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Math Anxiety in Children with and Without Fluid Intelligence Deficits

Ansiedade Matemática em Crianças com e sem Déficits na Inteligência Fluida

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Abstract

High levels of math anxiety (MA) and deficits in fluid intelligence can be associated with low arithmetical performance. The study's objective was to evaluate the differences between children with and without fluid intelligence (Gf) deficits in the math anxiety, arithmetical performance, working memory (WM), and inhibitory control (IC). Fifty-four children participated, a control group (CG) with children without Gf deficits, and an experimental group (EG) with children with Gf deficits**.** Each group included twenty-seven participants, with a mean age of 8.26 years, 74.1% of the students from public schools, and 55.6% of masculine sex. The control and experimental groups demonstrated a significant difference in visual WM and IC. Significant correlations were found between arithmetic performance and WM (visual and verbal), and between arithmetic performance and IC. Students from public school demonstrated lowest arithmetical performance in comparison with students from private schools. It was found that verbal WM, IC, and MA explained 78.5% of the CG's arithmetical performance and that only IC explained 51.8% of the EG. Our results demonstrated Gf has a fundamental role in arithmetical and cognitive performance, and that MA is one of the predictors of better arithmetical performance results in children without Gf deficits.

Keywords: Math Anxiety. Mathematics. Learning Disability. Fluid Intelligence.

Resumo

Níveis elevados de ansiedade matemática (AM) e déficits na inteligência fluida podem estar associados com o baixo desempenho em aritmética com impactos negativos para o desenvolvimento escolar. O objetivo desse estudo foi investigar se existem diferenças entre crianças com e sem déficits de inteligência fluida para as medidas de ansiedade matemática, desempenho em aritmética, memória de trabalho (MT) verbal, MT visual e controle inibitório (CI). Participaram 54 crianças no total, um grupo controle formado por crianças com inteligência típica, e um grupo experimental por crianças com baixa performance na inteligência fluida. Cada grupo incluiu 27 participantes com idade média de 8,26 anos, sendo 74,1% estudantes da rede pública e 55,6% do sexo masculino. Os grupos, controle e experimental, demonstraram uma diferença significativa para a MT visual e CI. Correlações significativas foram encontradas entre desempenho em aritmética e MT (visual e verbal), e entre desempenho em aritmética e CI. Estudantes de escolas públicas demonstraram desempenho em aritmética inferior aos estudantes de escolas privadas. Foram encontradas diferenças significativas entre os grupos experimental e controle para memória de trabalho visual e controle inibitório. Foi verificado que a MT verbal, CI e AM explicam juntas 78,5% do desempenho em aritmética do grupo controle e que apenas o CI explica 51,8% desse desempenho no grupo experimental. Os resultados apontam que a inteligência fluida tem papel fundamental no desempenho cognitivo e aritmético, e que a AM é um dos preditores para melhores resultados no desempenho em aritmética em crianças sem déficits de inteligência.

Palavras-chave: *Ansiedade Matemática. Aritmética. Dificuldade de Aprendizagem. Inteligência Fluida.*

1 Introduction

Math anxiety (MA) can be defined as a specific phobia of mathematical stimuli that can cause reactions of (1) physiological nature, such as headaches, tired facial expression, increased sweating, and stomach disorders; (2) behavioral nature, such as escaping and avoiding the aversive situation; and (3) cognitive nature, including dysfunctional thinking, such as "math is difficult," "I will not learn," "I am a dumb" (Dowker, Sakar, & Looi, 2016; Tobias & Weissbrod, 1980). The intensity and frequency of these behaviors characterize the diversity of the MA profile, which can vary from mild to extreme degrees of anxiety (Ashcraft & Ridley, 2005).

Advances in MA strengthen its multidimensional nature, considering the division between cognitive and affective dimensions (Haase et al., 2012; Krinzinger, Kaufmann, & Willmes, 2009). The cognitive dimension is related to attitudes in the learning process and the affective one to the negative emotions towards mathematics. MA is also divided into state-MA, responses during the execution of a task involving numbers or calculation, and trait-MA, corresponding to lasting characteristics that the person identifies as part of his/her repertoire (Orbach, Herzog, & Fritz, 2019). In the study by Cargnelutti, Tomasetto, and Passolunghi (2017), more significant effects were found on mathematics performance for MA status in school-aged children.

Studies on MA in school children have found patterns of negative emotions associated with math in first-grade children with a significant increase in the second year (Ramirez, Chang, Maloney, Levine, & Beilock, 2016; Wu, Barth, Amin, Malcarne, & Menon, 2012). At the beginning of schooling, contact with math includes introductory content and the first contact with mathematical operations without teachers' significant interference. It is considered that children who have MA in the first year can be considered to present the possible genetic determinants as evidenced by Júlio-Costa et al. (2019) or be under the possible influence of environmental variables such as the effects of the parents' expectations (Maloney, Ramirez, Gunderson, Levine, & Beilock, 2015). On the other hand, the expectations of parents and the profile of teachers (Gunderson, Ramirez, Levine, & Beilock, 2012) associated with genetic vulnerability and increased complexity of content in the second and third years can be explanatory variables for findings that identify these phases as being linked to higher levels of MA (Ramirez et al., 2016; Wu et al., 2012).

It is noted that the causality of MA is still undefined, but there is strong evidence about its multivariate nature in studies that demonstrate genetic causes (Gomides et al., 2018) and others that demonstrate the association with teaching strategies (Chang, Lee, & Yen, 2019). Another set of environmental variables that have been associated with children's MA emerges when high levels of MA are present in parents and/or teachers acting as a model, and MA can be introduced into the child's repertoire by learning mechanisms (Dowker, 2019; Feio, Borges, & Silva, 2019). The effects of MA have been demonstrated from the low performance in math tasks in groups of individuals who have higher scores of MA (Namkung, Peng, & Lin, 2019).

There is evidence that MA can indirectly impair a person's performance because anxiety may be associated with low working memory capacity (Ashcraft & Krause, 2007; Figueira & Freitas, 2020), attentional control, and less gray matter volume in the left anterior intraparietal sulcus of the brain (Hartwright et al., 2018). Working memory has a fundamental role in storing and processing information, being responsible for memorizing numbers, spatial representation, and direction and monitoring of procedures involved in the resolution of mathematical problems. Its impairment can lead to poor school performance and prevent the adequate development of math skills (Corso & Dorneles, 2012).

Besides the presence of MA levels, poor performance in fluid intelligence (Gf) may be associated with learning difficulties in maths, contributing to increased anxiety levels. The most consolidated model of structured intelligence was proposed by McGrew and Flanagan (1998), known as Cattell-Horn-Carroll (C-H-C), and shows intelligence as a multifactorial and hierarchical organized system of several cognitive skills that interact with each other. The skills are classified into two levels: top and bottom. The first corresponds to broader skills and the second to specific skills (Weiss, Saklofske, Prifitera, & Holdnack, 2006). Fluid Intelligence is a broad skill that bases more specific skills, such as inductive, quantitative, and sequential reasoning (McGrew & Flanagan 1998). These are fundamental to good arithmetical performance (Flanagan, Ortiz, Alfonso, & Mascolo, 2006; Hale, Fiorello, Kavanagh, Holdnack, & Aloe, 2007).

Schleepen and Van Mier (2016) reported evidence of the difference between genders, showing significant and negative correlations between MA and performance in math and fluid intelligence in female, but not in male children. According to that study indicated that high MA levels are associated with poor arithmetical performance and fluid intelligence in female children. Other studies sought to identify which variables are related to MA (Soni & Kumari, 2017, Jameson, 2014). In one of them, the time of the day (morning or afternoon) when the student studies and the type of school (public or private) were investigated, and it was seen that students in the afternoon shift and attending public schools had higher levels of MA concerning peers (Cain & Gradisar 2010; Wheaton, Chapman, Croft, 2016).

Although the MA profile found in children may be different, with specific origins and triggers, low performance in fluid intelligence is a variable that needs further investigation. Associated with the learning difficulties of mathematics, low scores in fluid intelligence can indirectly contribute to MA's development, considering the bidirectional effect between low performance and MA (Krinzinger et al., 2009).

The aim of this study was to investigate differences in MA levels in children with low fluid intelligence scores in a comparative study. Children with low intelligence scores may have higher MA scores and lower math performance, this possibility is still under-investigated considering that most studies only investigate children with typical or higher-than-typical intelligence performance. Other cognitive measures, such as verbal and visual working memory and inhibitory control, were also investigated considering that executive functions' flaws are a vital dimension for performance in mathematics and strongly related to intelligence. Differences between genders and types of schools were also tested and the relation between MA of parents and teachers.

The study hypothesizes that the experimental group (low scores in fluid intelligence test) has higher MA levels, low arithmetical performance, inhibitory control, and working memory than the control group. Levels are also expected to relate to cognitive variables and arithmetical performance. Another hypothesis is, regarding differences between genders, that the female sex is the group with the highest anxiety scores. As for school types, we consider that public school children have higher anxiety scores and worse performance. Considering the relevance of MA in parents and teacher, this study test in a comparative way.

2 Method

2.1 Sample

For comparison purposes, the study was conducted with two paired samples of the case-control type. The total sample of the study was 54 Brazilian children aged 7 to 10 years. The research took place in five schools - two public and three private schools - in Vitória da Conquista at the state of Bahia, Brazil. Children were distributed in experimental and control groups, and children diagnosed with neurodevelopmental disorders and those with uncorrected sensory and/or motor disabilities were excluded based on exclusions reasons defined previously.

Experimental group: The participants in the experimental group were 27 children with a mean age Mean (M) = 8.26 and Standard Deviation (SD) = 0.94, who had low scores in the assessment of fluid intelligence (M = 10.41, SD = 5.27). Participants were selected from the percentile equal to or less than five, with a lower-than-expected age classification in the Raven's Coloured Progressive Matrices Test. Most of the children in this group were from public schools, 74.1% (20 children), being 25.9% (7 children). The children's distribution among gender was homogeneous, with 55.6% (15 children) belonging to males and 44.4% (12 children).

Control Group: For the composition of the control group, children paired by age, type of school, and gender were selected among those who performed as expected in the fluid intelligence test. The number of participants in this group was the same as in the control group based on the pairing criterion. These children reached the expected scores in the fluid intelligence assessment (M = 20, SD = 4.78). The selected participants obtained results between the 26th and 49th percentiles, with the classification within the expected age in the Raven's Coloured Progressive Matrices Test, the measure of fluid intelligence. Most children in this group were from public schools, 74.1% (20 children) and being 25.9% (7 children) with 55.6% (15 children) were male, while 44.4% (12 children).

2.2 Instruments

Corsi Blocks (Corsi, 1972): This test was applied to assess short-term memory and visuospatial working memory. The instrument has the shape of a wooden board with nine cubes. The applicator makes pre-established movements in direct and indirect order over them, progressively increasing the level of difficulty. The child's total number of correct answers is compared with the reference group's average, being classified as below, above, or within the average.

Digits Span Subtest (Wechsler, 2013): This test was applied to assess auditory working memory and auditory attention. It is divided into two parts: in the first, the appraiser asks the appraisee to repeat a sequence of pronounced numbers, and in the second, the appraisee is asked to speak the numbers in reverse order after being pronounced by the appraiser. The number of correct answers is counted and compared with the standardization table.

Stroop task - numerical version (Rubinsten & Henik, 2005): This tool aims to evaluate the inhibitory control and make a symbolic comparison of magnitude. The task is computerized; the stimuli appear on the computer screen, with 45 items that are presented at different time intervals with different values and sizes. The evaluation is based on the number of correct answers in the function of the response time.

Raven's Colored Progressive Matrices (Angelini, Alves, Custódio, E.M. Duarte, & Duarte, 1999): This is an analytical reasoning instrument used to assess fluid intelligence and measure non-verbal reasoning. It consists of three levels (A, AB, B) with 12 items, each increasing difficulty. The classification is defined based on the total number of correct answers about the child's age, ranging from four years and nine months up to 11 years and three months.

Math Anxiety Questionnaire (MAQ) (Wood et al., 2012): This instrument measures the level of MA present in children. It consists of 24 items divided into four subscales: (A) self-perceived performance; (B) attitudes in mathematics; (C) unhappiness related to problems in mathematics; and (D) anxiety related to problems in mathematics. The questions are asked from six different categories related to mathematics. Answers are given according to a Likert scale. The score ranges from 1 to 5, and the higher the score, the higher the level of math anxiety.

Math Anxiety Scale - MAS (Carmo et al., 2008): This instrument is used to measure the levels of mathematical anxiety of teachers and parents of students. It is a scale composed of 24 items related to mathematics experiences in the classroom and other environments. For each situation, the examinee must choose only one option among five alternatives: no anxiety, low anxiety; moderate anxiety; high anxiety; extreme anxiety. The classification is defined based on the total scores, 24 points correspond to no anxiety; between 25-48 points low anxiety; between 49-72 points moderate anxiety; between 73-96 points high anxiety; and between 97-120 points, extreme anxiety for scores.

School Achievement Test (SAT) - Arithmetic subtest (Stein, 1994): This test aims to measure school achievement. It was used to evaluate the performance index in mathematics, composed of mathematical calculations equivalent to the content learned during elementary school. It has 38 items; three are answered orally, and 35 are mathematical operations to be answered in writing. The performance score is provided from the number of correct answers of the child compared to the total with the reference group's average for the age group and school year.

Trail test (Capovilla, 2006): The trail test aims to assess inhibitory control and working memory. The test consists of three parts: the first has twelve letters (A to L), the second has twelve numbers (1 to 12), and the third has twelve letters (A to L) and twelve numbers (1 to 12). The appraisee has one minute to answer each stage. The score in each stage is counted and measured based on the standardization table.

2.2.1 Design

This study adopted a quantitative, cross-sectional design with a convenience sample and hypothesis testing through predictor analysis. The study used a database that is part of a broad line of research, linking different projects on Math Anxiety carried out by the Center Neuropsychological Studies of Childhood and Adolescence.

The research was submitted and approved by the research ethics committee of the Federal University of Bahia, following ethical procedures. Data collections were carried out in public and private schools in the city of Vitória da Conquista in Bahia, Brazil, after meetings with parents and teachers to invite them to participate clarify possible doubts and sign the Informed Consent Form for children and their participation. Teachers signed the appropriated Informed Consent Form for their participation. The testing was carried out by a trained team consisting of psychologists from the Center Neuropsychological Studies of Childhood and Adolescence. The participating children signed the Informed Agreement Form and participated in the testing in individualized sessions lasting 50 minutes.

The data were submitted to statistical analysis with the Statistical Package of the Social Sciences (SPSS) version 25. Descriptive statistical analyses were performed to characterize the sample, and the Mann-Whitney test was used to compare the math anxiety, cognitive, and arithmetical performance profile of children with low fluid intelligence scores and those with scores within expected values, and in order to compare differences between sex and type of school. The Spearman correlation coefficient and multiple linear regression analysis with the stepwise method were used to assess which variables contribute to explain the arithmetical performance of children with and without fluid intelligence deficits. To test the models, the following variables were included: math anxiety, working memory, and inhibitory control in all tests; $p < 0.05$ was established for the alpha (α) value.

3 Results and Discussion

The instruments' norms were used to find that the averages were within the expected for both groups in part B of the trail test, which measures inhibitory control, and in all items of math anxiety. In part A of the trail test, both groups showed low results, and for arithmetical performance, the control group presented results within the expected, and the experimental group presented inferior results.

Table 1 presents the results of the descriptive analysis and the comparison between the experimental and control groups for the measures of working memory, inhibitory control, MA, and arithmetical performance, showing significant differences in the trail test (part A), visual working memory forward, and backward, and total score. No significant differences were found in the other tests. Low levels of MA were found in math teachers of the control group and moderate levels in those of the experimental group. The parents had moderate levels of MA in both groups.

Table 1 - Comparison of measures of verbal and visual working memory, inhibitory control, math anxiety, and arithmetical performance between the control and experimental groups

	Control		Experimental		Mann – Whitney	
	M	SD	M	SD	U	P
Digits Forward	6.22	2.50	6.30	1.99	339.00	0.64
Digits Backward	3.78	1.84	3.70	2.05	339.000	0.64
Digits Span score	10.15	3.31	10.00	3.24	351.500	0.82
Corsi Forward	6.11	1.98	5.19	1.81	264.000	0.07*
Corsi Backward	5.33	2.28	3.33	2.21	196.000	0.003**
Corsi score	11.56	3.72	8.59	3.40	202.000	0.005**
Trails A	62.41	45.10	49.44	45.83	254.500	0.056*
Trails B	102.74	21.84	94.00	15.05	284.000	0.161
Stroop	51.58	19.67	49.31	14.16	125.000	0.512
MAC A	12.59	4.61	12.74	3.49	347.000	0.761
MAC B	13.48	5.84	13.04	5.43	352.000	0.828
MAC C	14.96	5.72	16.85	4.90	288.500	0.188
MAC D	16.89	6.20	17.59	5.49	350.500	0.808
SAT Arithmetic	8.11	5.82	5.15	3.99	258.500	0.066
MA – Teacher	48.27	19.90	51.93	18.46	307.000	0.432
MA – Parents	51.52	22.48	57.00	22.36	280.500	0.402

Note: * $p < 0.05$; ** $p < 0.01$; Digits Forward; Digits Backward; Corsi Forward; Corsi Backward. SAT - School Achievement Test; MAQ - Mathematical Anxiety Questionnaire; MA-T – Teacher's Math Anxiety; MA-P –Parent's MA; SD - Standard Deviation.
Source: Authors.

Another hypothesis tested was the relationship between MA and cognitive variables and arithmetical performance. In Table 2, the results showed that in the experimental group, moderate and positive correlations were found between arithmetical performance and the total score in the digits span test (rho = 0.58; $p < 0.001$), digit span test in reverse order (rho = 0.64; p < 0.001) the total score in the Corsi Blocks (rho = 0.51; p < 0.01) and in reverse order (rho = 0.57; p < 0.01).

There was a strong and positive correlation between the total number of correct answers in the Stroop task and arithmetical performance (rho = 0.76; p < 0.001). Part B of the trail test (rho = 0.45; p < 0.05) showed a moderate and significant correlation with arithmetical performance. There was also a moderate and negative correlation between math teachers' MA levels and the students' arithmetical performance (rho = -0.40; p < 0.05).

Table 2 - Correlation between arithmetical performance and measures of verbal and visual working memory, inhibitory control, and MA in the control and experimental groups

Variables	**Total score in the School Achievement Test-Arithmetic Subtest**					
Groups	**Control**			**Experimental**		
	n	rho	P	n	rho	p
Digit Forward	27	0.50	0.008**	27	0.29	0.137
Digit Backward	27	0.53	0.004**	27	0.64	0.000***
Digits Span score	27	0.68	0.000***	27	0.58	0.001***
Corsi Forward	27	0.50	0.008**	27	0.37	0.056
Corsi Backward	27	0.62	0.001***	27	0.57	0.002**
Corsi score	27	0.64	0.000***	27	0.51	0.007**
Trails A	27	0.24	0.221	27	0.17	0.394
Trails B	27	0.40	0.040*	27	0.45	0.018*
Stroop	18	0.45	0.059	16	0.76	0.001***
MAQ A	27	0.02	0.908	27	0.11	0.574
MAQ B	27	-0.12	0.545	27	-0.04	0.86
MAQ C	27	0.21	0.298	27	0.12	0.547
MAQ D	27	0.26	0.184	27	0.04	0.840
MA – Teacher	26	-0.08	0.706	27	-0.40	0.039*
MA – Parents	25	-0.45	0.025*	26	0.01	0.949

Note: Working Memory assessment: Digits Forward; Digits Span Backward; Corsi Forward; Corsi Backward. SAT - School Achievement Test; MAQ - Mathematical Anxiety Questionnaire; MA-T – Teacher's Math Anxiety; MA-P –Parent's MA SD - Standard Deviation * Significant Values p < 0.05; ** Significant Values p < 0.01; *** Significant Values p < 0.001.
Source: Authors.

In the control group, moderate and positive correlations were found between arithmetical performance and all measures of verbal working memory: digits span forward (rho = 0.50; p < 0.01), digits span backward (rho = 0.53; p < 0.01), and gross digits span score (rho = 0.68; p < 0.001). Correlations with the same strength and in the same direction were also demonstrated with the measures of visual working memory, Corsi forward (rho = 0.50; p < 0.01), Corsi backward (rho = 0.62; p < 0.001), and gross Corsi score (rho = 0.64; p < 0.001).

Regarding the inhibitory control, a moderate and positive correlation was found with the trail test (part B) (rho = 0.40; p < 0.05). A significant, weak, and negative correlation was observed between the students' arithmetical performance and the levels of MA of their parents (rho = -0.45; p < 0.05). As in the experimental group, the control group's arithmetical performance did not show significant correlations with the trail test (part A), which measures inhibitory control, and with the items on the scale that measure the students' MA levels.

The hypotheses of higher MA scores in girls and lower performance and higher levels of anxiety in public school students were investigated by comparing the genders and school types. Comparisons between these groups were also made using the Mann-Whitney test. Tables 3 and 4 show the comparisons between types of schools (public and private) and genders, with differences in the study variables tested in both the experimental and control groups.

Table 3 - Comparison of measures of verbal and visual working memory, inhibitory control, MA, and arithmetical performance between girls and boys of the control group and the experimental group

	Control				**Experimental**			
	Female	**Male**	**Mann-Whitney**		**Female**	**Male**	**Mann-Whitney**	
	M	M	U	P	M	M	U	p
Digits Forward	15.33	12.93	74.000	0.422	11.75	15.77	63.500	0.173
Digits Backward	13.96	14.03	89.500	0.980	12.25	15.40	69.000	0.288
Digits Score	14.83	13.33	80.000	0.621	11.79	15.77	63.500	0.189
Corsi Forward	12.83	14.93	76.000	0.486	13.17	14.67	80.000	0.615
Corsi Backward	13.67	14.27	86.000	0.843	13.33	14.53	82.000	0.688
Corsi Score	13.79	14.17	87.500	0.902	12.71	15.03	74.500	0.447

	Control				Experimental			
	Female	Male	Mann-Whitney		Female	Male	Mann-Whitney	
Trails A	13.00	14.80	78.000	0.556	13.13	14.70	79.500	0.806
Trails B	13.67	14.27	86.000	0.845	12.75	15.00	75.000	0.606
Stroop	11.06	7.94	26.500	0.216	8.38	8.63	31.000	0.916
MAQ A	14.88	13.30	79.500	0.607	15.00	13.20	78.500	0.459
MAQ B	13.58	14.33	85.000	0.806	14.13	13.00	88.500	0.557
MAQ C	16.92	11.67	55.000	0.087	14.50	13.60	76.500	0.941
MAQ D	15.96	12.43	66.500	0.250	8.38	8.63	84.000	0.508
MA-T	15.42	12.87	73.000	0.405	13.58	14.33	85.000	0.769
MA-P	15.05	12.37	65.500	0.376	14.46	13.63	84.500	0.787

Note: Digits Forward; Digits Backward; Digits Score; Corsi Forward; Corsi Backward, Corsi Score; MAQ - Mathematical Anxiety Questionnaire; MA-T – Teacher's Math Anxiety; MA-P –Parent's MA* Significant Values p < 0.05; ** Significant Values p < 0.01; *** Significant Values p < 0.001.
Source: Authors.

The results of Table 3 did not indicate significant differences between girls and boys in the measures evaluated ($p > 0.05$). As for the comparison between the types of school, there were significant differences in the experimental group for the performance of the variable in mathematics ($U = 26.500$; $p < 0.05$) and teachers' MA ($U = 7.000$; $p < 0.001$). The results showed better mathematical performance for students from private schools and higher MA levels in teachers from public schools in the experimental group.

Different results were found for the participants in the control group; significant differences were observed between the public and private education in the trail test (parts A and B) ($U = 20.50$; $p < 0.01$); ($U = 11.00$; $p < 0.001$). Significant differences were also identified in terms of arithmetical performance ($U = 34.00$; $p < 0.05$) and teachers' MA levels ($U = 19.50$; $p < 0.05$). Private school students showed better performance for inhibitory control, and in arithmetical performance, public school teachers showed higher levels of math anxiety.

Table 4 - Comparison of measures of verbal and visual working memory, inhibitory control, MA, and arithmetical performance between public and private schools of the control group and the experimental group

	Control				Experimental			
	Public	Private	Mann-Whitney		Public	Private	Mann-Whitney	
	M	M	U	P	M	M	U	p
Digits Forward	12.65	17.86	43.000	0.124	13.18	16.36	53.500	0.336
Digits Backward	13.03	16.79	50.500	0.269	12.58	18.07	41.500	0.102
Digits Score	12.38	18.64	37.500	0.069	12.63	17.93	42.500	0.122
Corsi Forward	12.40	18.57	38.000	0.071	13.63	15.07	62.500	0.669
Corsi Backward	13.58	15.21	61.500	0.634	13.75	14.71	65.000	0.776
Corsi Score	13.05	16.71	51.000	0.289	13.78	14.64	65.500	0.802
Trails A	11.53	21.07	20.500	0.006**	13.78	14.64	65.500	0.802
Trails B	11.05	22.43	11.000	0.001***	13.80	14.57	66.000	0.823
Stroop	9.00	18.00	0.000	0.101	8.50	0.00	-	-
MAQ A	14.13	13.64	67.500	0.889	13.33	15.93	56.500	0.453
MAQ B	14.15	13.57	67.000	0.867	13.65	15.00	63.000	0.698
MAQ C	12.75	17.57	45.000	0.166	13.90	14.29	68.000	0.911
MAQ D	13.53	15.36	60.500	0.598	14.25	13.29	65.000	0.782
MA-T	12.20	19.14	34.000	0.046*	11.83	20.21	26.500	0.015*
MA-P	15.53	6.75	19.500	0.013*	17.15	5.00	7.000	0.000***

Note: Digits Forward; Digits Backward; Digits Span Score; Corsi Forward; Corsi Backward, Corsi Score. MAQ - Mathematical Anxiety Questionnaire; MA-T – Teacher's Math Anxiety; MA-P –Parent's MA* Significant Values p < 0.05; ** Significant Values p < 0.01; *** Significant Values p < 0.001.
Source: Authors.

The contributions of the cognitive variables verbal working memory, inhibitory control, and MA of the student to the control and experimental group's mathematical performance were analyzed using the multiple linear regression analysis found in Table 5. For the control group, the digits span scores ($\beta = 1.11$; $\tau = 6.16$; $p < 0.001$), total correct answers in the Stroop task ($\beta = 0.09$; $\tau = 2.59$; $p < 0.05$), and MAC-D ($\beta = 0.23$; $\tau = 2.16$; $p < 0.05$) showed statistically significant values. Together, these measures explained 78.5% of students' mathematical performance without impairing fluid intelligence. In these students, verbal working memory, inhibitory control, and the MA subscale that measures anxiety related to mathematics problems are variables that predict higher scores on the arithmetic test of these students.

In the experimental group, among the variables analyzed, only the Stroop task, which evaluates the inhibitory control, presented statistical significance ($\beta = 0.167$; $\tau = 4.009$; $p < 0.001$). It explained 51.8% of the arithmetical performance of participants with low performance in fluid intelligence.

Table 5 - Comparison between the control group and the experimental group for the contributions of the measures of verbal working memory, inhibitory control, and MA

	Control				Experimental			
	Coeff. B	**SD**	**T**	**P**	**Coeff. B**	**SD**	**T**	**P**
DS	1.113	0.181	6.160	0.000***	-	-	-	-
Stroop	0.095	0.037	2.595	0.021*	0.167	0.042	4.009	0.001***
MAQ-D	0.232	0.107	2.161	0.048*	-	-	-	-

Note: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; DS – Digits Span; MAQ-Mathematical Anxiety Questionnaire; SD - Standard Deviation; Control Group: n = 18; Multiple R = 0.907; Adjusted R^2 = 0.785; F = 4.672 ($p < 0.05$); DF = 3.14; Residue: 0.000; AIC = 2.437; Experimental Group: n = 15; Multiple R = 0.744; Adjusted R^2 = 0.518; F = 16.072 ($p < 0.001$); GL = 1.13; Residue: 0.000; AIC = 2.437.
Source: Authors.

The observation of divergence between intelligence tests and age can indicate delays in cognitive development that result in academic performance failure. Fluid intelligence is a significant predictor of academic performance and a strong correlation with working memory, thus forming a set of functions that strongly influence the development of mathematical skills. In this study, the focus was on verifying whether children with low scores of fluid intelligence have higher MA levels than children performing within the expected for this measure. Another hypothesis investigated was the relationship of working memory and inhibitory control with arithmetical performance, comparing the two groups.

According to Hartwright et al. (2018), the reduced capacity for executive functions may be a consequence of anxiogenic conditions towards mathematics, contributing to difficulties in school learning and low performance. In the present study, differences were found between the mean of correct answers in the visual working memory and the inhibitory control of children with different fluid intelligence profiles. Children with low fluid intelligence scores obtained a lower score than expected in the arithmetical performance test (see Table 1). In comparing children in the experimental and control groups, statistical differences were found in the measures of verbal working memory and inhibitory control. The results may indicate the importance of fluid intelligence for the performance of executive functions (Rey-Mermet, Gade, Souza, Bastian, & Oberauer, 2019). The data found are in the same line as those of Ashcraft and Krause (2007); they found that performance in mathematics depends significantly on working memory and can be directly affected by the fluid intelligence profile. Furthermore, in their study, high levels of MA were responsible for the compromised performance of working memory and mathematics, a result not found in our data.

The results found did not demonstrate the relationship between MA and arithmetical performance of the participating children. MA did not differ between groups, suggesting that the emotional component for both children with typical intelligence and children with deficits has a similar pattern, with MA levels within the expected range for the age group. That is, their levels of MA did not significantly influence their performance in mathematics. Results that point in the same direction can be observed in Schleepen and Van Mier (2016) study. These authors analyzed the relationship between working memory and MA and found higher MA levels when working memory and mathematical performance were lower. Similar results were also found in other studies that showed that MA, especially in students at an early stage, may affect motivational mechanisms, causing responses associated with performance concerns (Krinzinger et al., 2009; Haase et al., 2012).

It is observed that performance in mathematics was related to working memory and inhibitory control, among the participants, the higher the performance in executive functions, the greater the arithmetical performance. A similar result was demonstrated by Ashcraft and Krause (2007) when they identified the effects of MA on working memory because MA consumes the working memory system's resources, causing losses and consequently reduced performance in the subject in tasks involving math and working memory.

It is important to consider education and the school environment as one of the vital means for developing intellectual skills and maintenance of learning strategies (Gomes & Golino, 2012). However, some teaching strategies may be responsible for regulating emotional responses before specific stimuli (Gurin, Jeanneret, Pearson, Salinas, & Castillo-Garsow, 2017; Chang et al., 2019). This interaction was found in the present study: there was an inversely proportional relationship between the MA levels of math teachers and their respective students' arithmetical performance, with indications of deficits in fluid intelligence. In children with preserved intelligence, an inversely proportional relationship was found between their arithmetical performance and the parents' MA levels.

Several studies have shown the relationship between gender, MA levels, and arithmetical performance, with a worse performance in mathematics and higher MA levels in the female gender (Schleepen & Van Mier, 2016; Van Mier, Schleepen, & Van den Berg, 2019). In this study, no differences were found between boys and girls in terms of MA and arithmetical performance or in the evaluated cognitive measures; the data did not reach the established significance value. These results are in line with the findings of the study by Suárez-Pellicioni, Núñez-Peña, and Colomé (2016), who identified a moderate anxiety profile in boys and girls, without significant differences between both genders concerning MA. Over the school years, girls are exposed to gender stereotypes present inside and outside classrooms (Ramirez, Shaw, &

Maloney, 2018). The beliefs related to the lesser capacity and ability to learn and manipulate mathematics may reinforced by environmental variables as parents' or teachers' math anxiety. And that may increase the MA and result in learning difficulties and poor arithmetical performance in female students (Beilock, Gunderson, Ramirez, & Levine, 2010). For the comparison between the type of school, it was observed in the experimental group that only the arithmetical performance showed a significant difference, considering the comparison between the types of schools of students with atypical intelligence. Among the participants with low performance in fluid intelligence, students from the public system had lower averages of arithmetic knowledge than those from the private system. The results showed that students from private schools performed better in inhibitory control and mathematics. This result is an essential indication of how the effects of better stimulation can even control low intelligence.

Regarding MA, differences in the anxious profile were expected between students from public and private schools for the control and experimental groups, with higher MA levels among students from public schools. However, the results did not point out statistically significant differences in MA between the types of schools in any group. Contrary to these findings, differences were found in the study by Suárez-Pellicioni et al. (2016). They investigated the influence of school type on MA, and in this study, students from public schools had higher MA levels. However, it is essential to note that both groups presented anxious profiles. In another study by Fassis, Mendes, and Carmo (2014), no significant differences in MA were seen between public and private schools; participants of both types of the school had moderate MA levels.

On the other hand, significant differences were found in comparing the control and experimental groups for the variables working memory and inhibitory control, with the lowest scores for the group of children with fluid intelligence deficits. In the investigation of these measures' explanatory power on arithmetical performance, distinct and significant contributions from the variables of verbal working memory, inhibitory control, and MA related to problems in mathematics were observed for the control and experimental group in the present study. Among the measures evaluated, verbal working memory, inhibitory control, and MA demonstrated that, together, they were able to significantly predict 78.5% of the group of students' arithmetical performance without impaired fluid intelligence. Among participants with fluid intelligence deficits, only inhibitory control was able to explain arithmetical performance, with an explanatory percentage of 51.8% (see Table 5).

It is crucial to observe the participation of the inhibitory control for the mathematical performance of both groups. According to Diamond (2013), inhibitory control is related to inhibiting external and internal distracting stimuli. It involves controlling attention, thoughts, emotions, and behaviours, helping the individual carry out daily activities (Rey-Mermet et al., 2019). A study by Brookman-Byrne, Mareschal, Tolmie, and Dumontheil (2018) observed that inhibitory control plays a fundamental role in arithmetic reasoning. Another study pointed out that children with difficulties in inhibitory control and working memory have low performance in mathematics (Figueira & Freitas, 2020). Gonçalves et al. (2017) also demonstrated this relationship by verifying a moderate and robust correlation between inhibitory control and arithmetical performance in elementary school students.

The study results demonstrated that cognitive factors such as fluid intelligence might be responsible for difficulties in math learning, but its interaction with the MA was not seen as expected, as according to Gomes and Golino (2012), who indicated fluid intelligence as a factor responsible for 34,34% of arithmetic success. The contributions of this study can help understand the factors that influence the presence of MA. It was observed that significant differences in MA did not accompany the difference in intelligence. Studies on MA and arithmetical performance seek answers on the emotional and motivational dimensions of learning in mathematics (Barroso et al., 2020). Another contribution was the observation of how the variables of working memory and inhibitory control differ in groups with typical and atypical intelligence scores. These findings help the school context since they make it possible to map the most significant difficulties encountered and help education professionals outline more effective teaching strategies, promoting improved children's learning (Haase et al., 2020).

It is essential to consider the study's limitations due to the small number of participants selected for convenience. It would be interesting to evaluate more information about the development profile of children with low intelligence scores in future studies. It is also important to note that a diagnostic evaluation was not made. Only the Raven's Colored Progressive Matrices test was used to assess fluid intelligence, not considering environmental variables such as adaptative functioning.

However, it is possible to observe the importance of detailed assessment of these children with below-average performance in the intelligence test to detect if they have signs that cover clinical conditions such as Disorder of Intellectual Development and support appropriate models of teaching mathematics. Despite any diagnosis, the group that had lower scores in intelligence tests deserves stimulation, guidance, and monitoring of the family appropriately, and the possibility of strategies to be applied by the school. These are essential aspects to be considered in future research on the theme.

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