP, Hudson PJ (2007). Using Evidence-Based Practices to Build Mathematics Competence Related to Conceptual, Procedural, and Declarative Knowledge. *Learning Disabilities Research Practice*, 22(1):47-57.
- MTA Cooperative Group. (1999). A 14-month randomized clinical trial of treatment strategies for attention-deficit/hyperactivity disorder. *Archives General Psychiatry*, 56(12):1073-1086.
- National Mathematics Advisory Panel. (2008). Foundations for success: The final report of the National Mathematics Advisory Panel. US Department of Education.
- New Zealand (2007a). Ministry of Education. The Diagnostic Interview. Wellington: Crown. Book 2. (Numeracy Professional Development Projects). Retrieved Feb 10, 2007, from <www.nzmaths.co.nz/Numeracy/2007numPDFs/pdfs.htm>.
- New Zealand (2007b). Ministry of Education. The Number Framework. Wellington: Crown. Book 1. (Numeracy Professional Development Projects). Retrieved Dec 10, 2007, from www.nzmaths.co.nz/Numeracy/2007numPDFs/pdfs.htm.
- New Zealand (2007c). Ministry of Education. Teaching Number Knowledge. Wellington: Crown. Book 4. (Numeracy Professional Development Projects) Retrieved Dec 10, 2007, from <www.nzmaths.co.nz/Numeracy/2007numPDFs/pdfs.htm>.
- Nunes T, Bryant P (1997). Children doing mathematics. Wiley-Blackwell.
- Orrantia J (2006). Dificultades en el aprendizaje de las matemáticas: una perspectiva evolutiva. *Revista Psicopedagogia*, 23(71):158-180.
- Orvaschel H (1984). Psychiatric interviews suitable for use in research with children and adolescents. *Psychopharmacology bulletin*, 21(4):737-745.
- Ota KR, DuPaul GJ (2002). Task engagement and mathematics performance in children with attention-deficit hyperactivity disorder: Effects of supplemental computer instruction. *School Psychol. Q.* 17(3):242-257.
- Piffner LJ, Barkley RA, DuPaul GJ (1998). Treatment of ADHD in school settings. *Attention deficit hyperactivity disorder: A handbook for diagnosis and treatment*. 2:458-490.
- Powell SR, Fuchs LS, Fuchs D, Cirino PT, Fletcher JM (2009). Effects of Fact Retrieval Tutoring on Third-Grade Students with Math Difficulties with and without Reading Difficulties. *Learning Disabilities Research Practice*, 24(1):1-11.
- Raggi VL, Chronis AM (2006). Interventions to address the academic impairment of children and adolescents with ADHD. *Clinical child and family Psychol. Rev.* 9(2):85-111.
- Rhee SH, Hewitt JK, Corley RP, Willcutt EG, Pennington BF (2005). Testing hypotheses regarding the causes of comorbidity: examining the underlying deficits of comorbid disorders. *J. Abnormal Psychol.* 114(3):346-362.
- Rogers MA, Wiener J, Marton I, Tannock R (2009). Parental involvement in children's learning: Comparing parents of children with and without Attention-Deficit/Hyperactivity Disorder (ADHD). *J. school psycho.* 47(3):167-185.
- Rohde LA, Biederman J, Busnello EA, Zimmermann H, Schmitz M, Martins S, Tramontina S (1999). ADHD in a school sample of Brazilian adolescents: a study of prevalence, comorbid conditions, and impairments. *J. Am. Acad. Child Adolescent Psychiatry*, 38(6):716-722.
- Rohde LA, Jellinek MS (2002). ADHD in Brazil: the DSM-IV criteria in a culturally different population. *J. Am. Acad. Child Adolescent Psychiatry*, 41(9):1131-1133.
- Rohde LA, Szobot C, Polanczyk G, Schmitz M, Martins S, Tramontina S (2005). Attention-deficit/hyperactivity disorder in a diverse culture: do research and clinical findings support the notion of a cultural construct for the disorder?. *Biological Psychiatry*, 57(11):1436-1441.
- Russell RL, Ginsburg HP (1984). Cognitive analysis of children's mathematics difficulties. *Cognition and Instruction*, 1(2):217-244.
- Sella F, Re AM, Lucangeli D, Cornoldi C, Lemaire P (2012). Strategy selection in ADHD characteristics children: A study in arithmetic. *J. attention disorders*, 1087054712438766.
- Shanahan MA, Pennington BF, Yerys BE, Scott A, Boada R, Willcutt EG, Olson RK, DeFries JC (2006). Processing speed deficits in attention deficit/hyperactivity disorder and reading disability. *J. abnormal child psycho.* 34(5):584-601.
- Swanson JM, Kraemer HC, Hinshaw SP, Arnold LE, Conners CK, Abikoff HB, Clevenger W, Davies M, Elliott GR, Greenhill LL, Hechtman L, Hoza B, Jensen PS, March JS, Newcorn JH, Owens EB, Pelham WE, Schiller E, Severe JB, Simpson S, Vitiello B, Wells K, Wigal T, Wu M (2001). Clinical relevance of the primary findings of the MTA: success rates based on severity of ADHD and ODD symptoms at the end of treatment. *J. Am. Acad. Child & Adolescent Psychiatry*, 40(2):168-179.
- Tirado JLA, Martín FDF, Lucena FJH (2004). Trastorno por déficit de atención con hiperactividad: intervención psicopedagógica. *Psicothema*, 16(3):408-414.
- Tournaki N (2003). The differential effects of teaching addition through strategy instruction versus drill and practice to students with and without learning disabilities. *Journal of Learning Disabilities*, 36(5), 449-458.
- Van de Walle JA (2007). *Elementary and middle school mathematics: Teaching developmentally*. 6th ed. Boston, MA:Pearson Education.
- Wechsler, D. (1991). *WISC-III: Wechsler intelligence scale for children: Manual*. 3. Psychological Corporation.
- Willcutt EG, Pennington BF, Olson RK, Chhabildas N, Hulslander J (2005). Neuropsychological analyses of comorbidity between reading disability and attention deficit hyperactivity disorder: In search of the common deficit. *Developmental neuropsychology*, 27(1):35-78.
- Woodward J (2006). Developing automaticity in multiplication facts: Integrating strategy instruction with timed practice drills. *Learning Disability Q.* 29(4):269-289.
- Woodward J (2004). Mathematics Education in the United States Past to Present. *J. Learning Disabilities*, 37(1): 16-31.
- Zentall S (2007). Math performance of students with adhd. In: Berch, D.B., Mazzocco, M.M. (Eds.). *Why is math so hard for some children*, 219-243. Baltimore, Maryland: Paul H. Brookes.
- Zentall SS (1993). Research on the educational implications of attention deficit hyperactivity disorder. *Exceptional children*, 60:143-153.