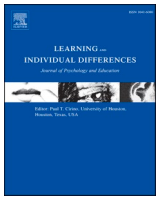
Learning and Individual Differences 105 (2023) 102316

Contents lists available at ScienceDirect

Learning and Individual Differences

journal homepage: www.elsevier.com/locate/lindif



Gender stereotypes about math anxiety: Ability and emotional components

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ARTICLE INFO

Keywords:
Math anxiety
Gender stereotypes
Gender differences
Math achievement
Emotion gender stereotypes
Math gender stereotypes

ABSTRACT

Gender stereotypes are believed to play a role in the heightened math anxiety (MA) reported by female students. We investigated, first, whether adolescents hold the stereotyped beliefs that girls experience more MA than boys (emotional facet), and that boys perform better in math (ability facet); second, whether gender differences in MA are due to self-report bias; and, third, whether gender differences in MA are related to gender-stereotyped beliefs, in terms of both ability and emotional facets. A total of 257 secondary school students completed math-related and gender stereotype measures. The results revealed that female students were perceived as being more prone to MA than male students, but no self-report bias was observed. Regarding the math ability facet, students endorsed either egalitarian or female-favoring views. Finally, gender differences in MA, as well as other math-related performance measures, were related to gender stereotypes about math ability, but not about emotion.

1. Introduction

Mathematics is a core subject for science, technology, engineering and mathematics (STEM) and fundamental part of the curriculum at all levels of compulsory education. Unfortunately, many students find mathematics difficult, which makes them anxious (Organization for Economic Cooperation and Development [OECD], 2014). The negative emotions, worry and nervousness that individuals experience in mathematical situations is commonly referred to as math anxiety. It is well known that math anxiety may interfere with performance during numerical tasks and undermines math achievement in school (see Beilock & Maloney, 2015; Dowker et al., 2016; Suárez-Pellicioni et al., 2016, for reviews).

Adolescence is a period in which the likelihood of experiencing math anxiety, as well as its negative consequences, may be increased (Dowker et al., 2016; Hembree, 1990). In a recent meta-analysis, Barroso et al. (2021) noted that the negative relation typically observed between math anxiety and achievement becomes stronger during the adolescent years. Moreover, math anxiety may influence the career plans of secondary school students, who are in a period crucial for identity development in which vocational interests crystallize (Levy et al., 2021; Starr & Simpkins, 2021). In a longitudinal follow-up study of a large sample of 7th grade students, Ahmed (2018) observed that adolescents whose math anxiety levels increased over time tended to avoid STEM careers. Therefore, it is important to better understand the factors associated with these emotions during adolescence.

Math anxiety seems to be more pervasive among female students even when they achieve math proficiency levels comparable to their male classmates (e.g., Voyer & Voyer, 2014). Numerous researchers have observed higher levels of self-reported math anxiety in female students across all educational levels (Bander & Betz, 1981; Bieg et al., 2015; Frenzel et al., 2007; Hembree, 1990; Hill et al., 2016; Maloney & Beilock, 2012; Martín-Puga et al., 2022; Primi et al., 2014; Sokolowski et al., 2019; Vos et al., 2023), and gender differences remained even after controlling for general or test anxiety (Devine et al., 2012; Hill et al., 2016). Gender effects have been also reported in recent large-sample studies that examined math anxiety in a large number of countries (Else-Quest et al., 2010; Lau et al., 2022; Stoet et al., 2016).

Several different explanations, which are not mutually exclusive, have been offered for the gender differences seen in math anxiety (see Dowker et al., 2016). One possibility is that cultural and social factors related to gender stereotypes[1] contribute to math anxiety (Beilock et al., 2007; Devine et al., 2012; Rossi et al., 2022). Gender stereotypes are shared beliefs about individuals based on their gender that may refer to attributes in various domains, such as personality, emotion, cognition, and behavior (for a review, see Ellemers, 2018). Regarding gender

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[1] Examples of social factors include family or school contexts, and membership of social groups (e.g., gender groups). Cultural factors encompass beliefs and values held by a culture. Examples in the present context would be ideas about gender roles, gender equality, or the importance given to mathematics.

https://doi.org/10.1016/j.lindif.2023.102316
Received 7 November 2022; Received in revised form 27 May 2023; Accepted 30 May 2023

stereotypes related to math anxiety, a distinction can be drawn between shared beliefs about emotion (e.g., women are more math-anxious than men) and beliefs about math ability (e.g., men are more talented in mathematics than women). Although gender stereotypes related to math ability have been documented in the literature (Dowker et al., 2016), possible stereotypes related to emotions have not yet been systematically studied. We aimed to investigate both facets of stereotypes (emotion and ability), as well as their possible relationship to self-reported math anxiety.

1.1. Gender stereotypes about the emotional facet of math anxiety

The belief that women are more emotional than men is a pervasive gender stereotype (Plant et al., 2000) with a high degree of cross-cultural consensus (Brody et al., 2016). According to this stereotype, women express and experience certain emotions more frequently, and with more intensity, than men. Among the gender-specific emotions, a number of studies have confirmed that women report higher levels of general anxiety than men (for a review, see McLean & Anderson, 2009).

Gender stereotypes about emotions can be detected in very young children. Preschoolers have already developed gender beliefs about specific emotions; for example, they associate sadness, happiness and general emotionality with females, and anger with males (Birnbaum et al., 1980; Birnbaum & Chemelski, 1984). Interestingly, children also perceive the intensity of emotional experience (e.g., anger) to differ between men and women (Brechet, 2013). As children grow older, their knowledge about stereotypes increases, as well as their flexibility with respect to the application of emotional gender stereotypes (Alfieri et al., 1996; Halim & Ruble, 2010); this may be attributable to cognitive development and advances in moral reasoning and perspective taking (Leaper, 2015). To our knowledge, no prior research has investigated gender stereotype-related anxiety in adolescents, although it seems reasonable to assume that they are in operation during adolescence.

One explanation of gender differences in math anxiety is that they reflect gender differences in the proneness to openly admit anxiety, rather than actual differences (see Devine et al., 2012). From this viewpoint, women and men experience emotions in similar ways, but during the process of socialization, they learn what (and to whom) emotions can be openly expressed, and when it is appropriate to do so. Thus, men may be more reluctant to openly admit anxiety (Hill & Saranson, 1966, as cited in Zeidner, 1998; Hunsley & Flessati, 1988; Meece et al., 1982), because its expression is likely to be viewed as incompatible with a traditional male gender role (see McLean & Hope, 2010). Boys may have been trained to confront their fears and anxieties in order to satisfy the stereotyped gender role that encourages avoidance of being perceived as vulnerable and weak (Bem, 1981). Conversely, women may be more willing to disclose feelings of anxiety (e.g., Ashcraft, 2002; Ashcraft & Ridley, 2005; Hembree, 1990). Thus, it would likely be considered more acceptable for them to disclose their negative feelings, where the traditional feminine gender role permits the expression of fear and anxiety without negative social consequences. In both cases, gender role identification would likely lead to reporting bias as a way of presenting oneself in a positive light. If this hypothesis is correct, boys who underreport their high levels of math anxiety may forgo opportunities for guidance or counselling.

Flessati and Jamieson (1991) examined the hypothesis of gender response bias in the reporting of math anxiety by asking undergraduate students whether math anxiety is perceived as a female experience. They found gender differences in math anxiety, with females scoring higher than male undergraduates; however, contrary to the gender response bias hypothesis, the students believed that math anxiety (as well as anxiety about other subjects) affected both genders similarly. This result is inconsistent with the idea that the expression of anxiety in general, and math anxiety in particular, is more characteristic of female students. Despite this interesting and somewhat surprising finding, there has been no further research into this issue to our knowledge. Therefore, a goal of the present study was to investigate the possibility of stereotyped beliefs about math anxiety in terms of the emotional component (e.g., girls are more math-anxious than boys); secondly, we aimed to determine whether self-reporting bias and gender stereotyping in the emotional facet could account for gender differences in math anxiety.

1.2. Gender stereotypes about math ability

A second gender stereotype that has been proposed to account for gender differences in math anxiety relates to the ability rather than the emotional domain, and holds that women perform worse at mathematics than their counterpart men (Ramirez et al., 2018). According to this view, girls may have been socialized to believe that they are less competent in mathematics (see Devine et al., 2012), and as a consequence may become anxious in math-related situations. It has been argued that the traditional stereotype that favors men over women in mathematics (i.e., boys are better at mathematics than girls) is widely accepted worldwide (Nosek et al., 2009). However, this stereotype may not be as widespread as previously thought (Devine et al., 2012); and indeed, alternative beliefs, such as egalitarian or favoring-females views, may actually be common. Moreover, the prevailing belief may depend on different factors, including the age and gender of the individual.

Younger children tend to adopt an in-group stereotype that favors their own gender (Master, 2021), with boys endorsing the traditional stereotype while girls maintain the opposite belief, that is, that girls are better at mathematics than boys (e.g., Kurtz-Costes et al., 2014; Martinot et al., 2012; Nowicki & Lopata, 2017; Passolunghi et al., 2014; Plante et al., 2009). As they grow up, boys may gravitate more toward egalitarian or female-favoring math stereotypes; at the secondary school level, there is evidence that boys support a stereotype favoring female students, as do also many girls. For instance, in the study by Passolunghi et al. (2014), 3rd, 5th, and 8th grade children completed self-report questionnaires about explicit math-gender stereotypes. Whereas 3rd graders rated their gender ingroup as better at math, 8th graders rated both gender groups as equally proficient (see also, Bieg et al., 2015; Vuletich et al., 2020). It is also the case that some boys and girls of all ages hold a gender-neutral or egalitarian view as it pertains to math ability (e.g., Ambady et al., 2001; Martinot et al., 2012 [in primary school]; Morrissey et al., 2019 [in secondary school]). In a large-scale longitudinal study, Starr and Simpkins (2021) showed that the majority of adolescents in the 9th and 11th grades endorsed an egalitarian view with respect to math and science ability according to gender, although there was a shift toward a stereotype favoring males between those two grades. Therefore, gender stereotypes about math held by certain groups appear to be amenable to adjustment throughout childhood and adolescence.

1.3. Relations among gender stereotypes about math ability and math-related measures

In addition to consensual and group gender stereotypes, it is important to consider stereotype endorsement at the level of the individual. Wolff (2021) showed that both levels may have an independent impact on math related-outcomes. Even when a group does not support the belief that men are more capable than women in mathematics, individuals may endorse such a view. Thus, in a group holding an egalitarian view, there may be girls who believe that males have superior math ability. Girls who have developed the stereotype that mathematics is not a subject for girls may not identify themselves with mathematics. Endorsing a math gender stereotype favoring men is related to more negative attitudes regarding the math ability of female students across educational levels (Eccles, 1994; Kurtz-Costes et al., 2008; Schmader et al., 2004), as well as to lower levels of self-concept and math achievement (Cvencek et al., 2015; Nosek et al., 2002; Passolunghi et al., 2014; Wolff, 2021). It is therefore plausible that gender stereotypes

might relate to math anxiety in a similar way.

Some theoretical approaches have emphasized the influence of social stereotypes on academic outcomes. Eccles' expectancy-value theory proposes that socialization processes, such as those associated with gender stereotypes, could influence students' competence beliefs (e.g., self-concept), values and emotions, such as math anxiety (Eccles, 1994, 2009; Wigfield & Eccles, 2000). Research on stereotype threat has also linked gender stereotypes and anxiety. According to this view, the activation of negative stereotypes has a detrimental effect on performance, which is mediated by a depletion of working memory resources due to an increase in anxiety (Steele, 1997; Schmader & Johns, 2003; see also Tomasetto, 2019, for a recent review in the context of math anxiety).

Despite its potential relevance, very little research has specifically examined the effect of gender stereotypes on math anxiety. Bieg et al. (2015) found that female adolescents from grades 9 and 10 who endorsed the traditional stereotype tended to anticipate a higher level of math anxiety than they actually experienced in math situations. Similarly, Rossi et al. (2022) showed that, in university students, endorsing math-gender stereotypes favoring males was associated with greater math test anxiety in women, but not in men. These results are consistent with the view that gender stereotypes regarding math ability induce anxiety in stereotyped students. Casad et al. (2015, study 2) also observed the expected positive relationship between the math ability gender stereotype and math anxiety in 7th–8th-grade female students; however, an analogous result was found for boys, such that there was no specific gender effect (see also Rossi et al., 2022 for additional similar results). In contrast to previous studies, Vos et al. (2023) failed to detect a relationship between gender stereotype endorsement and math anxiety in young adults. These latter findings do not fit well with the idea that levels of anxiety in male and female students are differentially affected by gender stereotypes. Given the scarcity and inconclusiveness of the research, we aimed to gather additional data using a range of measures of math ability stereotypes.

1.4. The present study

Two explanations based on gender stereotypes about gender differences in math anxiety have been offered: self-report bias and math-ability beliefs, which are based on the emotional and ability facets of the stereotype, respectively. Research has focused largely on the math ability component; little effort has been devoted to understanding the emotional facet. Here, we examined both components simultaneously, with the purpose of determining the extent to which gender differences in math anxiety are influenced by both facets of math-related gender stereotypes. The following research questions were addressed in the present study:

1.4.1. Gender stereotypes about the emotional facet of math anxiety

1.4.1.1. Do adolescents endorse gender stereotypes about math anxiety?. Regarding the emotional facet of the gender stereotype of math anxiety, we aimed to investigate whether male and female adolescents held the stereotyped belief that math anxiety is experienced to a greater extent by girls than boys. The possible stereotypical perception of math anxiety was compared to the gender-stereotyped belief regarding general anxiety. Given that women are believed to experience a diverse range of emotions more than men (e.g., Plant et al., 2000), we expected to find a gender effect that would provide initial evidence about the emotional component of the stereotype of math anxiety.

1.4.1.2. Are gender differences in math anxiety due to self-report bias?. Additionally, we sought to test the hypothesis that gender differences in math anxiety are due to self-report bias. People may rate themselves differently from how they generally rate others of the same gender. For example, Hentschel et al. (2019) found that women tended to view themselves in more stereotypical terms (e.g., less assertive) compared to their views of other women. Therefore, self-rated anxiety levels may be higher than perceived anxiety levels in other students of one's own gender. It is also possible that males and female adolescents differ in terms of their perceptions about the level of anxiety experienced by other students of each gender. Both of these possibilities are consistent with the explanation that gender differences in math anxiety are attributable to self-report bias. However, if adolescents of both genders agree in terms of their perceptions of the math anxiety experienced by students of each gender, or if they believe that math anxiety affects both genders similarly (i.e., no gender difference, as in Flessati & Jamieson, 1991), the self-report bias explanation for gender differences in math anxiety would be less tenable.

1.4.2. Gender stereotypes about math ability

1.4.2.1. Do adolescents endorse gender stereotypes about math ability?. Regarding the ability facet of the math stereotype, we examined math gender stereotypes using direct and indirect explicit measures. Direct measures, which often consist of a single item, refer to the stereotype in a clear and direct manner (e.g., "males perform better in mathematics"). However, direct questions can be affected by social desirability, that is, the tendency to respond according to prevailing cultural norms. One approach to reducing this bias is to use indirect measures (Paulhus & Vazire, 2007), which also consist of explicit questions such that individuals are fully aware that they are responding to statements related to the stereotype; however, such measures are formulated in a less obvious way, for example by using more subtle items or alternative wording. For example, when measuring consciousness, Bäckström et al. (2009) exchanged the direct item "Feel little concern for others" for a more indirect item: "Believe it is better if everyone cares for himself or herself". Studies on math gender stereotypes have typically used a direct question; few have included indirect questions (e.g., Martinot et al., 2012; Nowicki & Lopata, 2017); however, we are not aware of any investigation that has compared the two types of self-report measures.

In addition, we also assessed awareness of the math gender stereotype, that is, the knowledge of adolescents about other people's beliefs regarding the math ability of male and female students. Although endorsement and awareness are related (Master, 2021), they may not be fully aligned. Children may be aware of stereotypes held by adults but not necessarily endorse them. For instance, Kurtz-Costes et al. (2014) reported differences between endorsement and awareness in relation to math gender stereotypes (see also Nasir et al. (2017) for discrepancies in the context of math-related racial stereotypes). It is therefore possible to identify discrepancies between the different measures of stereotypes.

1.4.3. Relations among gender stereotypes, math anxiety and other math-related measures

1.4.3.1. Are gender differences in math anxiety related to gender-stereotyped beliefs about math ability?. Finally, we investigated the hypothesis that gender differences in math anxiety are related to individual gender-stereotyped beliefs, in terms of both the ability and emotional facets. Given that previous research has demonstrated a relationship between math stereotyping and math performance-related measures, such as self-report grades and self-concept (e.g., Cvencek et al., 2015; Nosek et al., 2002, 2009; Passolunghi et al., 2014; Steffens et al., 2010, see Tomasetto, 2019, for a review), we also assessed these math-related outcomes to obtain convergent evidence of the effect of gender stereotyping. We expected to find that the endorsement of traditional stereotypes regarding math ability would be negatively correlated with math performance-related measures in girls. Accordingly, we also expected to find a positive relationship between the traditional stereotype and self-reported math anxiety in girls.

We had no a priori hypothesis about the relationship between the emotional facet of the math gender stereotype and math performance-related measures, although we predicted a positive relationship between this gender stereotype facet and self-reported math anxiety in girls. Females that endorse an emotional stereotype of math anxiety favoring women may expect to experience more anxiety themselves in math-related situations, and consequently would report more anxiety than boys.

2. Method

2.1. Participants

The sample consisted of 257 secondary school students (46 % girls), aged between 12 and 15 years (mean age = 13.34 years, *SD* = 1.15). The children were primarily of White ethnicity and spoke Spanish as their first language. Students in grades 7 to 10 from all classrooms of one school participated in the study. The school was located in a major urban area of a medium-sized city (Jaén) in southern Spain. In this school, families with medium socioeconomic status predominate. The proportion of immigrants in the region is <3 % of the population. Following approval by the school board, parents or legal guardians whose children were in secondary school were informed about the study. Questionnaires were administered to those children whose parents or guardians provided written consent and volunteered to participate. No compensation was given for their participation. Ethical approval was obtained from the university ethics committee. Seven participants did not complete one or more of the scales and were thus excluded from the analyses of the measures with missing data.

2.2. Materials

A measure of math anxiety and two math performance-related measures (math self-concept and self-reported grades) were administered.

2.2.1. Math-anxiety measure

The Abbreviated Math Anxiety Scale (AMAS; Hopko et al., 2003; Martín-Puga et al., 2022) is a 9-item measure that assesses anxiety in math-related academic situations and comprises two subscales. The Learning Math Anxiety (LMA) subscale comprises five items that assess math anxiety experienced in learning or instructional situations (e.g., listening to a lecture in math class). The Math Evaluation Anxiety (MEA) subscale contains four items that measure math anxiety in evaluation contexts (e.g., being given an assignment of many difficult math exercises due the next class meeting). Responses are provided via a 5-point Likert scale (1 = not nervous at all; 5 = very nervous). Scores on the LMA range from 5 to 25, and those on the MAE range from 4 to 20, with higher scores indicating greater math anxiety. The Cronbach's alpha (α) values in the current study were 0.67 and 0.85 for the LMA and MEA subscales, respectively.

2.2.2. Math-related measures

2.2.2.1. Math self-concept. The Self-Description Questionnaire (SDQ-II; Marsh, 1992) was used to assess math self-concept. This questionnaire assesses self-perceptions of four non-academic and three academic areas, as well as the overall perception of the self. For the purpose of this study, we used only the math self-concept subscale, which comprises 10 items. Students rated their skill and ability in the math domain (e.g., Mathematics is one of my best subjects) using a 6-point Likert scale (1 = false; 6 = true). Scores on the SDQ-II range from 10 to 60, where higher scores reflected better self-concept. The α in this study was = 0.88.

2.2.2.2. Math self-reported grades. The children were asked to self-report their school grades in their previous math exam. Possible scores range from 0 to 10, with higher scores indicating better performance. Self-report grades have been found to be highly positively correlated with actual grades (e.g., Sticca et al., 2017).

2.2.3. Gender-stereotype measures

Five different gender stereotype measures for the emotional and ability facets were administered. Table 1 presents a description of each measure.

2.2.3.1. Math-anxiety gender stereotype. A scale to specifically assess gender-stereotyped beliefs about math anxiety was developed for the present study. It comprises four items from the AMAS (items 2, 4, 6, and 9) that describe school situations involving math evaluation or learning math concepts (see Appendix A). Participants were asked to rate the level of anxiety that two classmates (a boy and a girl) might experience in different math situations (e.g., listening to a lecture in math class). Responses are provided via a 5-point Likert scale (1 = not nervous at all; 5 = very nervous). The α values for the scales assessing perceived math anxiety in boys and girls were 0.70 and 0.72, respectively.

2.2.3.2. Anxiety-gender stereotype. A scale was developed to specifically assess the gender stereotype pertaining to anxiety in general, similar to a measure previously used to assess gender-stereotyped beliefs about emotional intelligence (López-Zafra & García-Retamero, 2021). The developed scale consists of 12 anxiety-related emotional words: 6 negative (e.g., worry) and 6 positive (e.g., happiness) names. The words were taken from the State Trait Anxiety Inventory STAI Form X-1 (Spielberger et al., 1983) in its Spanish form (Seisdedos, 1990) (see Appendix B). Participants rated how applicable each item was to boys and girls using a 5-point Likert scale (1 = a little, very much = 5). Two scores were computed (one for boys and the other for girls) by summing the answers given to each item; positive items were reverse-scored. Higher scores indicate higher perceived anxiety in others. The α values for the scales assessing attributes in boys and girls were = 0.62 and = 0.69 respectively.

2.2.3.3. Math-gender stereotype. A Math Gender Stereotype scale was adapted from the Explicit Mathematics Stereotype Test developed by Nowicki and Lopata (2017). The developed scale comprises eight positive (e.g., brilliant) and eight negative (e.g., fail) adjectives that were used to describe boys' and girls' math performance (see Appendix C). Items were presented in two tables, each having one column for boys and another for girls. Participants were asked to indicate how well each word describes boys and girls (1 = a little, very much = 5). Two scores were obtained (one for boys and the other for girls) by summing the

Table 1
Description of the gender-stereotype measures.

Measure	Description
Emotional facet	
Math-anxiety gender stereotype	Rate the level of anxiety that a male and female classmate might experience in four different math situations (e.g., listening to a lecture in math class)
Anxiety-gender stereotype	Rate how applicable a series of anxiety-related words (e.g., worried) are to boys and girls
Math-ability facet	
Math-gender stereotype	Rate how well a series of positive and negative adjectives (e.g., brilliant) describe the math performance of boys and girls
Math-gender stereotype endorsement	Indicate the perceived math ability of men and women
Math-gender stereotype awareness	Indicate the level of math ability that people in general perceive men and women to possess

Note: for each measure, participants were asked to separately rate boys and girls.

answers given to each item; negative items were reverse-scored. Higher scores indicate higher ability. In this study, the α for the scales describing boys' and girls' math performance was 0.84 in both cases.

2.2.3.4. Math-gender stereotype endorsement. A single item, from Bonnot and Croizet (2007), was used as a direct measure of math stereotype endorsement. Participants were asked to indicate the math ability that they believe men and women possess using a 7-point Likert scale (1 = very low, excellent = 7).

2.2.3.5. Math-gender stereotype awareness. An additional item, also from Bonnot and Croizet's (2007) study, was included to assess stereotype awareness. Participants were asked to estimate the math ability that people generally perceive men and women to possess. Responses were provided via a 7-point Likert scale (1 = very low, excellent = 7).

For each of the five gender stereotype measures, an additional score was computed by subtracting the score for girls from that for boys, with values ranging from −4 to 4 (for a similar scoring procedure, see Cvencek et al., 2011). Positive scores indicate that participants perceive boys have more math anxiety than girls, for example, and vice versa.

2.2.3.6. Validity of the stereotype measures. Given that the measures of the emotional-facet of math gender stereotype were newly developed for this study, in addition to reliability, it was particularly important to gather some evidence of validity. There was a moderate correlation (r = 0.30) between the math-anxiety gender stereotype and anxiety-gender stereotype, which was of similar magnitude to the correlation between actual measures of math anxiety and general anxiety (r = 0.35) reported in Hembree's (1990) meta-analysis.

Regarding the measures of the math-ability facet of the stereotype, a moderate correlation (r = 0.41) was found between measures that assessed adolescents' own beliefs (math-gender stereotype and math-gender stereotype endorsement), which suggests reasonable concurrent validity. In contrast, the correlations for measures from different informants (adolescents vs. adults) were weaker. Specifically, the correlation between math-gender stereotype and math-gender stereotype awareness was 0.17, whereas the correlation between math-gender stereotype endorsement and math-gender stereotype awareness was 0.26. This latter correlation is in line with the one reported by Kurtz-Costes et al. (2014), who also used single items to assess endorsement and awareness of math stereotypes.

Finally, no significant correlations were observed between the measures corresponding to different facets (emotional and ability) of the stereotype. Overall, the results revealed moderate correlations for measures assessing similar constructs and no associations between indicators of different constructs. These results provide some evidence of convergent validity among the measures of each facet of math-related gender stereotypes.

2.3. Procedure

Two versions of the questionnaires were constructed. In one version, items about boys were presented first on the answer sheet, followed by items that referred to girls. In the second version, the order was reversed. One version was assigned to each class. Questionnaires were group administered in the same fixed order presented in this section. Measures were completed in the classroom during one session lasting about 45 min.

2.4. Data analysis

Preliminarily, we aimed to determine whether the stereotype measures differed as a function of participant gender and gender group rated (target gender). To this end, a series of mixed-model ANCOVAs was conducted on each measure of both facets of stereotypes: emotional (math anxiety and anxiety) and ability (math gender stereotype, stereotype endorsement, and awareness). In these analyses, participant gender was included as a between-participant factor and target gender as a within-participant factor. Given that math-anxiety related measures may change across the secondary school years, age (in months) was included as a covariate.

For the math-anxiety gender stereotype, an additional analysis was performed to compare the self-reported math anxiety of boys and girls with the perceived levels of math anxiety of other students of the same gender. Two variables were included in this analysis to ensure equivalent scores. Self-rated math anxiety (me) was calculated as the sum of the scores for the same four items of the AMAS included in the math-anxiety gender stereotype measure. A measure of perceived math anxiety in same-gender classmates was obtained based on the math anxiety scores assigned to other students of the same gender as the respondent. To address this issue, a 2 × 2 (participant gender × rated student [me, same-gender classmate]) ANOVA was run.

Finally, to determine whether the different measures of gender stereotypes (e.g., about math anxiety) were related to different outcomes (e.g., math self-reported grades), we followed the statistical approach used by Nosek et al. (2002; see also Cvencek et al., 2015). The idea underpinning these moderator analyses was that the interaction should be statistically significant if stereotypes have opposing effects on the outcomes for boys and girls. Therefore, the main predictor of interest here was the interaction term between participant gender and stereotype. Two-step hierarchical regression analyses were performed, in which gender stereotypes and participant gender (coded as girl = 0, boy = 1) were entered in the first step, and the interaction between both predictors (gender stereotype × participant gender) was entered in the second step for test for moderation. Thus, we conducted a total of 20 two-step hierarchical regression analyses (4 outcomes by 5 gender stereotypes). All of the continuous predictors were centered. A Bonferroni correction was applied to control for multiple testing, such that the alpha value was set at 0.0025 (i.e., 0.05/20) for the interactions.

3. Results

3.1. Bivariate correlations among gender-stereotype and math-related measures

Bivariate correlations among the different gender stereotype and math related measures are presented in Table 2. Notably, measures pertaining to the same facets of math gender stereotypes were related to each other, whereas measures of different aspects were unrelated. These results suggest that the emotional and ability facets of the math-gender stereotype are unrelated.

3.2. Gender differences in gender-stereotype measures

One objective was to determine whether the gender stereotype measures (in their emotional and math-ability facets) differed as a function of participant gender and gender group. Table 3 provides the means and standard deviations of the scores for the gender-stereotype measures, and Fig. 1 shows the gender-stereotype scores (calculated as the difference between the estimates for boys and girls) on each measure.

3.2.1. Emotional facet

3.2.1.1. Math-anxiety gender stereotype. The 2 (participant gender) × 2 (target gender) ANCOVA (with age of the rater as covariate) on math-anxiety gender stereotype scores revealed, after controlling for the effect of age, a significant main effect of target gender only, $F(1, 247) = 92.29$, $p < .001$, $\eta_p^2 = 0.27$, where the scores were higher for target girls ($M = 2.68$, $SD = 0.7$) than boys ($M = 2.24$, $SD = 0.65$). The absence of an

Table 2
Correlation coefficients among the math anxiety, math related performance, and gender stereotype measures.

	1	2	3	4	5	6	7	8	9
1. Learning math anxiety		0.64**	−0.46**	−0.37**	0.02	0.04	−0.27*	−0.12	−0.12
2. Math evaluation anxiety	0.69**		−0.61**	−0.51**	−0.11	0.03	−0.30**	−0.11	−0.15
3. Math self-concept	−0.57**	−0.65**		0.70**	−0.02	−0.03	0.40**	0.15	0.19*
4. Math self-reported grades	−0.51**	−0.55**	0.70**		−0.08	−0.06	0.25*	0.20**	0.14
5. Math-anxiety gender stereotype	−0.09	−0.03	0.01	−0.12		0.27**	−0.01	−0.02	−0.06
6. Anxiety-gender stereotype	−0.23*	−0.11	0.05	−0.03	0.29*		−0.12	−0.08	0.01
7. Math-gender stereotype	0.08	0.22*	−0.17	−0.14	0.11	0.03		0.40**	0.20*
8. Math-gender stereotype endorsement	−0.00	0.11	−0.10	−0.16	0.08	0.16	0.46**		0.25*
9. Math-gender stereotype awareness	0.06	0.17	−0.01	0.05	−0.06	−0.05	0.11	0.27*	

Note. Correlations for girls ($n = 115$) are shown below the diagonal, and correlations for boys ($n = 135$) are shown above the diagonal.
* $p < .05$.
** $p < .001$.

Table 3
Means and standard deviations of the scores for each gender-stereotype measure as a function of participant gender and target gender.

Participant gender	Range	Target gender	
		Boys	Girls
		Mean (*SD*)	Mean (*SD*)
Emotional facet			
Math-anxiety gender stereotype			
Boys	1–5	2.26 (0.67)	2.64 (0.78)
Girls	1–5	2.23 (0.63)	2.72 (0.59)
Anxiety-gender stereotype			
Boys	1–5	2.41 (0.43)	2.76 (0.52)
Girls	1–5	2.36 (0.38)	2.82 (0.43)
Math-ability facet			
Math-gender stereotype			
Boys	1–5	3.44 (0.52)	3.61 (0.49)
Girls	1–5	3.26 (0.5)	3.5 (0.46)
Math-gender stereotype endorsement			
Boys	1–7	5.21 (1.2)	5.08 (1.17)
Girls	1–7	5.03 (1.26)	5.02 (1.12)
Math-gender stereotype awareness			
Boys	1–7	5.06 (1.32)	4.44 (1.5)
Girls	1–7	4.97 (1.49)	4.24 (1.42)

interaction with participant gender indicated that both gender groups perceived that women have higher levels of math anxiety. Age was a statistically significant covariate, $F(1, 247) = 26.78$, $p < .001$, $\eta_p^2 = 0.098$, $r = 0.25$, i.e., perceived math anxiety increased with age. The means and standard deviations are reported in Table 3, and the gender-stereotype score (as the difference between the estimates for boys and girls) is depicted in Fig. 1A.

3.2.1.2. Self-reported math anxiety levels vs. perceived math anxiety in other students. To determine whether gender differences in math anxiety are due to self-report bias, a key analysis was the comparison of the self-reported math anxiety of boys and girls with the perceived levels of math anxiety of other students of the same gender. Fig. 2 displays the self-rated math anxiety scores as well as the perceived math anxiety scores for the boys and girls.

The 2 × 2 (participant gender × rated student [me, same-gender classmate]) ANCOVA (with age of the rater as a covariate) showed that, after controlling for the effect of age, there was a main effect of gender, $F(1, 247) = 38.35$, $p < .001$, $\eta_p^2 = 0.13$, as expected, where girls ($M = 2.66$, $SD = 0.68$) received higher scores than boys ($M = 2.21$, $SD = 0.72$). The main effect of rated student reached also significance, $F(1, 247) = 5.35$, $p = .022$, $\eta_p^2 = 0.02$, where the scores of self-reported math anxiety (i.e., me) ($M = 2.36$, $SD = 0.78$) were slightly lower than the perceived math anxiety scores for same-gender classmates ($M = 2.47$, $SD = 0.67$). The interaction effect was not significant ($F < 1$), indicating that boys and girls underestimated their own level of math anxiety to the

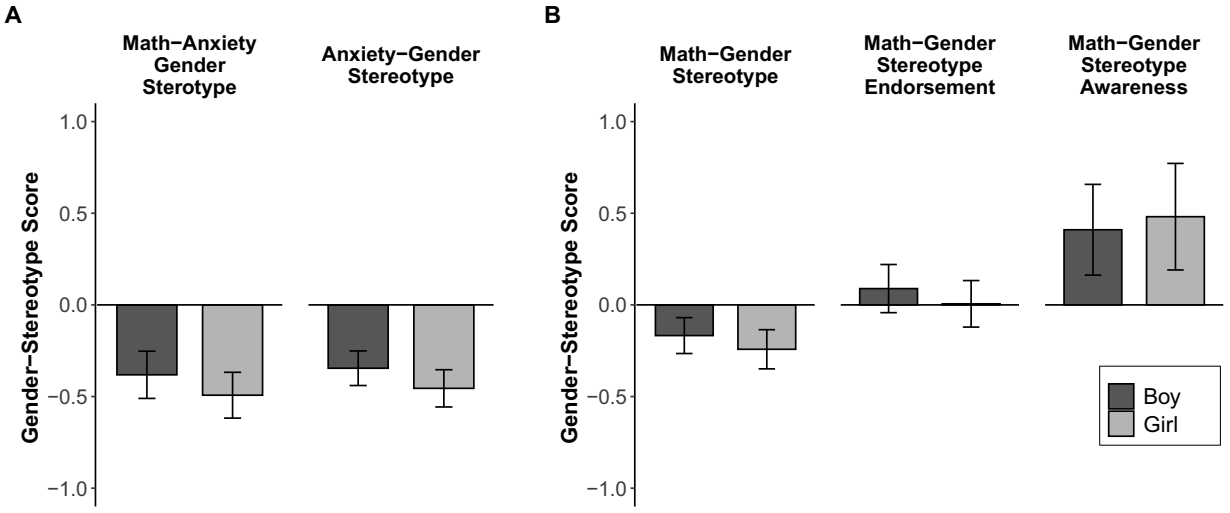

Fig. 1. Gender-stereotype scores as a function of the stereotype measure and participants' gender.
Note. The gender-stereotype score represents the difference between the estimates for boys and girls on each stereotype measure. Positive values indicate stereotypes favoring boys, and negative values reflect stereotypes favoring girls. Error bars represent standard error. Panel A: Measures of the emotional facet of the stereotype. Panel B: Measures of the math-ability facet of the stereotype.

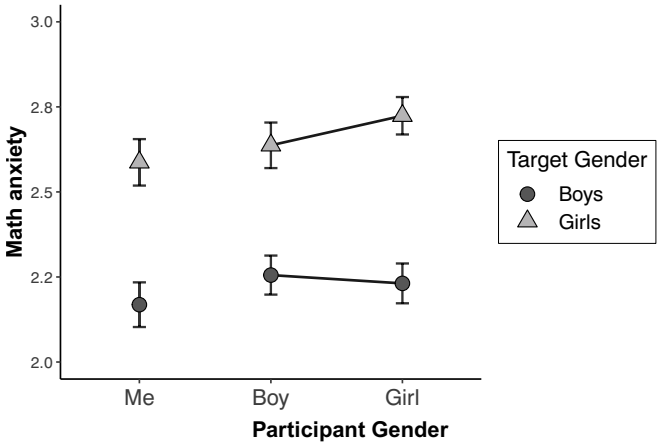

Fig. 2. Self-rated math anxiety, and ratings for male and female classmates as a function of participant (rater) gender.
Note. The first category on the x-axis (Me) displays self-ratings of math anxiety reported by boys and girls. The second and third categories represent the levels of math anxiety in boys and girls perceived by the participants in each gender group. Error bars represent standard errors.

same extent compared with the perceived level of math anxiety in their same-gender classmates. Age was significantly positively related to the scores, $F(1, 247) = 16.87$, $p < .001$, $\eta_p^2 = 0.06$, $r = 0.20$, reflecting an increase in self-reported and perceived math anxiety with age. In summary, the boys and girls experienced different levels of math anxiety, and both perceived that the levels of math anxiety were slightly higher in other students of the same gender. The medium effect size obtained indicates considerable overlap between the distributions of math anxiety for boys and girls (see Devine et al., 2012).

3.2.1.3. Anxiety-gender stereotype. To examine possible gender differences in perceptions of anxiety exhibited by girls and boys, a 2 × 2 (participant gender × target gender) ANCOVA with age of the rater as a covariate was performed on anxiety-gender stereotype scores. Means and standard deviations are displayed in Table 3 and the gender-stereotype score (as the difference between the estimates for boys and girls) is depicted in Fig. 1A. The analysis showed that, after controlling for the effect of age, only the main effect of target gender was significant, $F(1, 247) = 136.54$, $p < .001$, $\eta_p^2 = 0.36$, where the scores were higher for target girls ($M = 2.79$, $SD = 0.48$) than target boys ($M = 2.39$, $SD = 0.41$). There was a positive effect of the covariate, $F(1, 247) = 23.21$, $p < .001$, $\eta_p^2 = 0.09$, $r = 0.21$, as well as an interaction between the covariate and target gender, $F(1, 247) = 12.35$, $p < .001$, $\eta_p^2 = 0.05$, which was driven by an increase in perceived anxiety with age for girls ($r = 0.34$, $p < .001$) but not for boys ($r = 0.10$, $p = .101$). Thus, raters of both genders agreed that girls exhibit more general anxiety than boys, and these differences become more pronounced with age.

Given that an effect of target gender was observed for the two measures of math gender stereotypes related to the emotional facet, it appeared possible that gender stereotypes about anxiety could fully account for the effect of target gender on gender stereotypes about math-anxiety. In a subsequent analysis, we fitted a linear mixed model with math-anxiety gender stereotype scores as the outcome variable, and target gender (girls coded as 0 and boys as 1) and anxiety gender stereotype score as predictors. The results showed that both predictors were significant. Female gender, $\beta = 0.25$, $t(299) = 5.06$, $p < .001$, and anxiety gender stereotype, $\beta = 0.45$, $t(480) = 7.36$, $p < .001$, led to an increase in math-anxiety gender stereotype scores. Therefore, the effect of target gender remained after controlling for the effect of gender stereotype on general anxiety.

3.2.2. Math ability facet

3.2.2.1. Math-gender stereotype. To evaluate possible gender differences in the math ability stereotype, a 2 × 2 (participant gender × target gender) ANCOVA with the age of the rater as a covariate was conducted for math-gender stereotype scores (see Table 3 for means and *SD*s and Fig. 1B for the gender-stereotype score). Results showed that the main effects were significant after controlling for the effect of age. Regarding the effect of participant gender, $F(1, 247) = 8.75$, $p = .003$, $\eta_p^2 = 0.03$, boys ($M = 3.52$, $SD = 0.51$) reported higher scores than girls ($M = 3.38$, $SD = 0.49$). In terms of the effect of target gender, $F(1, 247) = 32.96$, $p < .001$, $\eta_p^2 = 0.12$, girls ($M = 3.56$, $SD = 0.48$) received higher scores than boys ($M = 3.36$, $SD = 0.52$). The age covariate, $F(1, 247) = 19.07$, $p < .001$, $\eta_p^2 = 0.07$, $r = -0.21$, and its interaction with target gender, $F(1, 247) = 13.61$, $p < .001$, $\eta_p^2 = 0.05$, were also significant. The interaction was due to a reduction in girls' perceived math ability with age ($r = -0.36$, $p < .001$), which was not observed in boys ($r = -0.08$, $p = .203$). Therefore, in opposition to the traditional stereotype that men have higher mathematics ability, the raters of both genders in this study perceived girls' math performance to be superior to that of boys. Nonetheless, these differences decreased with age mainly due to a steeper reduction of girls' perceived math ability with age. Thus, younger adolescents' beliefs were more favorable toward girls, while older adolescents' beliefs tended to be more egalitarian.

3.2.2.2. Math-gender stereotype endorsement and awareness. To examine potential gender differences in the math-gender stereotype depending on who makes the assessment: the participant (endorsement) or people in general (awareness), a 2 × 2 × 2 (participant gender × target gender × informant [participant, people]) ANCOVA, with age of the rater as covariate, was performed on the math-gender stereotype scores (see Table 3 and Fig. 1B). After controlling for the effect of age, the main effects of target gender, $F(1, 247) = 17.95$, $p < .001$, $\eta_p^2 = 0.07$, and informant, $F(1, 247) = 39.20$, $p < .001$, $\eta_p^2 = 0.14$, and their interaction, $F(1, 247) = 17.47$, $p < .001$, $\eta_p^2 = 0.07$, were significant. To decompose the two-way interaction, separate analyses were conducted for each informant. When the informant was the participant (i.e., endorsement) there was no main effect of participant gender or target gender, and no interaction effect (all $ps > 0.3$). This implies that both boys and girls consider students of both genders to be similar in terms of math proficiency, reflecting an egalitarian view. In contrast, when the informant was people in general (i.e., awareness) the effect of target gender was significant, $F(1, 248) = 21.61$, $p < .001$, $\eta_p^2 = 0.08$, with a lower score seen for girls ($M = 4.35$, $SD = 1.4$) than boys ($M = 5.02$, $SD = 1.4$). Participant gender, age (as a covariate), and the interaction effect did not approach significance. These results indicate that students perceive that people hold traditional views about gender differences in math ability, that is, men are believed to be more proficient than women in mathematics.

3.3. Relations among gender-stereotype and math-related measures

A final set of analyses were conducted to investigate whether the different measures of gender stereotypes (e.g., about math anxiety) had an effect on the different outcomes (e.g., math self-reported grades). A series of two-step hierarchical regression analyses were run, with gender stereotypes and participant gender were entered as predictors in the first step, and their interaction was entered in the second step. Results for all the models are displayed in Table 4.

There was a gender effect for the math anxiety and math self-concept outcomes. Girls showed lower math self-concept scores, and higher learning and evaluation math anxiety levels. More importantly, interactions between gender and the math-gender stereotype measure were observed for math evaluation anxiety, math self-reported grades and math self-concept, indicating that the slopes of the regression lines

Table 4
Summary of regression analyses predicting math anxiety and math-performance related scores from measures of math-gender stereotypes and gender.

Outcome	Gender stereotype (predictor)	Step 1										Step 2					R^2
		Gender stereotype					Gender					Gender stereotype × gender					
		b	*SE*	*β*	*t*	*p*	*b*	*SE*	*β*	*t*	*p*	*b*	*SE*	*β*	*t*	*p*	
Math evaluation anxiety																	
Math-anxiety gender stereotype		−0.12	0.40	−0.03	−0.30	0.765	−2.39	0.50	−0.29	−4.75	<0.001	−0.33	0.51	−0.06	−0.65	0.515	0.09
Anxiety-gender stereotype		−0.40	0.37	−0.10	−1.06	0.291	−2.40	0.51	−0.29	−4.75	<0.001	0.51	0.51	0.09	1.01	0.314	0.09
Math-gender stereotype		0.81	0.36	0.20	2.27	0.024	−2.42	0.49	−0.29	−4.97	<0.001	−2.04	0.49	−0.36	−4.17	<0.001*	0.15
Math-gender stereotype endorsement		0.43	0.40	0.10	1.08	0.282	−2.44	0.50	−0.29	−4.86	<0.001	−0.84	0.51	−0.16	−1.64	0.101	0.10
Math-gender stereotype awareness		0.61	0.35	0.15	1.74	0.084	−2.43	0.50	−0.29	−4.89	<0.001	−1.25	0.50	−0.21	−2.51	0.013	0.11
Learning math anxiety																	
Math-anxiety gender stereotype		−0.28	0.30	−0.09	−0.93	0.355	−1.02	0.38	−0.17	−2.66	0.008	0.33	0.39	0.08	0.86	0.393	0.03
Anxiety-gender stereotype		−0.69	0.28	−0.23	−2.47	0.014	−0.97	0.38	−0.16	−2.56	0.011	0.80	0.38	0.19	2.11	0.036	0.05
Math-gender stereotype		0.23	0.28	0.08	0.84	0.402	−1.00	0.37	−0.17	−2.68	0.008	−1.04	0.38	−0.25	−2.76	0.006	0.07
Math-gender stereotype endorsement		−0.01	0.30	0.00	−0.05	0.963	−1.02	0.38	−0.17	−2.67	0.008	−0.32	0.39	−0.08	−0.82	0.413	0.04
Math-gender stereotype awareness		0.17	0.27	0.06	0.64	0.521	−1.04	0.38	−0.17	−2.74	0.007	−0.54	0.38	−0.13	−1.42	0.157	0.04
Math self-concept																	
Math-anxiety gender stereotype		0.17	1.11	0.01	0.15	0.877	6.23	1.41	0.27	4.41	<0.001	−0.34	1.44	−0.02	−0.23	0.816	0.07
Anxiety-gender stereotype		0.53	1.05	0.05	0.51	0.612	6.21	1.42	0.27	4.38	<0.001	−0.87	1.42	−0.06	−0.62	0.539	0.08
Math-gender stereotype		−1.87	0.98	−0.16	−1.90	0.058	6.09	1.34	0.27	4.56	<0.001	6.44	1.34	0.41	4.81	<0.001*	0.17
Math-gender stereotype endorsement		−1.15	1.10	−0.10	−1.04	0.299	6.22	1.40	0.27	4.44	<0.001	2.72	1.43	0.18	1.91	0.058	0.09
Math-gender stereotype awareness		−0.14	0.99	−0.01	−0.14	0.885	6.28	1.40	0.27	4.50	<0.001	2.42	1.39	0.15	1.73	0.084	0.09
Math self-reported grades																	
Math-anxiety gender stereotype		−0.22	0.18	−0.13	−1.27	0.207	0.23	0.22	0.07	1.03	0.304	0.08	0.23	0.04	0.35	0.725	0.01
Anxiety-gender stereotype		−0.05	0.17	−0.03	−0.31	0.759	0.22	0.22	0.06	0.97	0.335	−0.06	0.23	−0.03	−0.27	0.787	0.01
Math-gender stereotype		−0.24	0.16	−0.14	−1.50	0.135	0.19	0.22	0.05	0.87	0.383	0.69	0.22	0.29	3.16	0.002*	0.05
Math-gender stereotype endorsement		−0.30	0.17	−0.17	−1.70	0.090	0.20	0.22	0.06	0.92	0.359	0.63	0.22	0.27	2.78	0.006	0.04
Math-gender stereotype awareness		0.09	0.16	0.05	0.54	0.587	0.21	0.22	0.06	0.94	0.348	0.17	0.22	0.07	0.75	0.454	0.01

* Indicates a significant interaction after Bonferroni correction ($p < .0025$).

varied according to gender (see Fig. 3). The interactions between gender and the other measures of gender stereotypes did not reach significance.

To follow up on the significant interactions, simple regression analyses were conducted, separately for boys and girls, on each outcome, including the math-gender stereotype score as a predictor. The relationship between gender stereotype and math evaluation anxiety was positive for girls and negative for boys ($\beta = 0.22$, $t = 2.37$, $p = .02$; and $\beta = -0.30$, $t = -3.56$, $p < .001$ respectively). In contrast, the opposite pattern was observed for math self-concept ($\beta = -0.17$, $t = -1.88$, $p = .06$ for girls; and $\beta = 0.40$, $t = 5.06$, $p < .001$ for boys) and math self-reported grades ($\beta = -0.15$, $t = -0.14$; $p = .14$ for girls; and $\beta = 0.25$, $t = 3.03$, $p = .003$ for boys). In summary, differences in math gender stereotypes were differentially related to math anxiety, math self-concept and math self-reported grades. For boys, the larger the math gender stereotype (favoring males), the lower the math evaluation anxiety, the higher the math self-concept and the higher the mathematical achievement. The relationships for girls were in the opposite direction, but only reached significance for math evaluation anxiety.

4. Discussion

The present study sought to examine gender-stereotyped beliefs related to math anxiety, in terms of ability and emotion. Novel findings were obtained. Firstly, secondary school students held a stereotyped belief regarding the emotional facet of math anxiety, perceiving female adolescents as more math-anxious prone than male students. Raters of both genders agreed with respect to the perceived level of math anxiety of students of each gender. Secondly, regarding the math-ability facet of the stereotype, results differed depending on the measure from a traditional to a female-favoring stereotype. Finally, ability-related, gender stereotypes about math ability, but not about emotion, were related to math anxiety as well as to other math-related performance measures.

4.1. Gender stereotypes about the emotional facet of math anxiety

A main objective of this study was to determine whether boys and girls hold the stereotyped belief that math anxiety is experienced to a different extent by male and female adolescents. The results clearly indicate that both gender groups believed that female students experience higher levels of math anxiety than male students. It is noteworthy that the pattern of gender differences in math anxiety perceived by girls and boys was highly consistent with the actual measures of math anxiety for each gender group. This correspondence indicates that, in our sample, gender stereotypes regarding math anxiety have high consensual accuracy (Jussim et al., 2018).

The results regarding beliefs about math anxiety are consistent with the pattern of gender differences found for beliefs about anxiety in general: both boys and girls believed that females are more likely than males to experience the emotions associated with general anxiety (e.g., nervousness, worry). However, it is important to note that differences in perceived math anxiety between girls and boys persisted even when controlling for perceived general anxiety. This suggests that math-anxiety gender stereotypes cannot be fully explained in terms of general-anxiety gender stereotypes and that different factors may determine these two types of gender stereotypes. These novel findings are in agreement with previous evidence that other negative-valenced emotions (such as distress, sadness, fear, shame, and guilt) are also perceived to be experienced more by women (Plant et al., 2000), and they are also consistent with gender differences on objective measures of anxiety (e.g., Chapman et al., 2007; Costa et al., 2001; Feingold, 1994; see McLean & Anderson, 2009, for a review). It should be noted here that the gender effects were large. It is not unusual to find large gender effects for emotional stereotypes. Plant et al. (2000) reported similar effect sizes for sadness and fear in adults, and Koenig (2018) noted substantial effects for the emotional attribute in adolescents.

In this study, both gender groups perceived math anxiety in other students (boys or girls) in a remarkably similar way. Furthermore, the levels of self-reported math anxiety and perceived math anxiety in same-gender students were comparable; both of these findings cast doubt on the idea that the lower anxiety reported by men reflects less reluctance to openly admit anxiety (Hill & Saranson, 1966, cit. in Zeidner, 1998), and that the higher levels reported by female students are due to their greater willingness to disclose feelings of anxiety (Ashcraft, 2002; Ashcraft & Ridley, 2005) or bias toward using the higher end of the scale. If, for example, female students had overreported their own levels of math anxiety, their self-ratings would be higher than the perceived math-anxiety levels of other girls; however, this was not the case. It should be noted that boys tended to report slightly lower levels of math anxiety when assessing themselves than when assessing other boys. However, this effect was not specific to male students; girls showed the same pattern. This very small difference may be because the adolescents perceived the manifestations of math anxiety in others to be somewhat more evident than in themselves. The small magnitude of the difference suggests that the overall similarity between the scores deserves more consideration. Therefore, the extant data are not compatible with the idea that gender differences in math anxiety reflect gender differences in the proneness to openly admit anxiety.

The view that boys and girls might be biased toward different scale values may be rooted in the assumption that gender differences in anxiety are a psychometric artefact (Lowe, 2014; Reynolds, 1998). However, recent research aimed at math-anxiety scale validation has revealed high levels of measurement invariance (e.g., scalar invariance) across genders for math anxiety scales (e.g., Caviola et al., 2017; Martín-Puga et al., 2022), where the scales measure the same construct in a comparable way for both genders.

Furthermore, self-reported math anxiety levels corresponded quite

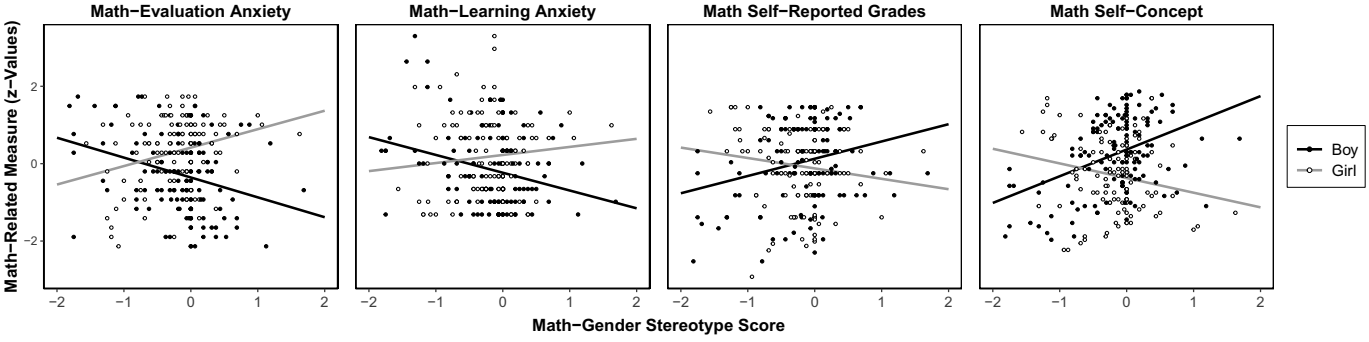

Fig. 3. Scatter plots of standardized scores for math-related measures as a function of math-gender stereotype and gender.
Note. Each point indicates an individual participant. Lines represent simple slopes for each gender based on linear regression coefficients. Interactions between gender and math-gender stereotype were observed for math-evaluation anxiety, math self-reported grades and math self-concept measures; the same interaction for math learning anxiety did not reach significance.

closely with perceived math anxiety in other students of both genders. In other studies of psychological dimensions as personality traits, high concordance was also found between observed and self-reported gender differences (e.g., Löckenhoff et al., 2014). Overall, these findings are consistent with previous research that indicates that, in general, gender stereotypes about emotions accurately reflect gender differences in actual behavioral measures (Brody & Hall, 2010). According to the stereotypes as knowledge hypothesis (see Jussim et al., 2021), the accuracy of these stereotypes may be explained by the fact that they constitute everyday knowledge that is representative of behaviors typically observed in the school context.

The present research reinforces the idea that male and female students actually experience different levels of math anxiety, and that these levels are similar to those perceived in other students of the same gender. Therefore, our study found no evidence for the hypothesis of gender response bias to account for gender differences in math anxiety. The first implication of these results is that girls should be considered as more vulnerable to math anxiety than boys. An additional implication is that math anxiety symptoms can be observed by other students. This raises the intriguing possibility that social transmission between peers might be a pathway for the development of math anxiety.

4.2. Gender stereotypes about math ability

Regarding the stereotype related to math ability, the outcomes differed depending on the type of measure considered. Using the relatively indirect measure of rating each gender using positive and negative adjectives (e.g., brilliant, fail), both gender groups perceived female adolescents as being somewhat more proficient in mathematics, which goes against the traditional gender stereotype. Applying a similar measure to younger participants (4th and 6th grade), Nowicki and Lopata (2017) observed that boys and girls both held beliefs that favored their own gender group. It is possible that, with age, beliefs tend toward egalitarianism or favor women (Passolunghi et al., 2014). Indeed, recent studies have reported that adolescents, the group of interest in the current study, may endorse either egalitarian or female-favoring stereotypes (Bieg et al., 2015; Vuletich et al., 2020). Notably, we found a trend toward more egalitarian beliefs in later secondary school years. These changes in beliefs may be driven by increased knowledge and experience, as well as maturation in terms of cognitive development and perspective-taking (Leaper, 2015). Stereotyped beliefs in adolescence may also be influenced by the greater sensitivity to social cues and contextual changes associated with secondary school, where assessments become more standardized and the scores of other classmates (of both genders) are thus more visible and readily comparable.

On the other hand, using a more direct measure of stereotype endorsement, we found that the adolescents, irrespective of gender, held egalitarian beliefs, a neutral position that was also reported in previous research (e.g., Ambady et al., 2001; Morrissey et al., 2019). Finally, concerning the awareness (or knowledge) measure of the math gender stereotype, the adolescents in both gender groups considered that other people hold the traditional gender stereotype favoring male over female students. These results are consistent with a number of previous studies on adolescents and young adults (Bonnot & Croizet, 2007; Steffens et al., 2010, study 2; but see Kurtz-Costes et al., 2014; Martinot et al., 2012). Therefore, similar to math stereotype endorsement, results regarding stereotype awareness are also diverse.

It is not uncommon to find that participants respond in different ways depending on the stereotype measure employed. For example, implicit and explicit math stereotypes may only be weakly associated, or even completely unrelated (Cvencek et al., 2011; Galdi et al., 2014; Passolunghi et al., 2014; Vuletich et al., 2020); this is in line with research on stereotypes in general (see the meta-analysis by Hofmann et al., 2005). Such divergence has been explained as the result of dissociation between implicit and explicit stereotypes, and their underlying mechanisms (e.g., Cvencek et al., 2011; Nosek et al., 2002). The present study shows that responses may differ even for explicit measures, depending on how direct or indirect they are. In this study, the responses to the more indirect questions favored females. This may indicate that students base their judgements on objective gender differences in school performance, where they may have observed academic superiority of girls over boys (for a similar interpretation, see Vuletich et al., 2020). In contrast, the direct question in this study, which induced a neutral response, is likely to be affected to a greater extent by social desirability. Since modern Western societies promulgate egalitarian values (e.g., Eagly et al., 2020), the participants may merely have been demonstrating their adherence to these socially normative values when answering the direct question. Thus, the participants' responses to the indirect measure, given the greater degree of spontaneity and less careful consideration of the values involved, might better reflect their true beliefs about gender differences in math ability. However, this interpretation should be treated with some caution, as the two measures differed not only in their approach (direct vs. indirect), but also in the target (children vs. adults) and response format (single vs. multiple questions). Additionally, when children respond to the indirect question, they may employ different strategies, such as thinking about a specific child or about children in general. It would be useful to determine which strategy they use. Therefore, validation of our interpretation is an important target for future research.

There was also a discrepancy between stereotype endorsement and stereotype awareness. Although adolescents held a stereotyped belief that favored females, they perceived that adults' beliefs favored males. It could be argued that awareness of this stereotype may have negative consequences for some girls, because perceiving these ideas may make them feel insecure and worried in situations requiring mathematics. This may be more likely in girls who are not able to refute stereotyped beliefs that do not favor their gender. Indeed, in the context of race stereotypes, Nasir et al. (2017) showed that students who were aware of racial stereotypes that they did not endorse, but lacked effective counterarguments, experienced poorer academic outcomes. Although no association was found between awareness and measures related to mathematics (see below) in the current study, it might be worthwhile to investigate the rationales given by children to justify their gendered beliefs about math ability.

4.3. Relations among gender stereotypes and math-related measures

One goal of the current study was to determine whether and to what extent gender stereotypes related to gender differences in math anxiety at the individual level. Rather than focusing only on math anxiety, we also included math performance-related measures to obtain convergent evidence of the effect of gender stereotyping. An important finding was that individuals' endorsement of stereotypes in terms of the ability facet, but not the emotional one, was related to math anxiety and to other math-related measures. It should be stressed that the factor contributing to math anxiety was the individual's stereotyped beliefs rather than the group's beliefs. Thus, girls who maintained a traditional view were more prone to math anxiety, irrespective of the level of agreement within their group with that belief. Furthermore, not all of the measures of math ability stereotypes were related to academic outcomes. The more indirect measure (math-gender stereotype), but not the direct one (stereotype endorsement), specifically predicted math anxiety and math performance-related outcomes. As discussed above, it may be that the indirect measure is less affected by social desirability bias and might better reflect the true beliefs.

A math stereotype favoring males (assessed with the indirect measure) was associated with lower levels of math evaluation anxiety for boys and higher scores for girls. Bieg et al. (2015) used a somewhat different math anxiety measure and observed a similar relationship, although it was limited to girls (see also Rossi et al., 2022 for a measure of test math anxiety). Stereotype threat theory could explain present results (Schmader & Johns, 2003; Spencer et al., 1999; Steele, 1997),

albeit only for female students. Stereotype threat refers to a decrease in performance that occurs when an in-group is negatively stereotyped. From this perspective, an effect would be expected only in girls; however, the opposite relationship between math anxiety and gender stereotyping was also observed in boys. Moreover, a stereotype favoring boys was associated not only with math evaluation anxiety, but also with positive math self-concept and higher math self-reported grades for male students. Therefore, these results suggest that gender stereotypes about math ability may benefit, rather than undermine, math-related outcomes, resembling the stereotype lift effect, that is, the increase in performance that occurs when an out-group is negatively stereotyped (Walton & Cohen, 2003). General frameworks, such as expectancy-value theory (Eccles, 1994, 2009; Wigfield & Eccles, 2000) may explain the different relationships that we found between math-related measures. Specifically, some gender beliefs would likely affect girls' competence beliefs, task values, and emotions, such as math anxiety, which in turn would influence academic achievement. Our results are consistent with this view, because girls who believed that girls are not as capable in math as boys experienced higher math anxiety (and lower math self-concept), as well as lower self-reported grades in mathematics.

Finally, in contrast to the stereotype about math ability, measures of the stereotype about emotions were not differentially related to any outcome as a function of gender. This indicates that math self-reported grades, math self-concept, and math anxiety share some of the variance with the math ability facet, but not with the emotional component, of gender stereotypes about math anxiety. Together, these results suggest that stereotyped beliefs about math ability, but not about emotion, might influence math-related outcomes.

A practical implication of the current results is that interventions aimed at the ability component of the stereotype may be useful. Assuming that there is a relationship between math anxiety and gender beliefs, as posited by socialization models (e.g., Eccles, 1994, 2009), it may be convenient to ensure that girls do not hold stereotypical math ability beliefs against their own gender, to alleviate math anxiety and improve self-concept. In this case, effort should be directed toward girls who hold negative stereotypes.

Certain aspects may require further consideration in future research. The present results were obtained in secondary school students. Some studies have demonstrated age differences in math stereotypes (e.g., Passolunghi et al., 2014; Vuletich et al., 2020). While this has been studied in the context of the math ability component, it has not been assessed in terms of the emotional dimension. Future research should address the various facets of stereotypes related to math anxiety, at different stages. Although a cross-sectional approach has proven informative, a longitudinal study would provide additional valuable information about possible intraindividual changes in stereotypes associated with math anxiety. It could also inform us about the direction of the relationship between the math ability stereotype and math related outcomes. It should be noted that the effect could occur in the opposite direction. For instance, high levels of math anxiety coupled with lower levels of math achievement and self-confidence in some girls may lead them to infer that their own gender performs worse in mathematics, thus underpinning the traditional stereotype. A further limitation of the present study concerns the generalizability of our results. The data were collected from one school with a specific cultural context, and the results may have been mediated by specific socio-cultural factors. For instance, gender differences in math anxiety are larger in countries with greater gender equality (Else-Quest et al., 2010; Stoet et al., 2016). Therefore, it is necessary to investigate the degree to which the present effects generalize to other countries, cultural contexts and ethnicities. Finally, we used new measures specifically adapted for the present study to assess gender stereotypes in terms of their emotional facet (see Appendices A–C). Although the instruments were based on well-known measures and showed relationships indicative of validity, further investigation is warranted to better determine their psychometric properties.

5. Conclusions

Regarding the emotional facet of math anxiety, we found that male and female adolescents both believed that girls experience more math anxiety than boys. The pattern of results is consistent with the stereotype that women are more prone than men to experience some negative emotions. We conclude that gender differences in math anxiety may reflect actual levels of math anxiety, rather than a gender bias in the reportage thereof. Regarding the math-ability stereotype, both girls and boys endorsed either egalitarian or female-favoring views, although they still considered that adults in general maintain a belief in the traditional stereotype. This finding adds to a growing body of evidence that the traditional stereotype favoring men may be becoming less prevalent in Western societies. Finally, gender stereotypes about math ability, but not about emotion, were related to math anxiety, as well as to other math-related performance measures. Girls who endorsed a traditional math ability stereotype exhibited lower math self-concept, lower math performance, and higher math anxiety. This finding underscores the relations of gender beliefs about math ability, self-concept, and achievement with math anxiety.

CRediT authorship contribution statement

S.P. and MJ.J.G. conceptualized the manuscript. MJ.J.G. wrote the manuscript under the supervision of S.P., and ME.M.P., and R.L. suggested revisions. S.P. and MJ.J.G. reviewed the literature. S.P. completed the data analysis. RL., and ME.M.P. planned and collected data.

Declaration of competing interest

None.

Acknowledgements

This work was supported by Grant PID2020-120065GB-I00 funded by MCIN/AEI/10.13039/501100011033 and “European Union NextGenerationEU/PRTR”.

Appendix A. Items for the “Math-Anxiety Gender Stereotype” measure

AMAS item number	English version	Spanish version
2	Thinking about an upcoming math test 1 day before	Pensando en el próximo examen de matemáticas el día antes de hacerlo
4	Taking an examination in a math course	Haciendo un examen en una asignatura de matemáticas
6	Listening to a lecture in math class	Escuchando una lección en la clase de matemáticas
9	Starting a new chapter in a math book	Empezando una lección nueva del libro de matemáticas

Note. AMAS: The Abbreviated Math Anxiety Scale (Hopko et al., 2003).

Appendix B. Items for the "Anxiety-Gender Stereotype" measure

STAI item number	English version	Spanish version
1[a]	Calm	calma
3	Tense	tensión
9	Anxious	angustia
11[a]	Self-confident	confianza en uno/a
12	Nervous	nerviosismo
16[a]	Content	satisfacción
17	Worried	preocupación
19[a]	Joyful	alegría
23	Feel like crying	ganas de llorar
30[a]	Happy	felicidad
33[a]	Secure	seguridad
35	Feel blue	tristeza

Note. STAI: State Trait Anxiety Inventory Form X-1 (Spielberger et al., 1983).
[a] Reverse-scored items.

Appendix C. Items for the "Math-Gender Stereotype" measure

English version	Spanish version
Bad[a]	malo/a
Brilliant	brillante
Clever	inteligente
Excellent	excelente
Fail[a]	suspenso/a
Fast	rápido/a
Good	bueno/a
Hard[a]	difícil
Mistakes[a]	erróneo/a
Perfect	perfecto/a
Right	correcto/a
Slow[a]	lento/a
Smart	listo/a
Stupid[a]	necio/a
Weak[a]	flojo/a
Wrong[a]	equivocado/a

Note. Items were taken from Nowicki and Lopata (2017).
[a] Reverse-scored items.

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