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Math Skills and Executive Functioning in Preschool: Clinical and Ecological Evaluation

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Abstract

This study compares the relationship between executive functioning, analyzed with clinical and ecological tests, and math skills in preschoolers. The children (255 children 5 to 6 years old) were evaluated using neuropsychological tests of inhibition, and working memory and the TEDI-MATH to estimate basic mathematical skills. The ecological evaluation of the executive functioning by the parents and teachers was carried out with the Behavioral Rating Inventory of Executive Function (BRIEF). Compared to the ecological ratings, the neuropsychological measures show more correlations with math skills and a greater predictive capacity. The teachers' BRIEF results were superior to those of the parents. In all cases, working memory is the process that shows the greatest predictive power.

Keywords: Executive functioning, preschool, basic math skills, working memory, inhibition.

Resumen

Este estudio compara la relación entre el funcionamiento ejecutivo, analizado a través de pruebas clínicas y ecológicas, y la competencia matemática en preescolares. La evaluación de los niños (255 de 5 y 6 años) incluía pruebas neuropsicológicas de inhibición y memoria de trabajo, y el TEDI-MATH para estimar las habilidades matemáticas básicas. La valoración ecológica del funcionamiento ejecutivo a través de los padres y maestros se realizó mediante el Behavioral Rating Inventory of Executive Function (BRIEF). En comparación con las estimaciones ecológicas, las medidas neuropsicológicas muestran más correlaciones con las competencias matemáticas y una mayor capacidad predictiva. Los resultados del BRIEF de los profesores han demostrado ser superiores a los de los padres. En todos los casos, la memoria de trabajo es el proceso que mayor poder predictivo manifiesta.

Palabras clave: Funcionamiento ejecutivo, preescolar, competencias matemáticas básicas, memoria de trabajo, inhibición.

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Introduction

Mathematical achievement is a basic instrumental competence throughout the educational system. However, in modern societies, between 6 and 7% of the school population experience mathematics learning difficulties. A disorder characterized by being resistant to instruction, appearing early in life, and remaining in later development stages (Chu, Van Marle, & Geary, 2013; Stock, Desoete, & Roeyers, 2009).

To identify the factors associated with this early deficit is essential for its prevention. Low math skills are generally the result of poor initial arithmetic competence (Geary, Hoard, Nugent, & Bailey, 2013), even though recent research has also pointed to the important role Executive Functioning (EF) can play in early mathematical learning (Clark, Sheffield, Wiebe, & Espy, 2013; Fuhs, Nesbitt, Farran, & Dong, 2014; Monette, Bigras, & Guay, 2011). Clark, Pritchard, and Woodward (2010), for instance, found that a composite measure of EF at age 4 correctly classified 80% of children with low math performance at age 6. The relationship between both constructs may be reciprocal, in the sense that further conceptual and procedural knowledge of mathematics EF releases resources that are used to perform the tasks (Welsh, Nix, Blair, Bierman, & Nelson, 2010).

Studies that have analyzed the relationship of EF with math measures in preschool highlight the importance of some components. Toll, Van der Ven, Kroesbergen, and Van Luit (2011) carried out a longitudinal study with a sample of 227 children aged 4-7 years with low and medium math achievement levels, in order to analyze the predictive power of different executive functions on math skills. They found that both verbal and visuospatial working memory (WM) tasks predicted belonging to the math learning disabilities group, even to a greater degree than basic math skills. Regarding to other analyzed functions, they found that only one inhibition task showed the same predictive power.

Several studies report that WM seems to be related to children's math learning and the emergence of disabilities (Li & Geary, 2013; Swanson & Jerman, 2006). Nevertheless, this relationship is not always easy to interpret. When the specific weight of each component of WM is investigated (verbal or visuospatial), the results are mixed. The visuospatial component could be important to mentally visualize and represent quantities on the mental number line (Gunderson, Ramirez, Beilock, & Levine, 2012). For example, Geary, Hoard, Nugent, and Byrd-Craven (2008) highlight its influence on the recognition of number sets, and performing simple arithmetic calculations. Also Bull, Espy, and Wiebe (2008) found that visuospatial WM in preschoolers, specifically predicts the development of arithmetic problem-solving, counting and graphical representations three years later. Some studies have investigated the possible influence of visuospatial WM-type task on math performance. In a study with adolescents, Kyttälä and Lehto (2008) found that the static tasks (focused on the form, size, color or location of the stimuli) were more related to arithmetic learning, while the dynamic tasks (movement, direction or sequence of stimuli) were more related to geometry.

The relationship between verbal WM and mathematical learning has also proved to be important. In their meta-analysis, Swanson and Jerman (2006) conclude that a deficient verbal WM characterizes children with disabilities. This relationship seems to be more evident on tasks with numerical content (Passolunghi & Cornoldi, 2008). The task modality also plays a decisive role. Counting tests, for example, have a greater capacity to discriminate between children with and without math learning disabilities than the more traditional digit span tasks (Wu et al., 2008). The verbal WM also seems to play a special role in some mathematical contents. It is related to encoding and processing of mathematical concepts like counting procedure, used for simple calculation tasks or retrieving number facts (Andersson, 2010; Krajewski & Schneider, 2009). Holmes and Adams (2006) found that the verbal WM was associated with simpler mathematical tasks and visuospatial WM tasks to more complex ones.

For some authors, inhibition has even greater predictive power in the area of mathematics than WM (Espy et al., 2004). In older children, inhibition has been specifically related to problem-solving (Marzocchi, Lucangeli, De Meo, Fini, & Cornoldi, 2002), but in small children its role could be more significant. Blair and Razza (2007) found that the inhibitory control at age 5, predicted math performance one year later. Bull and Scerif (2001) also highlighted Stroop's differential predictive power according to the characteristics of the stimulus (color or number). They also found that only the numerical version predicted the math skills of 6 to 8-year-old children.

The assessment of EF has traditionally been carried out with clinical tests in laboratory situations that are not always easy to apply in young children (Isquith, Roth, Kenworthy, & Gioia, 2014). A more ecological alternative is using questionnaires based on behavioral observations by people close to the child. The Behavior Rating Inventory of Executive Function (BRIEF; Gioia, Isquith, Guy, & Kenworthy, 2000) is an instrument that has to be filled out by parents and teachers. The items are organized in scales and evaluate a broad range of executive functions, obtaining two general indexes (behavioral-regulation and metacognition) and a global one. Some studies have analyzed the relationship between the BRIEF indexes and mathematics measures in children and adolescents. In children from 5 to 16 years old, McAuley, Chen, Goos, Schachar, and Crosbie (2010), found significant correlations between mathematical achievement and the BRIEF indexes completed by the parents, especially metacognition. Mahone et al. (2002) found similar results in a clinical setting, as did Waber, Gerber, Turcios, Forbes, and Wagner (2006) with the teacher's version. Nevertheless, both ways of assessing EF entail different levels of analysis. As evidenced from the review of Toplak, West, and Stanovich (2013), where only 24% of the correlations between the two modes of assessment were significant.

In summary, research has shown the significant association between EF and early mathematical development. However, works are needed to deepen in the relationship between basic math skills and both measures of EF, clinical and ecological, in preschoolers. Given the limited research conducted in our context, and its significance for prevention and intervention strategies, this study raise two specific objectives: (a) to analyze the relationships between clinical tests (WM and inhibition) and ecological ratings (through parents and teachers) of EF and basic math skills; and (b) to analyze the predictive power of the factors derived from the neuropsychological tasks and the EF ecological evaluation indexes on math skills.

Method

Participants

In order to cover a large number of schools, 6 children were selected per class using a simple random sampling procedure. The sample included 255 preschoolers (52.9% boys and 47.1% girls) 5 to 6 year-old (mean age = 70.09 months; *SD* = 3.66). 87.3% of the children were caucasian, belonging the rest to other ethnic minorities. Equivalent IQ was calculated following Spreen and Strauss's (1991) guidelines, namely: vocabulary and block design subtests from the WPPSI-R (Wechsler, 1967). The mean equivalent IQ was 99.62 (*SD* = 13.36; range 70-129). Those subjects who had an equivalent IQ below 70 were excluded from the sample, as well as the children with school reports of serious sensory or neurobiological abnormalities, psychological disorders or socio-cultural deprivation. 65.5% of the children attended public schools and 34.5% charter schools. The centers were located in middle socioeconomic leveled neighborhoods.

Instruments

Neuropsychological inhibition measures. Sun-Moon Stroop Task

(Archibald & Kerns, 1999) was used to evaluate inhibition through visual stimuli. This test consists of two conditions. In the congruent condition, the subjects are shown a page with 30 pictures of suns and moons placed randomly in rows and columns. The subjects have to respond "sun" to the images with suns, and "moon" to the images with moons, as quickly as possible (for 45 seconds). In the incongruent condition, the subjects are asked to respond "sun" when the evaluator points moon, and "moon" when a sun is pointed. This task has a high level of reliability, with test-retest scores of .91 for the incongruent condition (Archibald & Kerns, 1999). To evaluate inhibition with auditory stimuli the Luria's Tapping Task was used (Luria, 1966). This task also consists of two conditions with 12 trials each. In the first, the subject has to repeat the same number of taps as the evaluator makes on the table (1 or 2). Then, the subject has to do the opposite. It has noted the reliability of the task in 87 (Diamond & Taylor, 1996). In both tasks, the amount of correct interference assays of the incongruent condition was used as interference measure.

WM Neuropsychological measures. To evaluate visuospatial WM, the Odd-One-Out Task (Henry & MacLean, 2003), and the Mazes Memory Test (Pickering, Baqués, & Gathercole, 1999) were administered. The first test comprises 6 levels (1-6 rows), with 4 trials each. Each row has 3 figures, and the subject has to point out the odd one. At the end of each trial, the subject has to remember the location of each different figure in the correct order, pointing to its position (left/center/right). In the Mazes Memory Test, 12 mazes are presented with pre-established routes with 3 different difficulty levels. The subject has to trace the same routes on identical blank mazes. The test-retest reliability was set at .81 for both tasks (Alloway, Gathercole, & Pickering, 2006).To evaluate the verbal WM two tasks were also introduced. The Digit Span Task (Pickering et al., 1999) presents series from 2 to 9 digits (4 trials each). The task consists of repeating, in inverse order, the sequence the evaluator presents orally. The Working Memory-Counting Task (Siegel & Ryan, 1989) consists of 3 levels (2 to 4 cards) with 4 trials each one. Each card contains blue and yellow dots arranged randomly. The subject has to state the number of blue dots on each card and remember them in the correct order once the series has ended. The test-retest reliability was set at .64 (Alloway et al., 2006) and .62 (Gathercole, Pickering, Ambridge, & Wearing, 2004) respectively. For both tasks, the sum of the correct trials are taken for analysis.

EF Ecological assessment. The Behavior Rating Inventory of Executive Function-Preschool (BRIEF; Gioia et al., 2000) evaluates the EF of children and adolescents (5-8 years-old) through the behavioral observations by parents and teachers. It comprises 86 items that punctuate through a Likert scale (1 = never, 2 = sometimes, 3 = often), grouped in 8 scales: inhibition, shifting, emotional control, initiative, WM, planning/organization, organization of materials and monitoring. These scales, in turn, are grouped in two indexes: behavioral regulation (BR), and metacognition (MC). Their combined scores are included in a global score's scale. High scores indicate risk of executive disfunction. Its reliability and validity has been widely confirmed in English language (Clark et al., 2010). In the present study the Cronbach's Alpha was .86 for parent's version, and .99 for teacher's version. To complete the analysis, inhibition and WM scales, and indexes were used.

Basic mathematical skills. Preschool subtests of TEDI-MATH (Grégoire, Noël, & Van Nieuwenhoven, 2005) were applied to assess the following math skills: counting (counting as high as possible, with a lower and upper limit, backwards, and by steps), numbering (counting linear sets, random sets, isolation counted objects and knowledge of cardinal numbers), knowledge of the Arabic and oral numerical systems (numerical decision and numbers comparisons), logical operations (seriation, concatenation, classification, conservation, and inclusion), arithmetical operations supported by images, with arithmetical and verbal format, and subitizing. The test has a level of internal consistency ranging from .84 and .99 depending on each subtest and ascertained validity indexes (Gégoire et al., 2005). The correct answers in each domain were used as reference.

Procedure

Once the schools dismissed the children who met the exclusion criteria, the informed consent from the families to participate in the research was obtained. The assessment was conducted in classrooms enabled by the schools, which met optimal lighting, insulation and ventilation conditions. The evaluation process was conducted by psychologists familiarized with the use of the tasks. It comprised two 45-minute individualized sessions. The questionnaires were delivered in sealed envelopes to parents and teachers, and returned to the experimenters. A report of the child's performance in the different domains was handed over to the centers.

Statistical analysis

The analysis were performed with the Statistical Package for the Social Sciences, version 19.0 (IBM SPSS, 2010). At first, following the normality analysis, the relationship between the EF measures (clinical and ecological), and the mathematical competence results was analyzed using Pearson's bivariate correlation. For the second objective, a factorial analysis with neuropsychological tasks through the method of principal components was performed. The final solution was obtained through the varimax orthogonal rotation method (saturation ≥ .45) with three factors: (a) WM, grouping Digits Span, Counting Task, Odd-One-Out and Mazes; (b) visual-inhibition, with Stroop; and (c) auditory-inhibition, with Tapping Task. The predictive role of these factors and the indexes of behavioral regulation and metacognition (BRIEF) on mathematical competence was examined, using multiple linear regression analysis, by the stepwise method, introducing the factors and the indexes in separate analysis. In all cases, raw scores analysis were used.

Results

Correlations between clinical and ecological evaluations of EF and math skills

The correlations between mathematical abilities and the EF neuropsychological tests are positive and significant in almost all cases (see Table 1). Counting, logical and arithmetic operations (especially with verbal statement) are those with higher correlations. The lower correlations are obtained with subitizing. In regard to the EF variables, the verbal WM evaluated with

Table 1

Correlations Between EF Neuropsychological Tasks and Math Skills (TEDI-MATH)

	Inhibition		Visuospatial WM		Verbal WM	
	Stroop	Tapping Task	Odd-one-out	Mazes	Digit Span	Counting Task
Counting	.421***	.319***	.292***	.249***	.425***	.444***
Numerate	.251***	.207***	.227***	.246***	.201***	.342***
Aragic NS	.224***	.167**	.204***	.209***	.258***	.332***
SN Oral	.201***	.301***	.253***	—	.251***	.265***
Logical O.	.404***	.260***	.398***	.334***	.380***	.489***
Images O.	.267***	.285***	.248***	.226***	.214***	.420***
Arithmetic Statement O.	.433***	.364***	.258***	.237***	.289***	.380***
Verbal Statement O.	.470***	.417***	.388***	.281***	.420***	.536***
Subitizing	.155*	.198***	.187**	—	.145*	.135*

Note. NS = Numerical System; O = Operations; WM = Working Memory.

*$p \leq .05$. **$p \leq .01$. ***$p \leq .001$.

Table 2

Correlations Between the EF Rating Scale (BRIEF) and Mathematical Skills (TEDI-MATH)

	Parents					Teachers				
	IN	WM	BR	MC	Total	IN	WM	BR	MC	Total
Counting	–.164**	–.396***	–.174***	–.365***	–.328***	–.177**	–.468***	–.214***	–.428***	–.371***
Numerate	—	–.274***	–	–.277***	–.243***	–.138*	–.291***	–.150*	–.280***	–.247***
Arabic NS	—	–.255***	–.171**	–.222***	–.228***	–.150*	–.216***	–.172**	–.225***	–.219***
Oral NS	—	–.246***	—	–.215***	–.202***	–.199***	–.238***	–.231***	–.236***	–.251***
Logical O.	—	–.333***	—	–.342***	–.275***	–.175**	–.466***	–.214***	–.443***	–.381***
Images O.	—	–.335***	–.124*	–.340***	–.288***	–.254***	–.426***	–.279***	–.409***	–.384***
Arithmetical Statement O.	—	–.302***	—	–.249***	–.175**	–.195**	–.362***	–.210***	–.333***	–.306***
Verbal Statement O.	—	–.428***	–.132*	–.392***	–.328***	–.206***	–.462***	–.221***	–.439***	–.381***
Subitizing	—	–.153*	—	—	—	—	–.138*	—	–.123*	—

Note. BR = Behavioral Regulation; IN = Inhibition; MC = Metacognition; NS = Numerical System; O = Operations; WM = Working Memory.

$^{*}p \leq .05$. $^{**}p \leq .01$. $^{***}p \leq .001$.

the Counting task, is the one with higher correlations.

The correlations of math skills with the BRIEF results, completed by parents and teachers, are listed in Table 2. In the case of the parents, only counting skills correlate with the inhibition scale. Neither do correlations appear, or are reduced, with the index of behavioral regulation that encompasses it. Correlations of math skills with WM, metacognition and the global index are higher. Correlations are higher with the teacher's BRIEF. All math skills are negatively correlated with the BRIEF results, except subitizing. WM and metacognition are also the variables with the most significant results.

Predictive capacity of the EF measures on math skills

Table 3 shows the results of the regression analysis with the EF factors (WM, visual-inhibition and auditory-inhibition) that best predict the TEDI-MATH subtests. The three factors explain 28.3% of the variance of counting, 34.4% of logical operations, 24.4% of arithmetic statement operations and 39.9% of verbal statement operations. In all of these cases, WM is the factor that provides greater explana-

Table 3

Regression Analysis of EF Factors on Mathematical Skills (TEDI-MATH)

Processes/Predictors	F	R^2	ΔR^2	Beta
Counting				
WM			.167	.409
Visual-Inhibition			.061	.247
Auditory-Inhibition	32.96***	.283	.055	.294
Numerate				
WM			.110	.331
Visual-Inhibition	19.99***	.137	.027	.165
Arabic NS				
WM	24.77***	.089	.089	.299
Oral NS				
Auditory-Inhibition			.086	.293
WM	16.54***	.116	.030	.173
Logical O.				
WM			.289	.538
Visual-Inhibition			.036	.190
Auditory-Inhibition	45.36***	.344	.026	.161
Images O.				
WM			.125	.354
Auditory-Inhibition	25.76***	.170	.044	.210
Arithmetic Statement O.				
WM			.105	.324
Auditory-Inhibition			.101	.317
Visual-Inhibition	27.00***	.244	.038	.196
Verbal Statement O.				
WM			.231	.481
Auditory-Inhibition			.097	.312
Visual-Inhibition	55.46***	.399	.070	.265
Subitizing				
Auditory-Inhibition	7.31**	.028	.028	.168

Note. NS = Numerical System; O = Operations; WM = Working Memory.

*$p \leq .05$. **$p \leq .01$. ***$p \leq .001$.

Table 4

Regression Analysis of BRIEF Indexes on Mathematical Skills (TEDI-MATH)

	Parents				Teachers			
Processes/ Predictors	F	R^2	ΔR^2	Beta	F	R^2	ΔR^2	Beta
Counting								
MC	38.40***	.133	.133	–.365			.183	–.592
BR	n. s.				32.46***	.206	.023	.223
Numerate								
MC	20.75***	.077	.077	–.237	21.45***	.078	.078	–.280
Arabic NS								
MC	12.97***	.049	.049	–.222	13.43***	.051	.051	–.225
Oral NS								
MC	12.14***	.046	.046	–.215	14.92***	.056	.056	–.236
Logical O.								
MC			.117	–.418			.196	–.625
BR	18.72***	.131	.014	.140	36.16***	.224	.028	.247
Images O.								
MC	35.59***	.115	.115	–.340	50.67**	.167	.167	–.409
Arithmetic Statement O.								
MC			.062	–.347	32.32***	.111	.111	–.333
BR	11.51***	.085	.023	.180	n. s.			
Verbal Statement O.								
MC	45.29***	.153	.153	–.392			.193	–.607
BR	n. s.				34.65***	.216	.023	.227
Subitizing								
MC	n. s.				3.82*	.015	.015	–.123

Note. BR = Behavioral Regulation; MC = Metacognition; NS = Numerical System; O = Operations; WM = Working Memory.

$^*p \leq .05$. $^{**}p \leq .01$. $^{***}p \leq .001$.

tory value (ΔR^2 = .167, p < .001; ΔR^2 = .289, p < .001; ΔR^2 = .105, p < .001; ΔR^2 = .231, p < .001, respectively). WM and visual-inhibition explain 13.7% of the variance in numbering, whereas auditory-inhibition predicts 17% of images operations, and 11.6% of knowledge of the oral number system. Finally, two skills are predicted by a single factor. This is the case of knowledge of the Arabic number system, which predicts the WM 8.9% of the variance, and subitizing, where auditory-inhibition explains only 2.8% of the variance.

The regression analysis of the BRIEF results are shown in Table 4. In the case of parents, only metacognition predicts counting mathematical competence (R^2 = .133, p < .001), numbering (R^2 = .077, p < .001), Arabic numerical system (R^2 = .049, p < .001) and oral (R^2 = .046, p = .001), images operations (R^2 = .115, p < .001) and with verbal statement (R^2 = .153, p < .001). The two indexes predict 13.1% of logical operations (metacognition, ΔR^2 = .117, p < .001; behavioral regulation, ΔR^2 = .014, p = .048), and 8.5% of arithmetic statement operations (metacognition, ΔR^2 = .062, p < .001; behavioral regulation, ΔR^2 = .023, p = .013). There were no shown significant results for subitizing. The teachers' results are generally higher. Metacognition alone predicts the subtests numbering (R^2 = .078, p < .001), Arabic numerical system (R^2 = .051, p < .001) and oral (R^2 = .056, p < .001), images operations (R^2 = .167, p < .001), with arithmetical statement (R^2 = .111, p < .001) and subitizing (R^2 = .015, p = .050). Metacognition (ΔR^2 = .183, p < .001) with behavioral regulation (ΔR^2 = .023, p = .008) predict 20% of the variance on the counting subtest. As well as 22.4% of the variance in logical operations (metacognition, ΔR^2 = .196, p < .001; behavioral regulation, ΔR^2 = .028, p = .003), and 21.6% of verbal statement operations (metacognition, ΔR^2 = .193, p < .001; behavioral regulation, ΔR^2 = .023, p = .007). In all cases, the predictive power highlights metacognition index.

Discussion

The first aim of this study was to analyze the relationships between different mathematical skills and EF assessed by traditional neuropsychological tests and rating scales for parents and teachers. In the former case positive and significant correlations were obtained. The results highlight the relationship between math skills and inhibition (assessed with Stroop), especially with verbal WM (Counting span), which are consistent with those reported by Swanson and Jerman (2006), and Wu et al. (2008). We also agree with Raghubar, Barnes, and Hecht (2010) that the demands and nature of the tasks are difficult to interpret. This can explain why the results are not always as coincident as what would be desirable. Regarding to inhibition, Stroop higher correlation might be due to its spatial and visual presentation, remaining until the child responds. However, the tapping-task has an auditory stimulus displayed in a time sequence and subsequently disappears. It is also likely that the outperforming in verbal WM may be influenced by the numerical nature of the tasks (Passolunghi & Cornoldi, 2008). The lower result obtained with mazes could also be related to the dynamic nature of the test (Kyttälä & Lehto, 2008).

The age of the children is another factor to consider. In this sense, the results are consistent with previous research concluding that the weight of the different components of WM in mathematical performance may differ over time, reporting a greater relationship with verbal WM in the early years (Swanson & Jerman, 2006). Deepening into this question, a recent study carried out by Li and Geary (2013) analyzed the relationship between verbal and visuospatial WM and mathematical performance between 1st and 5th grades, finding only associations with the verbal component. Nevertheless, when examining the gains between both grades in the two forms of WM, they found that the gains in the visuospatial modality are the best predictors of subsequent mathematical achievement. Development seems to be critical in the relationship between the visuospatial component of WM and mathematical performance.

The relationship between mathematical competence and executive functions of inhibition and WM evaluated through ecological questionnaires is lower. Regarding BRIEF indexes, the results are consistent with those obtained by McAuley et al. (2010) and Mahone et al. (2002), in the sense of a higher correlation with metacognition. It is important to note the variation in results depending on the informant. Thus, the higher estimates of teachers could be due to their greater knowledge and experience on normative development.

The results suggest that both, inhibition as WM, seem to be closely related to math skills at early ages. Inhibition seems to be more correlated with math skills when it has been assessed by traditional neuropsychological tests. By contrast, the correlation of math skills with WM is noteworthy with the neuropsychological tasks and the BRIEF, with large differences between the type of mathematical skill tested. The results highlight an important correlation between logical operations (critical from the Piagetian model), and WM and interference control. The same applies to the counting ability, which is related to procedural knowledge of counting (Geary & Hoard, 2005). The relationship between EF and subitizing is much lower. Subitizing should not be especially critical because it's considered an automatic ability (Butterworth & Yeo, 2004). Moreover, the different measures of mathematical operations used (especially verbal statement operations) were significantly related to inhibition, and especially to WM assessed with both types of measures. Clinical assessment may reflect a higher involvement of verbal numerical processing in these operations.

The second goal aimed to analyze the predictive power of neuropsychological tests of EF grouped into three factors and BRIEF's indexes of behavioral regulation and metacognition on mathematics subtests. The regression analysis show different results depending on the measures employed, with a greater predictive power of clinical tasks over rating scales. In this case, the three factors (WM, inhibition and visual-auditory-inhibition) explained part of the variance of different math skills, emphasizing the explanatory power of WM. These results are consistent with those obtained by Bull et al. (2008), and Toll et al. (2011). With regard to ecological assessment, the predictive power of teacher's version was superior. Finally, consistent with the results of McAuley et al. (2010), and Waber et al. (2006), a higher predictive power of metacognition over behavioral regulation was observed.

In summary, our results highlight the important role of WM in mathematical learning and suggest that its deficit interferes with the development of basic math skills, especially with counting and logical operations. To a lesser extent, inhibition (assessed by clinical trials) was another executive function in our study that evidences a significant role in predicting mathematical processes, suggesting an interconnection within inhibition problems and processing overhead. However, although this study confirms the involvement of these executive functions in mathematical development, it is also true that these variables explain a moderate percentage of the variance. It is necessary to analyze the role of these and other executive functions such as planning and cognitive flexibility, in these and other mathematical domains and deepen into the tests. Among the limitations of this study, the absence of other explanatory variables of mathematical competence, such as verbal ability, education level or motivational factors (attributions, beliefs or attitudes) is highlighted.

One of the practical implications of this research is that the neuropsychological tests of inhibition and WM (especially verbal WM), of easy and fast application, are those which have shown higher relationships with mathematical competence. Its usefulness seems clear to detect EF deficits and to prevent possible mathematical learning disabilities. Likewise, the ecological assessment of EF through rating scales (especially the WM scale and metacognition index) is another interesting procedure to detect these problems Parents and teachers have a unique knowledge about the behavior of children in natural environments in detecting difficulties related to math performance. Nevertheless, while recognizing the value of both types of assessment, it is not advisable to use them interchangeably. They provide differentiated and complementary information.

Another interesting finding of this study, related to ecological assessment, is that the information provided by teachers showed a greater relationship with children's math skills than parent's reports. This contrasts with the fact that most studies have used the parents as informants. This work reflects that the teachers can help further understanding of the difficulties in learning mathematics in the school context, as well as to design individualized educational responses. Thus, it would be interesting that educational interventions include, along with the specific math instruction, training in cognitive skills (mainly WM and inhibition). In this sense, Tools of the Mind (Bodrova & Leong, 2007; Diamond & Lee, 2011) is a program for preschoolers that contemplates training in EF through a Vygotskian-based educational curriculum.

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