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THE RELATIONSHIP BETWEEN ORAL LANGUAGE AND MATHEMATICS COMPETENCIES IN ELEMENTARY SCHOOL

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Abstract

The aim of this paper is to analyze the relationship between oral language (morphology, syntax, semantics and pragmatics) and mathematics competencies (counting, numbering, Arabic numeral system, oral numerical system, logical operations, operations with arithmetic statement, operations with verbal statement and size estimation) moderated by sex and month of birth. For this, the BLOC-SR and TEDI-MATH tests have been administered to 13 children in the first year of elementary school. The results show existing relationships in some of the dimensions of oral language and calculus. Specifically, children who score higher in oral language (BLOC-SR) tend to obtain better results in calculus (TEDI-MATH), but the difference in the means in calculus of students who score above the language mean oral is not higher than the mean of students who score below. Furthermore, this paper examine the role of sex and month of birth on the relationship between oral language and mathematics competencies.

Keywords: Oral language, BLOC-SR, mathematics competencies, TEDI-MATH, sex, age.

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1. Introduction

Language skills "are tools through which students learn, apply and develop mathematical concepts and skills" (Serio, 2014, p.12). As well, achieving a good level of mathematical ability is important for success in school and achievement in activities of daily life. Poor performance in calculus skills can pose substantial problems for the development of early math with consequences within (overall academic performance) and outside of school (performance problems during adulthood, etc.). Therefore, this study focuses on the analysis of the relationship between oral language and mathematics competencies because they are two basic cognitive skills with the ability to influence all children's learning.

Many studies over the years have focused on the oral language or mathematics competencies, but the literature of the relationship between them is limited, therefore it is needed to analyze this relationship. Based on the model proposed by LeFevre, Fast, Skwarchuk, Smith-Chant, Bisanz and Kamawar (2010), Lesaux and Vukovic (2013) conducted a study where they examined how overall verbal ability was related to children's arithmetic knowledge. Third grade elementary school children were evaluated regarding verbal analogies, phonological decoding, ability of symbolic numbers and arithmetic problems. To carry out the research they used several tests, such as the analogy of the subtest WJ - Reading III Vocabulary Test (Woodcock, McGrew, & Mather, 2001). The results indicated that verbal analogies were indirectly related to arithmetic knowledge through symbolic numerical skills, while phonological decoding had a direct relationship with arithmetic. These results suggested that general verbal ability influences how children understand and reason while phonological skills are involved in the execution of conventional arithmetic problems. Thus, Jordan, Wylie, and Mulhern (2015) studied the linguistic influences on the performance of mathematics in children between 5 and 7 years. For mathematical ability they used the Mathemat-ICS Capacity 3, Form A (Ginsburg & Baroody, 2003) and for phonological ability, a test for the detection of rhyme and initial sounds, which the authors created for that purpose. The comparisons they made suggested that language plays a mediating role in most tasks. Correlational evidence suggests that children of different age groups may have been using different verbal and nonverbal strategies to solve mathematical problems. Therefore, they established that phonological capacity is important for children aged 5-7 years when they perform mathematical tasks, since this capacity is related to both language and reading ability, and can also directly influence performance in math’s. Thus, Moll, Snowling, Göbel, and Hulme (2015) examined the development of 93 children with a family risk of dyslexia (FRD) between 3 and 5 years of age, which mediates the influence of this disorder on the development of the arithmetic longitudinally. The aim of the study was to clarify the cognitive bases of formal arithmetic through a research where the influences between language and executive skills at 3 years were evaluated, and verbal number skills (accounting and knowledge of numbers) and phonological processing to 4 and 5 years old Language skills were assessed using two subtests of the current version of a standardized language test, CELF-2 (Semel, Wiig, & Secord, 2006) and numerical skills through the TEDI-Math test (Grégoire, Nöel, & Van Nieuwenhoven, 2015). The results suggest that verbal and executive processes provide the basis for verbal numerical skills, which in turn influence the development of formal arithmetic skills.

Finally, they explain that problems in the early development of language can explain the comorbidity between reading and alterations and difficulties in mathematics. To clarify the relationship among language and numerical skills, Koponen (2008) carried out a research on children in 4th grade. The results indicated

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that children with language problems seem to have a higher risk of presenting difficulties in different areas of numerical skills. Barbosa (2014) carried out experimental tests with children with hearing problems in public and private schools. The groups consisted of: deaf children from public schools (group 1), children with some hearing loss from public schools (group 2), hearing children from public schools (group 3) and children (in general) from private schools (group 4). The results showed a clear distinction between mathematical cognitive abilities more and less dependent on linguistic stimuli. Deaf children seemed to have the same performance, or, in some cases, even better performance than hearing children in terms of language skills. Thus, the results indicate that the associated pathologies may not be the cause of a poor academic performance in mathematics, but it may be a lack of linguistic stimuli. On the other hand, Pedraja, Santín, and Simancas (2015, p.1) state that the month of birth influences academic performance based on the study of the Organization for Economic Cooperation and Development (OECD) and Program for International Student Assessment (PISA) 2009 (OECD, 2013). Thus, García and Hidalgo (2013) obtain similar results and they state that birth month has an important impact on performance (p.14). Fernández and Rodríguez (2008) according to the Spanish section of the PISA Survey 2003 (OECD, 2005), highlight the relevance of the student's sex in the repetition of the course, with the boys almost the twice as likely to repeat grades when compared to girls (p.2). On the other hand, García and Hidalgo (2013), observe that children score better than girls in Mathematics and Science while the opposite occurs in Reading. For that reason the aim of this paper is to analyze the relationships between oral language (morphology, syntax, semantics and pragmatics) and the mathematics competencies (counting, numbering, Arabic numeral system, oral numerical system, logical operations, operations with arithmetic, operations with verbal statement and size estimation) depending on the sex and month birth.

1.1. Relationship between language skills (oral language) and mathematical competencies (calculation)

Kolupski (2014) arguing that language and mathematics are concepts that must occur simultaneously as they work together to produce the same idea, but still there are differences. What this means is that mathematics has a certain language independent of everyday speech. Certain words, letters, and phrases, represent something very specific in mathematical language. When this new language is taught to students, it is important that the new language matches the new topic directly. That is, when students create knowledge, they are also developing the capabilities corresponding to language development. In this sense, Serio (2014), affirms that communication is "an essential process in the learning of mathematics. Thus, students are able to reflect and clarify their ideas, their understanding of mathematical relations and their mathematical arguments "(p.12). Communication is an integral part of an individual's ability to succeed in today's world. "Involving students in the discussion of mathematics can promote their active meaning-making" (p.13).

In addition, Butterworth (2005) and Alcalá (2002) agree in arguing that mathematics rests in a language. Mathematical language is the support and, at the same time, a constituent part of mathematical knowledge itself. We must bear in mind that although the semiotic aspects of mathematical learning are very important, mathematical activity goes beyond any linguistic, representational or symbolic activity. To think we do not rely on the objects directly, but we do it by helping us with symbolisations of objects (icons, graphs, drawing, etc.) through a necessary process of conceptualization; using, also, symbolizations of

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feelings, of intentions (words); making use, at other times, of the silent gesture. In short, we use symbolic creations as mediators, as resources, as tools to think and communicate. Therefore, Alcalá (2002, p.26), states that mathematical language in the classroom describes four types of symbols: Logograms: signs invented especially to refer to total concepts such as "+", "-", "x "," = "; Pictograms: geometric icons: signs of angle, square, triangle, etc.; Punctuation symbols: taken from the normal spelling: "," "()"; Alphabetic symbols: letters taken from the alphabet: "a", "b", "c", "A", "B", "C", etc .; The own terminology and typical expressions written and spoken: "three", "four", "ten", "greater than". Dowker and Nuerk (2016) indicate that linguistic influences in the processing of numbers are omnipresent. They occur at a conceptual, semantic, syntactic, lexical, or phonological level, among others. Linguistic properties affect not only the verbal representations of numbers, but also the representation of numerical magnitude, calculation, representation of parity, representation of values of places, even the early acquisition of numbers. Therefore, they postulate that numerical and arithmetic processing are not independent of linguistic processing. In this way, they distinguish several linguistic levels in which the numerical processing can be influenced: (1) Conceptual influences. Beyond singular phonemes, graphemes, words and sentences, linguistic structures are formed by linguistic concepts. The linguistic concept suggests that for almost every adjective, a non-derived form (unmarked) and a derivative form (marked) exist (for example, efficient and inefficient: the marked form would be with "in"). Numbers have several attributes, which can be distinguished in unlabelled form (e.g., large, even, divisible) and marked (small, odd, indivisible). As for the spatial organization example as "right" it is not marked "left" if it is checked; (2) Syntactic influences. Number processing in real-life situations occurs in natural language and is described by a grammatical number (that is, singular for "1" and plural for two or more things). The languages differ substantially in their use of the grammatical number. In some cases, the syntactic structure of a language influences the development of numerical comprehension and the spatial assignment of numbers; (3) Semantic influences. Word meanings also influence numerical or arithmetic processing.

The addition seems to be more associated with words like "more", "buy", "get", etc., while the subtraction is similar to words like "less", "sell", "give", etc. When the problems of text are presented in a way that makes these deceptive associations acquire worse results. This comes to highlight an interrelation between the meaning of the word and arithmetic operations; (4) lexical influences. In general, a transparent structure of the numerical word it seems to help numerical performance even for problems that do not involve numerical words They conclude that lexical influences affect arithmetic, but not in the same way as other linguistic aspects, (5) Phonological influences For these authors (Dowker & Nuerk, 2016) the phonological skills are not related to the mathematical operation itself, but to the verbal representations / manipulations of the number. On the other hand, focusing on more specific aspects of the language, Moll et al. (2015) showed that the verbal-symbolic numerical system is not only based on the pre-verbal system, it also depends on the language and general mastery of the skills. Therefore, children with language or reading problems run the risk of having arithmetic difficulties. Koponen (2008) indicated that there are at least two cognitive skills that could function as early indicators of increasing risk for calculation in both children with difficulties as in children without them: the ability to learn and recite sequences number of verbal words and the fluency ability to access long-term memory in order to retrieve verbal tags for visual stimuli. Hence, Moll et al. (2015) state that variations in school pre-skills, especially in language and

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executive functions, influence the development of specific precursors in the domain of arithmetic such as counting skills and numerical knowledge. Numerical knowledge, in turn, plays an important role in formal arithmetic learning once schooling begins. Consequently, the relationship between linguistic skills (oral language) and mathematical skills (calculus) is clear, so the arithmetic skills in elementary school are directly preceded by the number of verbal skills in childhood and these skills, to in turn, they are influenced by previous variations in oral language skills.

Other studies focus on phonological skills, for example, Lesaux and Vukovic (2013) suggest that phonological skills directly influence arithmetic skills, while language impacts on arithmetic skills through symbolic numerical ability. Therefore, in general verbal ability affects the performance of children by influencing the mathematical thinking that involves the symbolic number system, phonological skills seem necessary for the execution of arithmetic tasks. As a result, it may be that while the numerical sense provides the basis from which children can think mathematically, general verbal ability shapes the way in which children acquire numerical and quantitative symbolic skills necessary for mathematics. On the other hand, Barbosa (2014) puts a strong focus on the vocabulary analyzing the performance of deaf and hearing children of 5 and 6 years through experimental tasks that include various cognitive aspects related to the numerical conceptualization, concludes that one has to have vocabulary to remember with numerical precision larger quantities. According to this argument, the numerical vocabulary functions as a cognitive tool that helps the individual to control the cardinal information of sets with a large number of items. Therefore, it highlights the close relationship between language and mathematical concepts. On the other hand, Pedraja et al. (2015), as mentioned above, state that the month of birth influences academic performance. After analyzing the data of 25,887 students from 889 Spanish schools, extracted from the Program for International Student Assessment, PISA 2009, these researchers found that those students who were born in November and December were 85% more likely to repeat the course than those who were born in January or February. Furthermore, García and Hidalgo (2013) argue that students born in the third or fourth quarter, get between 20 and 32 points less than those born in the first quarter of the year (p.12).

In addition, giving some examples of their research in the second year of Pre-school Education (thus, with children of five years of age), they point out that at the end of the course, 20% of the children born in the last quarter of the year had needed educational reinforcement compared to 6.34% of those born in the first months. García and Hidalgo (2013) also observed that the difference is progressively reduced as the student becomes older, during elementary Education and the first part of higher education. Fernández and Rodríguez (2008), make reference to the Spanish section of the 2003 PISA survey, explain that although the idea that the level of intelligence of both sexes is similar prevails, there are small but persistent differences favourable to males in mathematical skills, and women in linguistics.

Moreover, girls tend to do better than boys: they repeat less and are more likely than boys to reach the last grade of elementary school. Therefore, they affirm that the probability that a hypothetical male student with mean values in all the variables has repeated, is 51% higher than in the case of another student with the same conditions but of the female sex. Following the same line of argument, García and Hidalgo (2013) justify that children score better than girls in Mathematics and Science while the opposite occurs in Reading. Therefore, based on the results previously presented, sex and month of birth are proposed as possible modulating variables of the relationship between oral language and calculus. Therefore, it is

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possible that the fact that one is male or female or that one was born at the beginning or end of the year modulates the relationship between language and calculus. That is why this relationship is analyzed from a contingent perspective.

2. Problem Statement

Oral language and calculus have been studied mostly in isolation, the literature that relates both skills are limited. The joint study of both abilities supposes an improvement as far as difficulties that could derive from one or the other, as well as the facilitation of future learnings

3. Research Questions

Based on these arguments, we formulate the following hypotheses:

Hypothesis 1. Children who score high in oral language will score high in mathematics competencies (calculation).

Hypothesis 2. Students who score above the mean in oral language will score higher in mathematics competencies (calculation).

Hypothesis 3. The relationship between oral language and mathematics competencies (considered globally) will be different depending on the sex and birth month.

4. Purpose of the Study

The aim of this paper is to analyze the relationships between oral language and mathematics competencies or calculus moderated by sex and month of birth.

5. Research Methods

5.1. Sample

A total of 13 children from 1st grade of elementary school in Huesca participated in the study. 5 participants were boys representing 38.5% of the sample and 8 were girls, representing 61.5% of the sample. Subjects diagnosed with learning disorders have been excluded, because they were not the objective of the present study.

5.2. Measures

Two standardized tests have been used. These were BLOC-SR (*Batería del Lenguaje Objetivo y Criterial*), Objective and Criterial Language Battery Screening Revised (Puyuelo, Renom, Solana, and Wiig, 2007) and TEDI-MATH, Test for the diagnosis of basic competencies in mathematics (Grégoire et al., 2015).

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6. Findings

6.1. Hypothesis Testing

Descriptive results and correlations of the variables considered in the study are presented in Table 1. Hypothesis 1 suggested that children who scored high in oral league would also score high in calculus. The results show that when we jointly considered BLOC-SR (oral language) and TEDI-MATH (calculation) and the additional tests of TEDI-MATH (TEDI_A), positive and significant correlations were found among the variables. Thus, BLOC-SR correlated positively and significantly with TEDI-MATH ($r = .80$, $p <.01$). In addition, oral language (BLOC-SR) and the calculation provided by additional tests of TEDI-MATH (TEDI_A) also showed a positive and significant correlation ($r = .80$, $p <.01$). Therefore, H1 is confirmed.

Table 01. Means, Standard Deviations and bivariate correlations

	BLOC	TEDI	TEDI_A	SEX	MONTH
BLOC-SR	1				
TEDI	,80**	1			
TEDI_A	,80**	,98**	1		
SEX	-,19	-,11	-,01	1	
MONTH	-,40	-,31	-,37	,06	1

*Note: *p < .05; ** p < .01.* Men “0”, Women “1”

The hypothesis 2 proposed that the difference of the means in TEDI-MATH of the students that scored above the mean in BLOC-SR would be higher than the mean of the students that scored below. The students who score above the mean in BLOC-SR ($M = 70.06$) obtained a higher mean in TEDI-MATH ($M = 82.39$, $SD = 7.85$) than the mean of those who score below the mean in BLOC-SR ($M = 48.20$, $SD = 31.01$) (see table 02). In addition, students who score above the mean in BLOC-SR, obtained a higher mean in the calculation provided by the additional tests of TEDI-MATH (TEDI_A) ($M = 85.65$, $SD = 4.65$) than those who scored below the mean in BLOC-SR ($M = 56.63$, $SD = 27.48$). The results of the t test show no significant differences for the following variables: TEDI-MATH ($t = 2.17$, $df = 3.17$, $p = .11$), and TEDI_A ($t = 2.10$, $df = 3.08$, $p = .12$) due to that the variances are not equal. However, if the result of the Levene test had not been significant, these differences would have been significant for TEDI-MATH ($t = 3.25$, gl= 11; $p <.01$) and TEDI_A ($t = 3.24$, gl = 11, $p <.01$), respectively. Although the data are close to significance, they do not reach the required level. Therefore, although a certain tendency can be observed, H2 is rejected.

Table 02. Comparison of means and t test

	Oral Language (BLOC)	M	SD	t	gl	p
Calculation (TEDI)	High “Oral Language”	82,39	7,85			
	Low “Oral Language”	48,20	31	2,17	3,17	,11
Calculation (TEDI_ A)	High “Oral Language”	85,65	4,65			
	Low “Oral Language”	56,63	27,48	2,10	3,10	,12

*Note: *p < .05.* Men “0”, Women “1”

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Hypothesis 3 suggested that the relationship between oral language and calculus (taken as a whole) would be different depending on the sex and month of birth. As can be observed in table 03, there is a direct positive relationship between calculus and oral language (B = .33, p <0.5). However, in this study it is not clear that this relationship is moderated by sex, that is, it is positive in both boys and girls and the pattern of the relationship does not differ according to sex (B = .01, ns) (see figure 01). In addition, the sex variable did not show a direct relationship with BLOC (oral language) (B = -1.93, ns). Also, as shown in figure 02, the relationship between TEDI-MATH and BLOC-SR, for children born at the end of the year (younger), the relationship was positive, although weaker than in children born at mid-year, and practically nil in children born at the beginning of the year (B = .05, ns). Although these results are not significant and therefore cannot be taken into account, they have been graphed to observe the trends. The results seem to indicate that younger children show a greater relationship between TEDI-MATH (calculus) and BLOC-SR (oral language), this could be due to the interference of other context variables that are more outgoing in elementary school than in children such as preference, attention, level of effort, etc. Therefore, H3 is rejected.

Table 03. Results of the regression analysis for the BLOC-SR depending on sex and month

Variable	B	R2	R^2	Variable	B	R2	R^2
Sex	-1,93			**Month**	-4,33		
TEDI	.33*			**TEDI-MATH**	-.15		
Sex * TEDI	.01	.64*	.01	**Month * TEDI-MATH**	.05	.71*	.06

Note: B are non-standardized regression coefficients; †<.10; * p <.05; ** p <.01. Men “0”, Women “1”

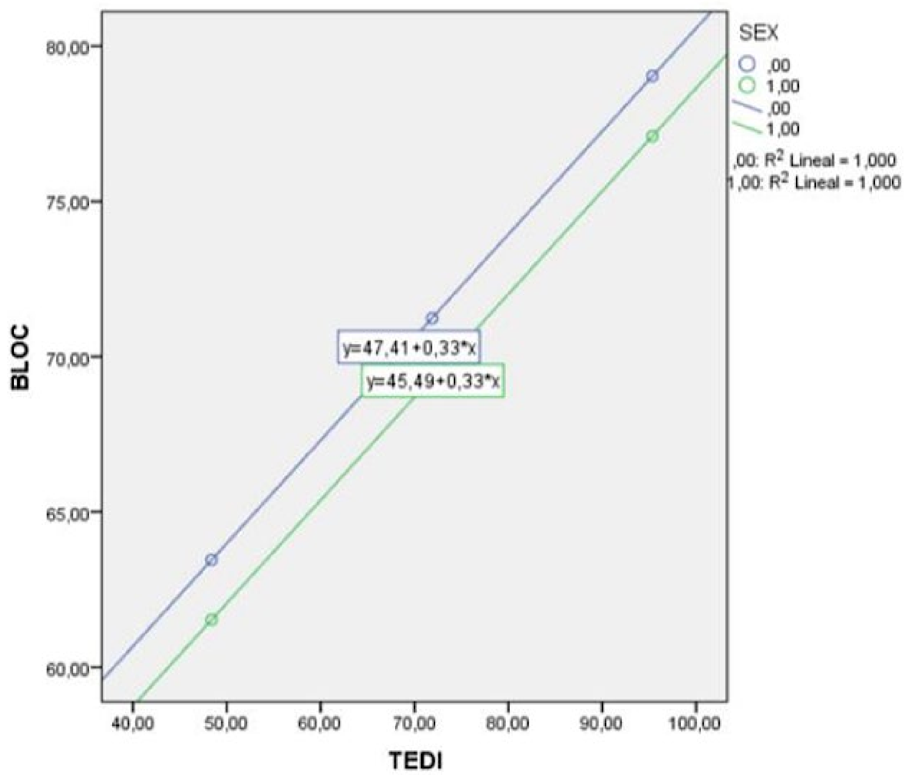

Figure 01. Results of the regression analysis for the BLOC-SR. TEDI*SEX

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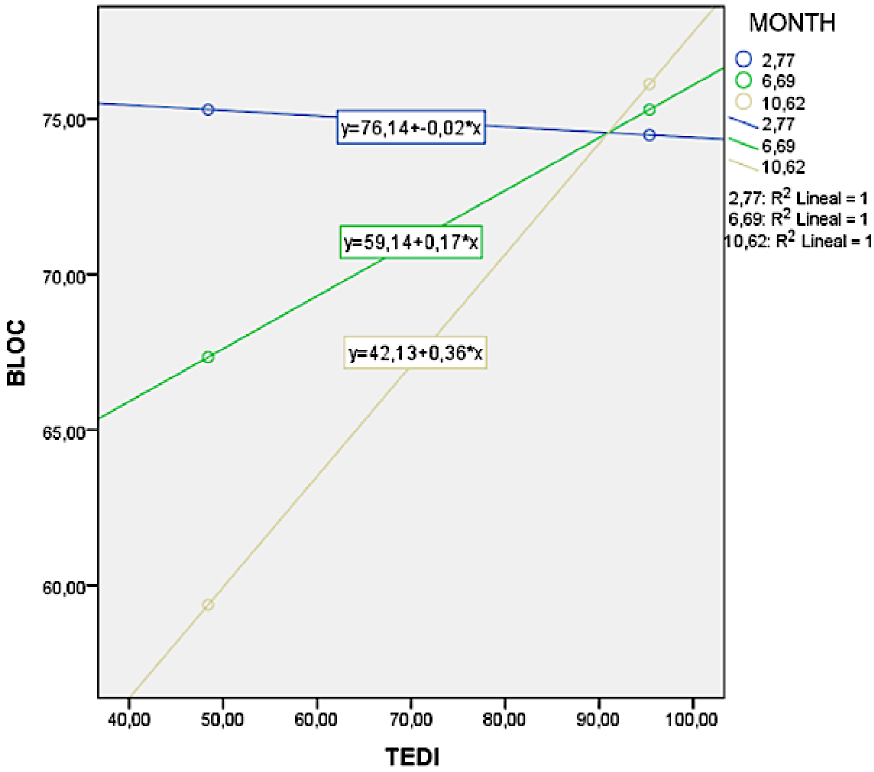

Figure 02. Results of the regression analysis for the BLOC-SR. TEDI*MONTH

7. Conclusion

The aim of the present study was to analyze the relationship between oral language and mathematics competencies (calculation) in first grade of elementary school. As we obtained, when jointly considered BLOC-SR (oral language) and TEDI-MATH (calculation) and additional tests of TEDI-MATH (TEDI_A), positive correlations were found and significant among the variables. Thus, BLOC-SR correlated positively and significantly with TEDI-MATH. In addition, oral language (BLOC-SR) and the calculation provided by additional tests of TEDI-MATH (TEDI_A) also showed a positive and significant correlation. That is, the boys and girls who score higher in BLOC-SR score higher in TEDI-MATH. These results are in line with what was suggested by the studies of Koponen (2008), Barbosa (2014), Moll et al. (2015) and Dowker and Nuerk (2016). In addition, when all the parts of BLOC-SR were considered together with all the parts of TEDI-MATH and the additional tests of TEDI-MATH (TEDI_A), they found positive and significant correlations between the variables. Considering BLOC-SR and TEDI-MATH, "syntax" correlated positively and significantly with oral numerical system, operations with arithmetic statement, size estimation, comparison of oral numbers and with sums with gaps. Regarding "pragmatics", he correlated positively and significantly with oral numerical system, coding, logical operations, operations with arithmetic statement, operations with verbal statement, size estimation, oral numerical decision, comparison of oral numbers, and reading no. Arabic aloud, numerical series, numerical classification, additive decomposition, simple sums, sums with holes, simple subtractions and with relative size. The correlations of BLOC-SR and TEDI_A are diverse and have been mentioned previously in the "Results" section. These results are in line with what was found in the studies by Dowker and Nuerk (2016) and Barbosa (2014) but

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differ from that found in the study by Lesaux and Vukovic (2013) and Jordan et al. (2015). Students who score above the average in BLOC-SR and their average in TEDI-MATH is higher than the average of those who score below the average in BLOC-SR.

In addition, students who score above the average in BLOC, obtained a higher mean in the calculation provided by the additional tests of TEDI-MATH (TEDI_A) than those who scored below the average in BLOC-SR. However, although the data are close to significance, they do not reach the required level. The relationship between TEDI-MATH (calculation) BLOC-SR (oral language) is significant, that is, there is a direct positive relationship between calculus and oral language. However, this relationship is not moderated by sex, that is, it is positive in both boys and girls and the pattern of the relationship does not differ according to sex. In addition, the sex variable did not show a direct relationship with BLOC (oral language). The relationship between TEDI-MATH and BLOC-SR, for children born at the end of the year (younger), the relationship was positive although weaker than in the children born at mid-year and practically nil in children born at the beginning of the year. Although these results are not significant and therefore cannot be taken into account, they have been graphed to observe the trends. The results seem to indicate that younger children show a greater relationship between TEDI-MATH (calculus) and BLOC-SR (oral language), this could be due to the interference of other children. Limits Like other work, this study is not exempt of limitations. In the case of experimental research, one of the major weaknesses is the lack of external validity.

Moreover, the sample is limited and although the study provides an interesting empirical evidence block about the relationship between language and mathematics, future studies would be necessary to clarify this relationship in larger samples and in a longitudinal way. The tests administered to the participants are extensive and allow the relationship to be established. That is why it should be taken into account when future studies analyze the school failure in mathematics and other areas the possible problems that are dragging perhaps from the acquisition of language in earlier stages.

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