Gender, general anxiety, math anxiety and math achievement in early school-age children

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Math anxiety is considered a predictor of mathematical achievement, but little is known about its characteristics in young children. In a longitudinal study of first to second grade children, the relationships between gender, general and math anxiety, and math achievement were tested. First, the results indicate that girls in comparison to boys have a higher level of general anxiety and that gender gap in math anxiety is affected by various types of math anxiety. Girls exceed boys in testing and total scores of math anxiety, however, no gender differences in learning math anxiety and math achievement in the first and second years were observed. Secondly, the full mediation effect of general anxiety in the relationship between gender and math anxiety was observed in first- and second-graders. Finally, the relationship between math anxiety and mathematical achievement in first and second grade children was tested, and the results depend on grade, gender, type of math anxiety and the level of general anxiety.

Introduction

Although having a high level of mathematical skills is desirable in contemporary societies (European Parliament and the Council of European Union, 2006; Gonzalez & Kuenzi, 2012; Holmlund, Lesseig & Slavit, 2018), many students find mathematics difficult (Dowker, Sarkar & Looi, 2016; Geist, 2010; Maloney & Beilock, 2012). One of the predictors of maths achievement in children, adolescents, and adults is maths anxiety. It is defined as "[...] a feeling of tension and anxiety that interferes with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (Haase, Guimarães & Wood, 2019; Richardson & Suinn, 1972, p. 551). Despite the fact that studies on math anxiety started around sixty years ago (Dowker et al., 2016), research into math anxiety in early school-age children only began relatively recently (Geist, 2010).

Studies conducted on young children mostly concerned the intensity and development of their math anxiety (Harari, Vukovic & Bailey, 2013; Hill, Mammarella, Devine, Caviola Passolunghi & Szűcs, 2016; Vukovic, Kieffer, Bailey & Harari, 2013), the specificity of math anxiety (Szczygieł, 2020; Young, Wu & Menon, 2012), its measurement (Carey, Hill, Devine & Szűcs, 2017; Ganley & McGraw, 2016; Szczygieł, 2019), and the relationship between math anxiety and mathematical performance (Cargnelutti, Tomasetto & Passolunghi, 2016; Gierl & Bisanz, 1995; Harari et al., 2013; Krinzinger, Kaufmann & Willmes, 2009; Ramirez, Chang, Maloney, Levine & Beilock, 2016; Ramirez, Gunderson, Levine & Beilock, 2013; Vukovic et al., 2013; Wu, Barth, Amin, Malcarne & Menon, 2012). There is less research on gender differences in the level of math anxiety and on the relationship between math anxiety and math performance in early school-age children (Hill et al., 2016; Van Mier, Schleepen & Van den Berg, 2019).

Studies conducted among secondary school learners and adults have mostly shown that females have a higher level of math anxiety than males (Núñez-Peña, Suárez-Pellicioni & Bono, 2016). However, other researchers observed no gender gap in this regard (Birgin, Baloglu, Catlioglu & Gurbuz, 2010; Ma & Xu, 2004; Newstead, 1995, 1998). Similar results have been observed in elementary school children. Girls exhibited a higher level of math anxiety than boys in some studies (Carey et al., 2017; Griggs, Rimm-Kaufman, Merritt & Patton, 2013; Hill et al., 2016; Szczygieł, 2019), but a lack of gender differences was observed in other studies (Gierl & Bisanz, 1995; Harari et al., 2013; Kucian et al., 2018; Ramirez et al., 2013; Young et al., 2012). Existing gender differences in the level of math anxiety are usually explained by the age of the children (Hembree, 1990), the type of math anxiety (Devine et al., 2012), teaching methods (Finlayson, 2014), and math stereotypes (Beilock, Gunderson, Ramirez & Levine, 2010).

An alternative and probably so far untested explanation may be that the higher level of math anxiety in females in comparison to males results from gender differences in their levels of general anxiety. General anxiety, defined as an individual's disposition to worry about a number of different things, events, behaviours, and competences (Spence, 1997), similarly to math anxiety is more intense in females than in males (Hill et al., 2016; Núñez-Peña et al., 2016; Zalta & Chambless, 2012). General anxiety may explain the gender gap in math anxiety, especially among early school-age children who have little experience with mathematics. Although young children are relatively inexperienced in mathematics, there are many studies that indicate that some math anxiety is already present (Carey et al., 2017; Cargnelutti et al., 2016; Ganley & McGraw, 2016; Gierl & Bisanz, 1995; Harari et al., 2013; Hill et al, 2016; Krinzinger et al., 2009; Ramirez et al., 2013, 2016; Szczygieł, 2019; Vukovic et al., 2013; Wu et al., 2012; Young et al., 2012). Therefore, it can be assumed that math anxiety is primarily determined by a predisposition to being anxious in young children (Baloğlu & Kocak, 2006; Carey et al., 2017; Dew, Galassi & Galassi, 1983; Hembree, 1990). Nevertheless, gender was not considered in previous studies when analysing the relationship between general anxiety and math anxiety in young children. Despite this, it is very likely that gender differences in math anxiety result from the gender gap in levels of general anxiety (Ganley & McGraw, 2016). Therefore, it can be assumed that general anxiety mediates the relationship between gender and math anxiety in young children.

Although researchers have found no significant gender differences in math achievement (Beilock et al., 2010; Dokwer et al., 2012; Hill et al., 2016; Ho et al., 2000; Hyde, Lindberg, Linn, Ellis & Williams, 2008; Van Mier et al., 2019), a gender gap has been observed in the relationship between math anxiety and math achievement, and contradictory findings on the nature of gender differences have been reported. On the one hand, it was found that levels of math anxiety correlate with mathematical performance in males but not in females (Hembree, 1990; Miller & Bichsel, 2004). On the other hand, it has been observed that the relationship between math anxiety and math performance is significant and negative for girls but not for boys (Betz, 1978; Erturan & Jansen, 2015; Hill et al., 2016; Schleepen & Van Mier, 2016; Van Mier et al., 2019). In addition, Betz (1978) indicated that when a more complex mathematical course was considered, no gender gap in the relationship between math anxiety and math performance was observed. A lack of gender

differences was also noted by Sepie and Keeling (1978) and Meece, Wigfield and Eccles (1990).

Moreover, it has been indicated that gender differences in the relationship between math anxiety and math achievement occur even if the level of test anxiety is controlled for (Devine et al., 2012; Van Mier et al., 2019). I am aware only one study (Hill et al., 2016) tested the relationship between math anxiety and math achievement in girls and boys; this revealed no correlation in primary children when general anxiety was controlled for, and a significant correlation in secondary school-age girls and boys. Therefore, it is worth bearing in mind that if there is no correlation at the educational stage, similar results should be observed among children starting school. Children in the first and second grade have little experience with math, so general anxiety should largely explain the relationship between math anxiety and math achievement if such a relationship exists. Thus, it is interesting to consider whether the relationship between math anxiety and math achievement in girls and boys is significant when general anxiety as a potential predisposition to the development of math anxiety is controlled for. It may be expected that the strength of the relationship between math anxiety and math achievement in girls and boys is affected by the level of general anxiety and, as a result, the strength of this relationship is weaker or disappears when general anxiety is controlled for. Assuming that math anxiety is moderately or strongly correlated with general anxiety (Hill et al., 2016), the strength of the relationship between math anxiety and math performance should decrease but not disappear altogether (Devine et al., 2012; Hill et al., 2016; Van Mier et al., 2019).

The findings that concern the role of gender and test/general anxiety may explain why the correlation between math anxiety and math achievement was observed in some studies in early school-age children (Aarnos & Perkkila, 2012; Cargnelutti et al., 2017; Caviola, Piri, Chiesi & Mammarella, 2017; Kucian et al., 2018; Wu et al., 2012), but not in other studies (Cargnelutti et al., 2017; Krinzinger et al., 2009; Thomas & Dowker, 2000). It can be assumed that the disparity between results was influenced by the size of the groups of girls and boys, and the significance and strength of the relationship between math anxiety and math achievement might have differed if gender had been included in the analysis. Therefore, it is likely that the significance and the strength of the relationship between math anxiety and math achievement is a result of gender-related variables such as the level of test anxiety (Ganley & McGraw, 2016) and the level of general anxiety (Hill et al., 2016).

Since little is known about the relationship between gender, general anxiety, math anxiety, and math performance in children starting school, these relationships were tested in the current longitudinal study. First, it was checked whether there are gender differences in general anxiety, math anxiety, and math achievement in first and second grade children. It was assumed that girls have a higher level of general anxiety and math anxiety, but there is no gender gap in math achievement. Then, whether there is a mediation effect of general anxiety in the relationship between gender and math anxiety in both grades was investigated. It was expected that general anxiety would mediate the relationship between gender and math anxiety: gender affects the level of general anxiety, and general anxiety

positively predicts math anxiety. Subsequently, the relationship between math anxiety and math achievement was tested for the whole group and separately for girls and boys in the first and second grades. Finally, the correlation between math anxiety and math achievement was tested when general anxiety was controlled for. The hypothesis was that a negative, weak relationship between math anxiety and math achievement would be observed and that the correlation would be weaker when general anxiety was controlled for. Moreover, it was assumed that gender differences might appear in the relationship between math anxiety and math achievement (especially when general anxiety is a covariate). The longitudinal plan of study was applied to observe whether there are any differences in the results that stem from the grade year. The longitudinal research makes it possible to control individual differences between children when the comparison of results obtained in different grade years is made (Caruana, Roman, Hernández-Sánchez & Solli, 2015).

Method

Participants

The longitudinal study was started in the first grade with 369 children (205 girls, 164 boys). The number of children tested in the second grade fell as some children were temporarily absent from school or had left the school. At the end of the first grade, children were aged 7 years 8 months (SD = 0.41; range = 6.6–8.7); in the second grade, they were one year older. The study was carried out in primary public schools in Krakow (Poland); all children received written permission to participate in the study from their parents.

Materials

Math anxiety

Children's math anxiety was measured using the modified *Abbreviated Math Anxiety Scale for Elementary Children* (mAMAS-E, Szczygieł, 2019). This is a nine-item scale based on mAMAS (Carey et al., 2017) and it consists of two subscales: testing and learning math anxiety. The researcher asked the children about levels of math anxiety in accordance with the nine-item scale and children stated whether they felt anxiety in various situations (yes, a little, no). The total score in the mAMAS-E ranged from 0 to 18 points (0-10 testing score, 0-8 learning score). The reliability of the scale was calculated by Cronbach's α and is .73 (at the end of the first grade) and .76 (at the end of the second grade).

General anxiety

The shortened version of the *Revised Children's Manifest Anxiety Scale* (Reynolds & Richmond, 1978; Stark & Laurent, 2001) was used as a measure of children's general anxiety. The sRCMS is a seven-item questionnaire with a yes/no answer scale. The minimum and maximum scores are 0 and 14 points respectively. The reliability of the scale is α = .72 (at the end of the first grade) and α = .70 (at the end of the second grade).

Math achievement

Mathematical achievement was measured by tasks prepared according to the core curriculum for primary schools and with regard to the mathematical education materials recommended by the Ministry of Education in Poland. The following topics were tested in the first grade: knowledge of numbers, counting, addition and subtraction, discovering rules, knowledge of money, knowledge of geometric figures, reading a tape measure. The following topics were tested in the second grade: addition and subtraction, multiplication and division, reading a tape measure, spatial orientation, discovering rules, clock reading. The mathematical tasks were written on an A4 sheet of paper and the children solved the mathematical tasks themselves. However, to eliminate the impact of reading skills on their mathematical performance, the researcher read the instructions aloud. The average time for solving tasks was around 30 minutes. The score in the mathematical tasks ranged from 0 to 36 points. The level of difficulty in the mathematical tests can be referred to as 'easy' or 'moderately difficult' (.77 for first grade; .71 for second grade; Janowicz, 2017).

Procedure

Approval was obtained from the Scientific Research Ethics Committee of the Institute of Psychology of Jagiellonian University of Krakow, from the head of each school, and from children's parents. The presented results are a part of a longitudinal study that began with the first grade and is still in progress. The presented data were collected in May-June 2018 (the end of the first grade) and in May-June 2019 (the end of the second grade). The study was conducted by seven trained research assistants. Each child was examined individually by one researcher. Children were informed about the purpose of the study and assured of the possibility of withdrawing from the study at any time, or choosing not to answer any question they wanted to avoid. All instructions were read aloud by the researcher. The children's answers in the general anxiety and math anxiety questionnaires were marked on the response forms by the researcher, and the children themselves completed the mathematical test. The average time of meetings was approximately 30 minutes per child.

Analysis

The descriptive statistics, correlation analysis, and group comparisons were prepared in *PS IMAGO PRO 5.1*. The effect size was calculated using a calculator (Lenhard & Lenhard, 2016) and the interpretation was performed in accordance with Dunst & Hamby (2012). The mediation analysis was tested in the *R lavaan* and *mediation* packages (Rosseel, 2012; Tingley, Yamamoto, Hirose, Keele & Imai, 2014). The model's fit was interpreted according to Browne & Cudeck (1993), Hu & Bentler (1999), and Kline (2016). Before performing each analysis, the assumptions for the test were checked.

Results

Descriptive statistics

The results (see Table 1) indicate that first grade children are moderately anxious, feel weak math anxiety, and achieve rather a high result in the mathematical test. Second

graders are characterised by weak general anxiety, weak math anxiety, and received a moderate result in the mathematical test. Although the measured variables slightly deviate from the normal distribution, non-normality was especially observed in math anxiety. The distribution of total, testing, and learning math anxiety in the first and second grade is a right-skewed distribution. The results in general anxiety and math achievement are close to normal distribution.

Table 1: Descriptive statistics

		N	*M*	*SD*	Min	Max	Skewness	Kurtosis	*W*
Grade 1	GA	297	5.64	3.50	0	14	.41	-.78	.95, $p < .001$
	MA	311	2.77	3.00	0	15	1.34	1.79	.85, $p < .001$
	MA-T	311	1.93	2.06	0	8	.98	.15	.85, $p < .001$
	MA-L	311	0.84	1.44	0	8	2.16	5.17	.64, $p < .001$
	MATH	316	47.12	7.68	22	60.5	-.69	-.06	.96, $p < .001$
Grade 2	GA	204	4.85	3.28	0	14	.49	-.61	.95, $p < .001$
	MA	263	3.76	3.41	0	15	.86	.18	.90, $p < .001$
	MA-T	263	2.50	2.22	0	8	.61	-.61	.90, $p < .001$
	MA-L	263	1.26	1.70	0	7	.15	1.74	.76, $p < .001$
	MATH	263	42.50	9.92	12	62	-.54	-.23	.97, $p < .001$

GA – general anxiety; MA – math anxiety; MA-T – testing math anxiety; MA-L – learning math anxiety; MATH – mathematical achievement; *W* – Shapiro-Wilk test.

Table 2: Gender differences in general anxiety, math anxiety, and math achievement

	Grade 1: Mean (*SD*)		Grade 2: Mean (*SD*)	
	Girls	Boys	Girls	Boys
GA	6.18 (3.62)	5.17 (3.36)	5.41 (3.10)	4.32 (3.38)
	$t_{(295)} = -2.50$; $p < .05$; $d = .29$		$t_{(202)} = -2.40$; $p < .05$; $d = .34$	
MA	3.21 (3.18)	2.37 (2.79)	4.33 (3.48)	3.23 (3.27)
	$t_{(309)} = -2.48$; $p < .05$; $d = .28$		$t_{(261)} = -2.64$; $p < .01$; $d = .33$	
MA-T	2.36 (2.26)	1.55 (1.78)	2.94 (2.27)	2.10 (2.10)
	$t_{(309)} = -3.54$; $p < .001$; $d = .40$		$t_{(261)} = -3.09$; $p < .05$; $d = .35$	
MA-L	.85 (1.47)	.82 (1.41)	1.40 (1.81)	1.13 (1.58)
	$t_{(309)} = -.18$; $p = .86$; $d = .02$		$t_{(261)} = -1.27$; $p = .21$; $d = .16$	
MATH	46.46 (7.64)	47.73 (7.68)	41.51 (10.15)	43.41 (9.65)
	$t_{(314)} = 1.47$; $p = .14$; $d = .17$		$t_{(261)} = 1.53$; $p = .12$; $d = .19$	

Note: GA – general anxiety; MA – math anxiety; MA-T – testing math anxiety;
MA-L – learning math anxiety; MATH – mathematical achievement;
d – effect size calculated by Cohen method;
Grade 1: *N* = 163 – 166 girls, 147 – 150 boys; Grade 2: *N* = 105 – 137 girls, 99 – 126 boys.

Gender differences in general anxiety, math anxiety, and math achievement

The next stage of the analysis was to check whether there are gender differences in general anxiety, math anxiety (total, testing, and learning scores), and math achievement in first and second graders (see Table 2). A series of independent samples *t*-tests was performed. The results indicate that girls exceed boys in levels of general anxiety and total and testing math anxiety in the first and second grade. The effect size calculated by Cohen's *d* indicates that the gender differences are small. A lack of gender differences in the first and second grade was observed in anxiety related to learning math and in mathematical achievement (the size of the effect is negligible).

The mediation mechanism of gender differences in math anxiety

To check whether general anxiety mediates the relationship between gender and math anxiety in first and second graders, mediation analysis was performed (Figure 1).

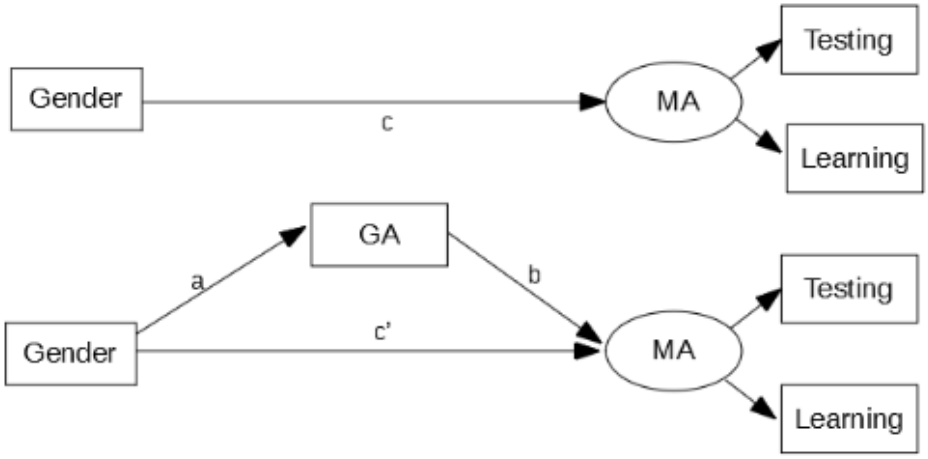

Figure 1: Theoretical mediation model for the relationship between gender, general anxiety, and math anxiety in first and second grade children; GA – general anxiety; MA – math anxiety.

Table 3: Direct and indirect effect of gender on math anxiety

Grade	Predictor	Mediator	Output	Standardised coefficient					*N*	Model fit			
				a	b	c	c'	Tot.		χ^2	CFI	RMSEA	SRMR
1	Gender	GA	MA	-.14 *	.71 ***	-.08	-.10 *	.49 ***	310	$\chi^2_{(1)}$= 9.23; p < .01	.96	.15	.04
2	Gender	GA	MA	-.17 *	.45 ***	-.16	-.07 *	.12 *	204	$\chi^2_{(1)}$= 5.16; p = .02	.96	.14	.03

Note: * p < .05, ** p < .01, *** p < .001;
GA – general anxiety; MA – math anxiety latent variable constructed by MA-T and MA-L; c – direct effect; c' – indirect effect.

Neither of the tested models (Table 3) obtained the required χ^2 value; however, the fit indices for the model were very good. In the first and second grades, the results were similar. It was possible to observe the full mediation effect of general anxiety in the relationship between gender and math anxiety. Gender determines the differences in general anxiety and, in turn, general anxiety strongly predicts math anxiety.

Relationships between general anxiety, math anxiety, and math achievement

To check whether general anxiety and math anxiety correlate with math achievement and whether there are gender differences in the tested relationships, a series of Pearson's *r* tests was performed (Table 4).

Table 4: Matrix of correlations

		GA	MA	MA-T	MA-L	MATH
Children	GA	-	.59***	.54***	.46***	.03
	MA	.41***	-	.91***	.80***	-.12*
	MA-T	.37***	.90***	-	.46***	-14*
	MA-L	.33***	.83***	.52***	-	-.04
	MATH	-.17*	-.30***	-.25***	-.27***	-
Girls	GA	-	.59***	.52***	.49***	.03
	MA	.36***	-	.91***	.77***	-.01
	MA-T	.29***	.90***	-	.43***	-.04
	MA-L	.33***	.81***	.81***	-	-.05
	MATH	-.16	-.24***	-.18*	-.24***	-
Boys	GA	-	.57***	.55***	44***	.05
	MA	.42***	-	.90***	.84***	-.21**
	MA-T	.41***	.92***	-	.53***	-.23**
	MA-L	.32***	.85***	.56***	-	-.13
	MATH	-.15	-.33***	-.30***	-.29***	-

Note: * $p < .05$, ** $p < .01$, *** $p < .001$;
GA – general anxiety, MA – math anxiety, MA-T – testing math anxiety, MA-L – learning math anxiety, MATH – mathematical achievement; Grade 1 (*N*): children = 308–316, boys = 163–166, girls = 145–150; Grade 2 (*N*): children = 204–263, boys = 105–137, girls = 99–126. Correlations for grade 1 are above the diagonal, and correlations for grade 2 are below the diagonal.

The results for all first-grade children show that total and testing math anxiety is weakly and negatively related to math achievement, while learning math anxiety and general anxiety are not related to math achievement. The same relationship direction was observed in the first-grade boys; however, the strength of the significant relationships for boys, in comparison to the whole group, is greater. In the first-grade girls, no relationship between general anxiety, total, testing and learning math anxiety and math achievement was found.

Among all second-graders, a negative and weak relationship between general anxiety and math achievement was observed, and negative and moderate correlations between total, testing and learning math anxiety and math achievement were found. The lack of a

relationship between general anxiety and math achievement was observed when the results were analysed separately for girls and boys. In girls and boys, there were negative correlations between total, testing, and learning math anxiety and math achievement. Nevertheless, the relationships were stronger in boys (moderate) compared to girls (weak).

To check whether math anxiety correlates with math achievement in first and second grade children when general anxiety is controlled for, partial correlation analyses were conducted (Table 5).

Table 5: Matrix of partial correlations (general anxiety as a covariate)

		MA	MA-T	MA-L	MATH
Children	MA	-	.86***	.73***	-.16**
	MA-T	.89***	-	.29***	-.19**
	MA-L	.81***	.45***	-	-.06
	MATH	-.22**	-.18*	-.21*	-
Girls	MA	-	.87***	.68***	-.03
	MA-T	.89***	-	.24***	-.07
	MA-L	.79***	.43***	-	.05
	MATH	-.16	-.12	-.16	-
Boys	MA	-	.86***	.80***	-.29***
	MA-T	.89***	-	.38***	-.31***
	MA-L	.84***	.49***	-	-.16*
	MATH	-.28**	-.23*	-.26**	-

Note: * $p < .05$, ** $p < .01$, *** $p < .001$;
MA – math anxiety, MA-T – testing math anxiety, MA-L – learning math anxiety, MATH – mathematical achievement; Grade 1 (*N*): children = 305, boys = 160, girls = 142; Grade 2 (*N*): children = 201, boys = 102, girls = 96. Correlations for grade 1 are above the diagonal, and correlations for grade 2 are below the diagonal.

The results show that total and testing math anxiety in first grade children negatively and weakly correlates with math achievement. No relationship was found between learning math anxiety and math achievement for first-graders. When the scores are analysed separately for girls and boys, negative and weak to moderate relationships between total, testing, learning math anxiety and math achievement are observed for boys, and a lack of correlations is noted for girls.

In children from the second grade, negative and weak relationships were observed between total, testing, and learning math anxiety and math achievement. When analysing the results by gender, it can be seen that there are negative and weak to moderate relationships between math anxiety and math achievement in boys, and there are no relationships in girls.

Discussion

The study was conducted to fill the gap in the knowledge about the relationships between gender, general anxiety, math anxiety, and math achievement in early school-age children.

Although the amount of research on math anxiety in these children has increased in recent years, little is known about gender differences in the domain of math anxiety. The findings on the gender gap in math anxiety among children were contradictory. Some of the previous studies in children showed that girls exceed boys in the level of math anxiety (Carey et al., 2017; Hill et al., 2016), but others do not (Ganley & McGraw, 2016; Gierl & Bisanz 1995; Harari et al., 2013; Krinzinger et al., 2009; Kucian et al., 2018; Ramirez et al., 2013; Young et al., 2012). The obtained results show that in comparison to boys, girls have a higher level of total and testing math anxiety, although no gender difference was noted in learning math anxiety. Therefore, it seems that the gender gap in math anxiety is affected by the type of math anxiety. Being tested in math triggers stronger anxiety in girls than in boys, but when children learn math, they feel a similar level of anxiety. It is likely that early school-age girls feel stronger anxiety related to testing math than boys because they generally feel a higher level of test anxiety and general anxiety (Cargnelutti et al., 2013; Ganley & McGraw, 2016; Hill et al., 2016; Van Mier et al., 2019).

Moreover, if girls have a higher level of general anxiety, it is very possible that general anxiety mediates the relationship between gender and math anxiety. Indeed, in the conducted study the girls had a higher level of general anxiety than boys did, and the full mediation effect of general anxiety in the relationship between gender and math anxiety was observed. This means that gender differences in anxiety related to math may be explained by girls' predisposition to feeling a higher level of general anxiety than boys do. These results explain why there is a gender gap in math anxiety despite the relatively low level of math anxiety in early school-age children. The results are consistent with the observation that gender differences in math anxiety occur until general anxiety is taken into account (Ganley & McGraw, 2016). This study has shown that math anxiety may be explained in terms of general anxiety, especially in groups of children starting school. The results also undermine the hypothesis concerning the role of avoiding mathematics as a reason for math anxiety (Ma & Xu, 2004); moreover, they indicate the significance of general anxiety and gender as important variables that explain the appearance of math anxiety.

The other purpose of the study was to determine gender differences in math achievement and the relationship between math anxiety and math achievement. In accordance with the assumptions, a lack of gender difference in mathematical achievement was noted (Beilock et al., 2010; Dowker et al., 2012; Hill et al., 2016; Ho et al., 2000; Hyde, Fennema & Lamon, 1990; Hyde et al., 2008). Instead, the gender gap was observed in the relationship between math anxiety and math performance. Math anxiety was not correlated with math performance in girls in the first grade, but math anxiety affects girls' math achievement in the second grade. In boys, a negative correlation between math achievement and math anxiety was observed in both first (except for learning math anxiety), and second grade. The studies conducted in older children, adolescents and adults showed correlations only in females (Betz, 1978; Erturan & Jansen, 2015; Hill et al., 2016; Schleepen & Van Mier, 2016; Van Mier et al., 2019), only in males (Hembree, 1990; Miller & Bichsel, 2004), or in both (Meece et al., 1990; Sepie & Keeling, 1978). This suggests the occurrence of some factors that influence the relationship between gender, math anxiety, and math achievement. The level of math anxiety of girls correlates with math achievement in first

grade but not in second grade. Moreover, math anxiety in boys correlates with math achievement more strongly in second grade than in first grade. Therefore, it is likely that teaching methods (Finlayson, 2014) or the complexity of mathematical tasks (Betz, 1978) are responsible for intensifying the level of math anxiety. As the level of difficulty of the mathematical tasks in first and second grade is similar, it would seem that other factors such as teaching methods are responsible for the increase in math anxiety and the deepening of the relationship between math anxiety and math achievement (Finlayson, 2014).

Not only may teaching methods explain the grade differences in the tested relationship, but it is also known that the relationship between math anxiety and math achievement changes when test anxiety (Devine et al., 2012; Van Mier et al., 2019) and general anxiety are controlled for (Ganley & McGrow, 2016; Hill et al., 2016). In the conducted study, it was shown that no relationship between math anxiety and math achievement was observed in girls, but a weak to moderate negative correlation occurred in boys. Therefore, it may be concluded that despite the higher levels of math anxiety in girls, the detrimental effect of math anxiety is stronger in boys. Indeed, the mathematical performance of boys in comparison to girls is more affected by math anxiety (Eden, Heine, & Jacobs, 2013). Where does this result come from? Girls are more prone to talking about their emotions (Ashcraft & Ridley, 2005) and it is probably the case that girls talk about their math anxiety more than boys do; this alleviates worrisome thoughts related to math and results in better math performance (Eysenck & Calvo, 1992; Eysenck, Derakshan, Santos & Calvo, 2007; Ramirez et al., 2013). Boys' stories about math anxiety are less socially acceptable than similar stories told by girls (Devine et al., 2012). Consequently, girls have more occasions to develop constructive strategies to deal with anxiety in comparison to boys. Finally, boys may also feel more pressure from teachers and parents to achieve the highest results in mathematics. It is possible that this issue is also dependent on cultural differences (Brown, Ortiz-Padilla & Soto-Varela, 2020).

Since research on the relationships between gender, general anxiety, various types of math anxiety and math achievement is very limited, it is important in the future to carry out similar research that takes into account different cultural backgrounds. Moreover, it cannot be ruled out that the results might depend on the type of mathematical task, the teaching methods used, and the various math-related expectations that are addressed to girls and boys. Indeed, it is possible that the results can be explained by the high demands placed on boys in comparison to girls and in accordance to the widespread stereotype shared by elementary teachers that boys have greater math potential than girls (Niederle & Vesterlund, 2010).

Finally, it should be noted what teachers and parents can do to help girls and boys to overcome math anxiety and achieve high math results. As the previous results suggest, different motivating strategies should be applied for girls and boys to alleviate math anxiety (Milovanović, 2020). Obtained results confirm that in the case of girls, different actions should be undertaken than in the case of boys. The level of general anxiety underlies girls' math anxiety and the relationship between math anxiety and achievements, therefore the intervention should be directed to a reduction of general anxiety. Although

both general and math anxiety are genetically determined (Wang et al., 2014), teachers and parents create a learning environment that strengthens children's general and math anxiety or reduces it. Therefore, despite it being a truism, creating friendly math learning conditions may result in girls' lower math anxiety and higher math achievement (Beilock & Willingham, 2014). Moreover, girls should have the opportunity to talk about their emotions toward math because it reduces worrisome thoughts and in turn enhances math outcomes (Ashcraft & Ridley, 2005; Beilock & Willingham, 2014).

The main objective of helping boys should be the reduction of the harmful effect of math anxiety on math achievement. Results show that boys have lower math anxiety than girls, but it is not known whether these results are an effect of the fact that boys don't report anxiety because of social reasons or whether they reflect real intensity of boys' anxiety. On the assumption that boys internalise teachers' and parents' stereotypical expectations according to which they should, in comparison to girls, have better math outcomes and lower math anxiety, it may be demanding and time-consuming to help boys to overcome math anxiety. This situation is caused by stereotypes which are deeply rooted in social systems and reproduced from generation to generation. Nevertheless, one of the recommendations is not to put pressure on boys about their results and to encourage them to express their feelings about math problem solving, math class, grades, etc. (Devine et al., 2012).

Conclusion

It is important to examine young children for math anxiety in order to prevent its development and the life-long negative consequences it can have. Diagnosis should be performed in both girls and boys at early school age. Young girls have higher levels of general anxiety as well as total and testing math anxiety than boys do, but this study found no gender gap in learning math anxiety and math achievement. However, gender differences in math anxiety can be fully explained by the level of children's general anxiety. With regard to the effect of math anxiety on math achievement when children start school, girls do not suffer the negative results of math anxiety on mathematical performance, but its detrimental effect can already be seen in the second grade of primary school. However, if girls' level of general anxiety is controlled for, the correlation disappears. Boys, regardless of the level of general anxiety, lose more than girls in mathematical performance due to math anxiety. Therefore, although early school-age girls exceed boys in the level of math anxiety, its detrimental effect is observed primarily in boys.

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