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Arithmetic Word Problem-Solving and Math Anxiety: The Role of Perceived Difficulty and Gender

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ABSTRACT

A crucial component of mathematics curriculum in primary education is represented by the ability to solve arithmetic word problems. Previous studies investigated predominantly the cognitive factors underlying this skill, neglecting the role of emotional (e.g. math anxiety – MA) and metacognitive aspects (e.g. perceived difficulty). Some findings suggested that emotional factors could influence perceived task difficulty which would, in turn, impair students' performance. However, the relation between MA, perceived difficulty, and math problem-solving has not been explored yet. Moreover, although many studies reported gender differences in MA levels, findings involving primary school children are contrasting. Thus, this study aimed to evaluate the role of MA and perceived task difficulty on arithmetic word problem-solving proficiency in a sample of Italian primary school students, and to investigate gender differences in those variables. Results showed that MA had a direct and indirect effect through perceived difficulty on problem-solving performance. Furthermore, findings confirmed that girls exhibited higher MA levels, however no gender difference was observed in problem-solving accuracy nor in perceived difficulty. The study underlines the need to consider emotional factors when investigating children's difficulties in math problem-solving and highlight the importance of MA interventions, especially for girls, already in primary education.

A crucial part of math school curriculum at all levels of education, starting from primary school onward, is represented by the ability to solve arithmetic word problems (Daroczy, Wolska, Meurers, & Nuerk, 2015). These represent a fundamental learning activity since they prepare students to apply mathematical notions to real-world situations (Pongsakdi et al., 2020; Swanson & Fung, 2016). However, many students from primary school through adulthood struggle with this type of math task (Daroczy, Wolska, Meurers, & Nuerk, 2015; Hegarty, Mayer, & Green, 1992; Lewis & Mayer, 1987; Verschaffel, De Corte, & Pauwels, 1992). Therefore, it is essential to investigate the underlying facilitating and debilitating factors affecting arithmetic word problem-solving ability.

Previous studies involving primary school children have focused greatly on cognitive abilities intervening in the process of arithmetic problem-solving (Fuchs, Gilbert, Fuchs, Seethaler, & Martin, 2018; Fung & Swanson, 2017; Mori & Okamoto, 2016; Passolunghi et al., 2022; Peng, Namkung, Barnes, & Sun, 2016; Wang, Fuchs, & Fuchs, 2016), neglecting

the influence of emotional and motivational aspects (Hoffman, 2010). Among these factors, math anxiety (MA) has been widely recognized to negatively impact students' general math achievement (see Namkung, Peng, & Lin, 2019). Nevertheless, far less is known about the specific relation between MA and arithmetic problem-solving proficiency and relatively few studies (e.g., Lai, Zhu, Chen, & Li, 2015; Passolunghi, Cargnelutti, & Pellizzoni, 2019; Ramirez, Chang, Maloney, Levine, & Beilock, 2016; Ramirez, Gunderson, Levine, & Beilock, 2013) investigated the abovementioned association in primary school children. Moreover, prior findings suggest that emotional aspects can influence perceptions of task difficulty: students with positive mood during a word problem-solving task are more likely to feel optimistic and to perceive the task as less difficult than students with negative affect (Efklides & Petkaki, 2005) and high evaluations of task difficulty are then related to lower performance (Nuutila, Tapola, Tuominen, Molnár, & Niemivirta, 2021). However, literature on perceived task difficulty is still very limited and, to the best of our knowledge, no study has examined the influence of MA on perceived task difficulty and children's arithmetic word problem-solving. Additionally, although several studies have shown that females are more prone to MA manifestation (e.g., Xie, Xin, Chen, & Zhang, 2019), it is not clear whether this gender difference is present also among school-age children (e.g., Dowker, Bennett, & Smith, 2012; Hill et al., 2016).

Hence, the overall aim of the present work was to address these shortcomings by evaluating the links between MA, perceived task difficulty, and arithmetic word problem-solving proficiency in a sample of primary school children, and by examining gender differences in these constructs. Such understanding can provide novel theoretical insight into the mechanisms through which MA affect problem-solving resolution and offer some practical guidance for those children who struggle with math problem-solving.

Arithmetic word problem-solving

Arithmetic word problems are defined as a particular type of arithmetic problems presented in a short narrative notation (Verschaffel, Greer, & De Corte, 2000). From a cognitive point of view, solving arithmetic word problems is a complex activity (Duque de Blas, Gómez-Veiga, & García-Madruga, 2021), as the complete process involves several phases (Mayer & Hegarty, 1996) and various cognitive abilities (e.g., nonverbal reasoning, reading comprehension, working memory, executive functions; Lin, 2021; Passolunghi et al., 2022). For successful problem-solving, individuals need to understand the problem text, translate each sentence into an internal representation of the problem situation, integrate, and detect relevant information, plan the mathematical procedure they are willing to apply, and finally execute the necessary arithmetical computations (Lewis & Mayer, 1987).

It must be noted that several different types of word problems exist. Riley, Greeno, and Heller (1983) identified three types of simple arithmetic word problems that are frequently offered in primary education: combine, change, and compare problems. In the present study, we focused on compare problems, which contain a relational term (e.g., more than, less than) that compares the numerical values of two variables. Based on the semantic of the relational term, we can distinguish two subtypes of compare problems (Hegarty, Mayer, & Green, 1992): consistent and inconsistent problems. In consistent problems (e.g., "Susan has 8 pencils. Michael has 5 pencils more than Susan. How many pencils does Michael have?"), the relational term (e.g., more than) is semantically coherent or consistent with the

arithmetic operation required to find the solution (e.g., addition). In inconsistent problems (e.g., “Susan has 8 pencils. She has 5 pencils more than Michael. How many pencils does Michael have?”), the relational term is semantically incoherent with the arithmetic operation (i.e., subtraction). The investigation of compare word problems is particularly important, since students exhibit significantly more difficulties with these problems than with other types although the corresponding math is similar (Boonen & Jolles, 2015; Giroux & Ste-Marie, 2001; Riley & Greeno, 1988; Schumacher & Fuchs, 2012; Stern, 1993).

Math anxiety

Mathematics and arithmetic word problem-solving depend not only on cognitive abilities but also on emotional factors. Among these, math anxiety has been recognized to play a significant role (Dowker, Bennett, & Smith, 2012). MA is a specific emotional response defined as a feeling of tension and anxiety that interferes with the execution of tasks involving numbers, not only in the academic context but also in everyday life situations (Richardson & Suinn, 1972). In literature, MA is both conceptualized as a trait or state construct (Cipora et al., 2022) reflecting different understandings of MA. It has been largely proven that trait MA has a detrimental effect on mathematical achievement: high levels of MA are linked to low math performance (for a review see, Barroso et al., 2021).

Although the modulating role of MA on math abilities has been extensively studied, mathematics is a heterogeneous school subject and each area of mathematics requires different combinations of skills (Dehaene, 1992; LeFevre et al., 2010) and could be differently affected by the same emotional response (Zhang, Zhao, & Kong, 2019). Previous research has mostly focused on investigating the effects of MA on general math achievement or on different arithmetical and computational tasks (e.g., Harari, Vukovic, & Bailey, 2013; Hill et al., 2016; Lee & Cho, 2018; Passolunghi, Caviola, De Agostini, Perin, & Mammarella, 2016), while much less attention has been paid to arithmetic word problem-solving activities (e.g., Kytälä & Björn, 2014; Passolunghi, Cargnelutti, & Pellizzoni, 2019). Recent studies have furtherly suggested that the relation between MA and math performance differs based on which aspect of mathematics is being evaluated (Caviola et al., 2022). In particular, MA seems to strongly impair the accuracy of mathematical reasoning tasks that involve complex cognitive skills (Wu, Barth, Amin, Malcarne, & Menon, 2012), whereas the association is less pronounced when assessing basic computational skills (Harari, Vukovic, & Bailey, 2013; Wu, Barth, Amin, Malcarne, & Menon, 2012). Therefore, our study aimed to extend previous research by evaluating the specific relationship between MA and arithmetic word problem-solving ability.

In addition, it must be noted that the role of MA on math achievement has been typically investigated in adults and older children, while the relationship between MA and math performance in elementary students is still contradictory (Zhang, Zhao, & Kong, 2019): some authors failed to find an association between MA and math proficiency in primary school students (Dowker, Bennett, & Smith, 2012; Haase et al., 2012; Krinzinger, Kaufmann, & Willmes, 2009; Thomas & Dowker, 2000; Wood et al., 2012), whereas others reported that the MA-performance link exists even at this early age (Cargnelutti, Tomasetto, & Passolunghi, 2017; Jameson, 2013; Vukovic, Kieffer, Bailey, & Harari, 2013; Wu, Barth, Amin, Malcarne, & Menon, 2012; Wu, Willcutt, Escovar, & Menon, 2014; Živković, Pellizzoni, Mammarella, & Passolunghi, 2022). It is particularly important to investigate

MA in young children in order to understand its role on the actual performance, and if possible, to prevent the early development of negative emotions toward math-related activities. Hence, we sought to clarify these inconsistencies by recruiting a sample of primary school children.

Perceived task difficulty

Besides MA, another factor related to student's performance is the construct of perceived task difficulty (Nuutila, Tapola, Tuominen, Molnár, & Niemivirta, 2021). This is a metacognitive experience (Efklides, 2011) defined as a subjective judgment of task difficulty that can be evoked before, during, and after the completion of a task (Efklides, Papadaki, Papantoniou, & Kiosseoglou, 1998). According to the theoretical model of metacognition, motivation and affect (MASRL model; Efklides, 2011), the feeling of task difficulty is metacognitive in nature since it derives from the monitoring of the ongoing cognitive processing of the task and its awareness provides input for self-regulation, strategy use, effort and affect (Efklides & Petkaki, 2005). In this study, we focused on retrospective evaluations of task difficulty (i.e., after completing the task) since they are believed to capture feelings of difficulty linked to the entire solving process (Brown, 1978; Efklides & Petkaki, 2005).

Importantly, the perceived difficulty is distinct from the objective difficulty of the task. Indeed, research has found that the evaluation of difficulty is partly based on assessments of objective difficulty, such as task characteristics, complexity, and novelty (Efklides, Papadaki, Papantoniou, & Kiosseoglou, 1998; Vangsness & Young, 2018), but it is also affected by subjective factors including emotional aspects (Efklides, 2002; Fulmer & Tulis, 2013). For instance, Efklides and Petkaki (2005) experimentally induced in a sample of late primary school children a positive or negative mood and found that students in a positive mood state were more likely to report that a word problem-solving task was easier than students whose induced affect was negative.

Moreover, some studies suggest that judging a task as moderately demanding may increase performance (Atkinson, 1957; Brunstein & Schmitt, 2010), whereas high levels of perceived difficulty are likely to impair one's achievement (Nuutila, Tapola, Tuominen, Molnár, & Niemivirta, 2021). Taken together, individual's emotional states (e.g., mood) seem to influence perceived difficulty, which, in turn, impacts students' performance (Hascher, 2010). However, the understanding on how trait emotions (i.e., stable personal characteristics) and perceived difficulty are related to math outcomes is still very scarce and to the best of our knowledge no study has investigated the relationship between math-related emotions such as MA, perceived difficulty, and arithmetic word problems.

Gender differences

A gender difference related to MA has been extensively documented. Previous research involving adults and high-school students has consistently found that females tend to have higher levels of MA (e.g., Else-Quest, Hyde, & Linn, 2010; Ferguson, Maloney, Fugelsang, & Risko, 2015; Jansen, Schmitz, & van der Maas, 2016; Xie, Xin, Chen, & Zhang, 2019). However, gender differences regarding MA in primary school students have been far less investigated (Hill et al., 2016). Some studies revealed that primary school girls experience

significantly higher MA than boys (e.g., Carey, Hill, Devine, & Szűcs, 2017; Hill et al., 2016; Szczygieł, 2019; Vanbinst, Bellon, & Dowker, 2020), while other studies did not replicate the same results (e.g., Dowker, Bennett, & Smith, 2012; Gierl & Bisanz, 1995; Harari, Vukovic, & Bailey, 2013; Punaro & Reeve, 2012; Ramirez, Gunderson, Levine, & Beilock, 2013; Young, Wu, & Menon, 2012). Thus, it remains unclear as to whether girls exhibit higher MA in primary education.

Concerning math achievement, older meta-analyses indicated a male advantage in mathematics (Hedges & Nowell, 1995; Hyde, Fennema, Ryan, Frost, & Hopp, 1990). However, this gender gap seems to be disappearing, with more recent studies suggesting small or insignificant gender differences in math attainment (Devine, Fawcett, Szűcs, & Dowker, 2012; Dowker, Bennett, & Smith, 2012; Hill et al., 2016; Hyde, Lindberg, Linn, Ellis, & Williams, 2008; Lindberg, Hyde, Petersen, & Linn, 2010; Rossi et al., 2022; Vanbinst, Bellon, & Dowker, 2020). Hence, it seems valuable to compare girls' and boys' performance to elucidate whether there is a gender related gap in math problem-solving ability among primary school students.

As regards perceived difficulty, a very limited number of studies sought to explore gender-related differences in this construct. Graf and Riddell's (1972) study investigated whether the retrospective evaluations of word problems' difficulty differed among male and female university students, finding no significant differences in terms of how difficult they perceived math word problems with neutral context to be. Interestingly, Nuutila, Tapola, Tuominen, Molnár, and Niemivirta (2021) found in a sample of middle schoolers that girls reported higher perceived difficulty in the beginning of a problem-solving task (i.e., expected perceived difficulty) compared to boys, however no gender differences were observed in the evaluations of difficulty during and after the completion of the task.

The present study

Considering the limited and contradicting findings on the issue, the overall purpose of the present study was to advance the understanding of the role of MA and perceived task difficulty in solving arithmetic word problems, more specifically compare problems, and to evaluate gender differences in those variables in primary school children. In doing this, we aimed to extend previous results in several ways.

Firstly, our aim was to explore the contributions provided by MA and perceived task difficulty in explaining the variance of children's problem-solving performance. We hypothesized, in accordance with studies conducted on other arithmetic word problem types (e.g., Passolunghi, Cargnelutti, & Pellizzoni, 2019; Ramirez, Chang, Maloney, Levine, & Beilock, 2016; Ramirez, Gunderson, Levine, & Beilock, 2013) and in accordance with studies that suggest a stronger relationship between MA and complex math tasks (e.g., Wu, Barth, Amin, Malcarne, & Menon, 2012), that MA would negatively impact proficiency on compare problems. In addition, we hypothesized that also perceived task difficulty would negatively predict children's arithmetic word problem-solving accuracy (Nuutila, Tapola, Tuominen, Molnár, & Niemivirta, 2021).

Secondly, we wanted to inspect the possible mediational role of perceived task difficulty in the relationship between MA and arithmetic word problem-solving achievement. Based on previous results on mood state (Efklides & Petkaki, 2005), we expected that high MA levels would lead to higher perceptions of difficulty, which would consequently negatively

impact problem-solving performance. We judged this analysis fundamental to provide understanding on the role and mechanisms of MA in arithmetic word problem-solving.

Lastly, we were interested in evaluating whether there were gender differences in MA, perceived problems' difficulty, and arithmetic word problem-solving performance in primary school children. Based on existing studies, we expected that girls would experience higher MA (Carey, Hill, Devine, & Szűcs, 2017; Hill et al., 2016; Szczygieł, 2019; Vanbinst, Bellon, & Dowker, 2020), but we hypothesized no gender differences in mathematics performance (Devine, Fawcett, Szűcs, & Dowker, 2012; Dowker, Bennett, & Smith, 2012) nor in perceived problems' difficulty (Graf & Riddell, 1972; Nuutila, Tapola, Tuominen, Molnár, & Niemivirta, 2021).

Method

Participants and procedure

Participants were 111 students attending Grade 5 of five different primary schools located in the northeast part of Italy. Four children were excluded from the analysis due to missing data. Thus, the sample analyzed included 107 students (59 F) with a mean age of 10 years and 3 months. The socio-economic status of the sample was primarily middle class, established on the basis of school records. For sample size estimation, an a priori power analysis was conducted. Results indicated that the minimum sample size needed to achieve power = .80 for detecting a medium effect, at a significance criterion of $\alpha = .05$, was $N = 80$ for mediation. Thus, our sample size of $N = 107$ is adequate.

After obtaining parental consent, children were tested in two sessions administered at school. In the first session, MA was evaluated. The second session included the assessment of arithmetic word problem-solving and perceived difficulty. The study obtained approval by the ethical committee of the University of Trieste and was carried out in compliance with the Declaration of Helsinki and the ethical guidelines of the Italian Association of Psychology.

Measures

Arithmetic word problem task

To measure students' arithmetic word problem-solving skills, we administered an untimed task adapted from Hegarty, Mayer, and Green (1992). In contrast to previous works that measured word problem-solving ability using a mixed variety of math problems (e.g., Ramirez, Gunderson, Levine, & Beilock, 2013; Wu, Barth, Amin, Malcarne, & Menon, 2012), the present study focused solely on compare problems. We employed these types of problems since they are frequently offered in primary education (Powell, Berry, & Barnes, 2020; Riley, Greeno, & Heller, 1983), and are particularly difficult to solve although the corresponding math and language are relatively simple (Boonen & Jolles, 2015; Daroczy, Wolska, Meurers, & Nuerk, 2015; Giroux & Ste-Marie, 2001; Riley & Greeno, 1988; Schumacher & Fuchs, 2012). Indeed, their complexity derives from the lexical inconsistency and the need to construct a mental representation of the problem situation (de Koning, Boonen, Jongerling, van Wesel, & van der Schoot, 2022; Passolunghi et al., 2022). In particular, the task contained eight compare word problems, which required two

elementary arithmetic calculations consisting of addition and subtraction to be solved. The problems are similar to those assigned by teachers to students at the considered school grade. Each problem included four short sentences. The first sentence was an assignment statement expressing the price of a variable (e.g., “A pair of skates at Outdoor costs 40 euros”). The second sentence was a relational statement denoting the value of a second variable in relation to the first one (e.g., “A pair of skates at Happy-bike costs 10 euros more than a pair of skates at Outdoor”). The third sentence was another relational statement indicating the value of a third variable in relation to the second one (e.g., “The pair of skates at Happy-bike costs 5 euros more than an electric skateboard”). The last part was a question asking about the value of the third variable (e.g., “How much does an electric skateboard cost?”). Thus, each problem contained two relational statements, one consistent and the other inconsistent. The order of the consistent and inconsistent statement was manipulated. Moreover, half of the problems contained only the relational term “more than” and the other half contained only the relational term “less than.” The score of 0 or 1 was attributed to each problem according to whether the answer was wrong or correct, respectively. Its measurement range was between 0 and 8. Cronbach’s alpha for internal consistency was .86.

Perceived difficulty of the problems

After completing each problem, students were asked to evaluate its perceived difficulty on a Likert scale ranging from 1 to 7 (1 = very easy, 7 = very difficult). A 7-point Likert scale was used in accordance with previous studies (Nuutila, Tapola, Tuominen, Molnár, & Niemivirta, 2021). The total score of perceived difficulty could range from 8 to 56. The internal consistency reliability was good ($r = .83$).

Math anxiety

The adaptation of the *Abbreviated Math Anxiety Scale* for primary school (AMAS; Hopko, Mahadevan, Bare, & Hunt, 2003; Italian version adapted for primary school students by Caviola, Primi, Chiesi, & Mammarella, 2017) was administered to evaluate children’s trait math anxiety. AMAS is a brief self-report tool that comprises nine items depicting situations involving mathematical activities and number manipulations (e.g., “Listening to a lecture in math class”). Participants had to judge every statement in terms of how anxious they would feel in each described situation, using a five-point Likert scale (1 = a little anxious; 5 = extremely anxious). The total score of each participant could range from 9 to 45. The internal consistency of the scale was good (Cronbach’s $\alpha = .81$). We decided to use AMAS since (1) it is one of the most widely used instrument to assess MA (Primi et al., 2020) allowing, thus, to compare our results to findings from numerous studies in literature; (2) it has shown psychometric properties comparable to those of the longer MA scale (MARS-R; Plake & Parker, 1982), as well as high convergent validity (Hopko, Mahadevan, Bare, & Hunt, 2003); and (3) its brevity makes it a convenient and appropriate measure for primary school children (Martín-Puga, Justicia-Galiano, Gómez-Pérez, & Pelegrina, 2022). Moreover, it must be noted that some MA measures used by previous studies (e.g., Ramirez, Gunderson, Levine, & Beilock, 2013; Wu, Barth, Amin, Malcarne, & Menon, 2012) are excessively age-restricted or adequate statistics supporting their validity are not provided (Carey, Hill, Devine, & Szűcs, 2017).

Table 1. Descriptive statistics and bivariate correlations between all variables.

Measures	M	SD	1.	2.	3.
1. AMAS	21.24	5.66	-	-.431**	.519**
2. Problem-solving	3.62	2.63		-	-.399**
3. Perceived difficulty	20.65	10.84			-

** $p < .01$.

Results

Statistical analyses were performed with SPSS software (version 21). Table 1 reports descriptive statistics of all variables, including the mean, standard deviation, and zero-order correlations. MA was negatively correlated with problem-solving scores ($r = -.431$, $p < .001$). Moreover, perceived difficulty was positively correlated with MA ($r = .519$, $p < .001$) and negatively associated with problem-solving performance ($r = -.399$, $p = .001$).

Multiple regression analysis

To verify the role of MA and perceived task difficulty in predicting the problem-solving accuracy, we conducted a multiple regression analysis. In particular, MA and perceived problems' difficulty were introduced as the independent variables while the problem-solving achievement as the dependent variable.

The overall regression was statistically significant ($R^2 = .213$), $F(2, 104) = 15.353$, $p < .001$. The model indicated that roughly one-fifth of the variance in problem-solving performance was accounted for by the linear combination of MA levels and perceived difficulty. The regression model showed that both MA ($\beta = -.306$, $t = -3.037$, $p = .003$) and perceived problems' difficulty ($\beta = -.240$, $t = -2.383$, $p = .019$) significantly and negatively predicted arithmetic problem-solving achievement.

Mediation analysis

We hypothesized that a higher MA would lead to a higher evaluation of problems' difficulty, which would then decrease respondents' ability to solve those problems. To test this assumption, the Model 4 of the SPSS add-on PROCESS was utilized (Hayes, 2017). 5000 bootstrap samples were used to generate 95% bias-corrected and accelerated confidence intervals; if the 95% confidence interval of the indirect effect excludes zero, significance of the effect can be assumed (Hayes, 2017).

A mediation model was calculated placing MA level as the focal regressor, problem-solving accuracy as the dependent variable and perceived difficulty as the mediator. The results of the mediation model are presented in Figure 1. Findings revealed that MA was significantly and negatively related to problem-solving performance ($\beta = -.306$, $s.e. = .047$, $p = .003$). Moreover, MA was significantly and positively associated to perceived task difficulty ($\beta = .519$, $s.e. = .159$, $p < .001$) and perceived task difficulty was negatively associated to problem solving performance ($\beta = -.240$, $s.e. = .024$, $p = .019$). Using 5000 bootstrapped samples, a significant indirect effect (IE= $-.058$, bootstrap $s.e. = .026$, 95% CI: $[-0.1090, -0.0047]$), and direct effect (DE= $-.142$, $s.e. = .047$, 95% CI: $[-0.2350, -.0493]$) were observed. Thus, it can be concluded that MA had both a direct effect and indirect effect

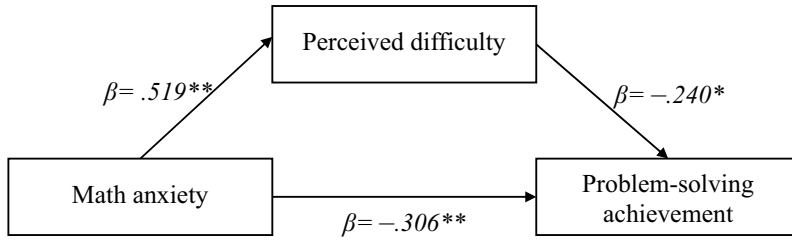


Figure 1. Math anxiety was inserted as the focal regressor, perceived difficulty as the mediator and problem-solving achievement as the outcome variable. Standardized regression coefficients are presented. * $p < .05$, ** $p < .01$.

through perceived problems' difficulty on arithmetic problem-solving performance. It must be pointed out that when positioning perceived difficulty as the focal regressor, MA as the mediator and problem-solving achievement as dependent variable, the indirect effect was significant. Nevertheless, we selected the model with perceived difficulty as the mediator since it is a theory-driven model: one could expect that a trait characteristic influences on-task metacognition, whereas the inverse directionality could be possible when considering state characteristics instead of trait ones (Hong, 1999).

Gender differences

To evaluate whether females and males differed on MA, perceived task difficulty and problem-solving performance a Multivariate Analysis of Variance (MANOVA) was conducted with gender as fixed factor and scores of MA, perceived difficulty, and arithmetic problem-solving as dependent variables. Cohen's criteria (Cohen, 1988) were used to classify the effect size: small ($\eta_p^2 = 0.01$), medium ($\eta_p^2 = 0.06$) and large effect ($\eta_p^2 = 0.14$).

A statistically significant MANOVA effect was obtained, Wilk's Lambda = .907, $F(3, 103) = 3.520$, $p = .018$. Follow-up comparisons indicated that girls ($M = 22.56$, $SD = 5.25$) compared to boys ($M = 19.63$, $SD = 5.77$) reported a significantly higher level of MA, $F(1, 105) = 7.558$, $p = .007$, $\eta_p^2 = .067$. There was no significant effect of gender on the problem-solving accuracy: girls ($M = 3.69$, $SD = 2.49$) and boys ($M = 3.52$, $SD = 2.81$) did not differ on problem-solving performance, $F(1, 105) = 0.115$, $p = .735$, $\eta_p^2 = .001$. Moreover, female ($M = 21.73$, $SD = 11.02$) and male students ($M = 19.33$, $SD = 10.58$) did not differ on perceived difficulty of problems, $F(1, 105) = 1.296$, $p = .257$, $\eta_p^2 = .012$.

Discussion

To date, most developmental studies on word problem-solving focused on cognitive skills associated with this ability, whereas research examining the influence of emotional and metacognitive aspects has remained relatively sparse. Given the prominent role of arithmetic word problems in mathematical education and everyday life (Fuchs et al., 2006), the main objective of the present research was to provide novel insight into the relation between emotional factors (e.g., math anxiety), metacognitive experiences (e.g., perceived task difficulty) and arithmetic word problem-solving proficiency in a sample of primary school students. In particular, we explored the contribution of both MA and perceived task

difficulty on problem-solving accuracy and investigated whether perceived difficulty could mediate the relationship between MA and problem-solving proficiency. Moreover, we sought to clarify whether gender differences in those variables may occur in children attending primary school.

Results confirmed our expectations revealing a negative direct effect of MA on children's performance on compare word problems. This finding is consistent with those of previous studies involving primary school students, which reported that MA is negatively related to general math achievement (Cargnelutti, Tomasetto, & Passolunghi, 2017; Sorvo et al., 2017; Vukovic, Kieffer, Bailey, & Harari, 2013; Wu, Barth, Amin, Malcarne, & Menon, 2012; Wu, Willcutt, Escovar, & Menon, 2014) and, specifically, to arithmetic word problem-solving accuracy (Lai, Zhu, Chen, & Li, 2015; Passolunghi, Cargnelutti, & Pellizzoni, 2019; Ramirez, Chang, Maloney, Levine, & Beilock, 2016; Ramirez, Gunderson, Levine, & Beilock, 2013). However, not all studies found a detrimental effect of MA on math performance among young children (Dowker, Bennett, & Smith, 2012; Haase et al., 2012; Krinzinger, Kaufmann, & Willmes, 2009; Thomas & Dowker, 2000; Wood et al., 2012). As reported by Zhang, Zhao, and Kong (2019), one possible reason explaining these conflicting results is that the relation between MA and math achievement depends on the measure used to assess math outcomes. In particular, the MA-performance link is stronger when students engage with demanding math tasks which require more cognitive engagement (Caviola et al., 2022). For instance, Wu, Barth, Amin, Malcarne, and Menon (2012) found a strong correlation between children's MA and scores on a complex mathematical reasoning task (e.g., math problems with both verbal and visual prompts). In contrast, the correlation was weaker between MA and a simple calculation math task that required well learned and automatized skills. Since solving arithmetic word problems is a complex process (Pongsakdi et al., 2020), it might be particularly hindered by MA, whereas more basic math abilities might be less affected (Beilock & Carr, 2001). Thus, our study provided evidence on the impact of MA on arithmetic problem-solving even in an untimed math task, highlighting the pervasive role of MA and the need to take into account this negative emotion when investigating children's difficulties in this math domain.

Moreover, the current work showed MA to also have an indirect effect on word problem-solving performance through the metacognitive experience of perceived task difficulty. More specifically, high levels of MA were related to a higher evaluation of problems' difficulty which, subsequently, was associated to a lower ability to solve arithmetic word problems correctly. These findings are relevant from a theoretical perspective since they provide an understanding of the mechanisms underlying the MA-performance link. Indeed, the mediation effect suggests that the tendency to worry about mathematics and numerical stimuli might influence task-specific metacognitive experiences, leading students to judge math-related tasks as more complex and demanding. The high perceived difficulty of the task is then likely to negatively affect students' expectancy of success (i.e., the higher the perceived difficulty, the lower students' likelihood to succeed; Eccles & Wigfield, 2020; Fulmer & Tulis, 2013), their interest and enjoyment (Fulmer & Frijters, 2011; Nuutila, Tapola, Tuominen, Molnár, & Niemivirta, 2021) and their self-regulation and strategy choices (Efklides, 2001), all of which would hinder their math performance (Nuutila, Tapola, Tuominen, Molnár, & Niemivirta, 2021). High evaluations of task difficulty are also linked to diminished willingness to engage with the task (Brehm & Self, 1989) and task avoidance (Atkinson, 1957). Additionally, it is interesting to point out that some research

found that students evaluating a task as particularly difficult experience increased negative situational affect such as state anxiety, frustration, and stress (Pekrun, Goetz, Titz, & Perry, 2002; van Steensel, Oostdam, & van Gelderen, 2019). For instance, Hong (1999) found in a sample of university students that perceived difficulty of a statistics exam influenced test performance indirectly. Specifically, evaluations of test difficulty aroused feelings of worry and anxiety which then negatively impacted students' performance. The perceived difficulty-state anxiety relationship is supported by a more recent work on reading tasks which showed that perceiving a task as demanding may result in higher situational negative affect (Fulmer & Tulis, 2013). Hence, to better understand the role of perceived difficulty and emotional factors, future studies could investigate the relation between stable affects (e.g., trait MA), situational affects (e.g., state MA), perceived task difficulty and math proficiency.

As to gender differences, results showed that in our sample girls reported higher levels of MA compared to boys, thus confirming the existence of gender differences in MA (Devine, Fawcett, Szűcs, & Dowker, 2012; Ferguson, Maloney, Fugelsang, & Risko, 2015; Goetz, Bieg, Lüdtke, Pekrun, & Hall, 2013; Jansen, Schmitz, & van der Maas, 2016; Xie, Xin, Chen, & Zhang, 2019) and additionally suggesting that this gap may occur already in late primary school (Carey, Hill, Devine, & Szűcs, 2017; Griggs, Rimm-Kaufman, Merritt, & Patton, 2013; Hill et al., 2016; Szczygieł, 2019). Higher level of MA in girls might originate from several sources, including children's exposure to stereotypic beliefs and expectations (i.e., mathematics-gender stereotypes which state that mathematics is for men, not for women), and the influence and social transmission of anxiety by parents, teachers, and other significant adults (Luttenberger, Wimmer, & Paechter, 2018). For instance, it has been found that female teachers who are anxious about math are likely to influence girls, but not boys, in endorsing the traditional mathematics-gender stereotype (Beilock, Gunderson, Ramirez, & Levine, 2010). Additionally, differences in MA between genders may be explained by the female's tendency to be more open to reporting anxiety than men (Dowker, Sarkar, & Looi, 2016). Future studies could advance our findings regarding gender differences in primary education by exploring the role of children's experience in the classroom or home environment. It must be noted that we found a medium effect size ($\eta_p^2 = .067$; Cohen, 1988) related to gender differences in MA. This implies that the gender gap in Grade 5 is still relatively modest, and it might increase over time, thus supporting meta-analytic findings on females being more prone to report MA during higher education compared to primary education (Else-Quest, Hyde, & Linn, 2010; Hembree, 1990). Moreover, it should be recalled that in this study a sample of Italian children was considered, and the present results on gender differences align well with similar Italian studies (e.g., Hill et al., 2016), however data are contrasting with some other European studies (e.g., Dowker, Bennett, & Smith, 2012), showing cultural and stereotypic effect that could contribute to the obtained results.

Our data did not support gender differences in problem-solving performance, which is in line with previous research (Devine, Fawcett, Szűcs, & Dowker, 2012; Hill et al., 2016; Lindberg, Hyde, Petersen, & Linn, 2010), nor in the perception of problem's difficulty. The lack of gender difference in perceived difficulty could be explained by the fact that judgments of difficulty depend partly on objective difficulty cues (Vangsness & Young, 2018). Since boys and girls have been exposed to the same word problems in class, they could be similarly (un)familiar to the task and therefore judge the problems' difficulty in the same way.

Limitations and implications of the study

Some limitations need to be acknowledged with respect to our study. First, we did not assess children's general anxiety nor test anxiety, which were observed to be related to MA and math performance (Caviola et al., 2022; Donolato, Toffalini, Giofrè, Caviola, & Mammarella, 2020; Hembree, 1990). Therefore, our results should be interpreted with caution and future investigations should explore the specific role of MA on problem-solving accuracy, after taking into account other forms of anxiety. Furthermore, given the correlational nature of the current work, causation should not be inferred. Our study provided some evidence on the association between emotional and metacognitive factors, and the ability to solve arithmetic word problems, however further studies that examine those constructs longitudinally may help to make causal claims about that relationship.

Nevertheless, outcomes of the present study are relevant since they extend previous literature by showing the significant role of affective and metacognitive aspects in solving compare problems among primary school children. The findings demonstrated that feelings of anxiety toward math do not only have a direct effect on performance of an untimed problem-solving task but do also have an indirect effect through perception of problems' difficulty. It is likely that individuals with high MA levels tend to view math-related tasks as more difficult and effort demanding. When a math task is evaluated as very difficult, success is believed to be impossible, and students could be willing to avoid or give up the task itself judging the effort not worthwhile (Atkinson, 1957). In this sense, it is possible that MA acts as an activator for negative on-task metacognitive and emotional states and in some cases leads to avoidance of math tasks as they are perceived to be too difficult. Therefore, recognizing MA and providing sufficient educational support in young students is crucial to prevent the development of avoidance of math tasks and math-intensive courses which might have lifelong effects (Ashcraft, 2002). As suggested by the present findings, this might be particularly important for girls, considering that they experience higher MA levels as early as in primary school. A strong MA manifestation could influence their future engagement in STEM careers (Levy, Fares, & Rubinsten, 2021), increasing the gender underrepresentation (Else-Quest, Hyde, & Linn, 2010; Wang & Degol, 2017) and shaping the stereotype that women are not suited to mathematics (Beilock, Gunderson, Ramirez, & Levine, 2010). In this respect, children with high MA levels may benefit from interventions based on anxiety control strategies and self-efficacy beliefs (e.g., through exercising on diverse types of word problems) which may lead to increased feelings of competence, a decrease in MA levels and, consequently, a reduction in perceived problem's difficulty (Passolunghi, De Vita, & Pellizzoni, 2020). However, the literature on perceived difficulty in math educational settings is very limited and further investigations are needed.

In conclusion, the current work highlighted the importance of both emotional factors and metacognitive experiences in accounting for individual differences in Italian children's word problem-solving performance and underlined the need to consider gender differences related to math learning within primary education.

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No potential conflict of interest was reported by the authors.

Data availability statement

The data supporting the findings of this paper are available from the corresponding author upon reasonable request.

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