MATH ANXIETY AND PERFECTIONISTIC CONCERNS IN MULTIPLE-CHOICE ASSESSMENT

Núñez-Peña, M. I.[1,2,3] & Bono, R.[1,2]

[1] Department of Social Psychology and Quantitative Psychology (Quantitative Psychology Section), Faculty of Psychology, University of Barcelona, Spain

[2] Institute of Neurosciences, University of Barcelona, Spain

[3] Institut de Recerca Sant Joan de Déu, Esplugues de Llobregat, Spain

Correspondence to:

Maria Isabel Núñez-Peña

Department of Social Psychology and Quantitative Psychology

Faculty of Psychology

University of Barcelona

Passeig Vall d'Hebron, 171

08035 Barcelona (SPAIN)

Tel. +34 93 312 58 53

E-mail: inunez@ub.edu

ORCID of the authors:

Núñez-Peña, M. I.: 0000-0002-3677-859X

Bono, R.: 0000-0001-7991-6668

Abstract

We examined the relationships between math anxiety, perfectionism, and academic achievement in undergraduates enrolled in a course with high mathematical content. Participants were 251 students who completed math anxiety and perfectionism questionnaires, and whose academic achievement was measured via a multiple-choice exam. The number of hits, errors, and unanswered questions on this exam were analyzed to explore the possible influence of math anxiety and perfectionism on students' performance. Results showed that highly math-anxious (HMA) students were more perfectionist than their low math-anxious (LMA) peers, insofar as they were more concerned about making mistakes and had more doubts about their own actions. The HMA group also obtained worse grades than did their LMA counterparts, although this was because they left more questions unanswered, not because they made more mistakes. Analysis of the relationship between math anxiety and the number of unanswered questions revealed that concern over errors and doubts about actions played a mediating role in this relationship. In conclusion, HMA students' fear of making mistakes and doubts about their own actions are important factors influencing their performance in multiple-choice tests.

Keywords: Math anxiety; Perfectionism; Multiple-choice exams; Academic performance; Higher education.

Introduction

Educators and educational administrators have invested considerable effort in identifying, across all levels of education, the main factors underpinning low academic achievement. The aim in doing so has been to introduce changes in the educational system (e.g., in instructional strategies, evaluation systems), and ultimately to enhance the effectiveness of teaching and students' learning achievements. In line with evidence that academic performance depends not only on cognitive ability but also on other personality factors (Richardson, Abraham, & Bond, 2012), educational psychologists have focused their attention on personality characteristics that might improve or hamper students' learning process (e.g., self-confidence, attitudes, perfectionism or anxiety, among others). Our focus in the present study was on two such personality characteristics that may hinder academic success in courses with high mathematical content, namely math anxiety and perfectionism, and specifically on how they might affect students' performance in multiple-choice exams in higher education. These are two personality factors within the affective domain that have scarcely been studied together in the field of mathematical education.

Math anxiety is the "state of nervousness and discomfort brought upon by the presentation of mathematical problems that may impede mathematics performance irrespective of true ability" (Hoffman, 2010, p. 276). It is highly prevalent among students, not only in elementary and high school but also in higher education (Beilock & Willingham, 2014; Chang & Beilock, 2016), and it is negatively related to math academic achievement (Ashcraft & Krause, 2007; see also the recent meta-analysis on the math anxiety/performance association in Zhang, Zhao, & Ping Kong, 2019, who discuss the factors that may moderate this relationship[1]). Hence, the interest of psychologists and educators in this topic has increased notably in recent years (for reviews of math anxiety, see Ramirez, Shaw, & Maloney, 2018; Suárez-Pellicioni, Núñez-Peña, & Colomé, 2016). For a math anxious student, facing a math task produces aversion or worry, and consequently they tend to avoid elective math courses and degrees in the STEM (Science, Technology, Engineering, and Mathematics) fields (Foley et al., 2017). Given the relationship between training in a STEM subject and high income, avoidance of this type of degree course puts highly math-anxious individuals at a disadvantage, not only professionally but also in terms of their salary compared with their low math-anxious peers.

The leading explanation for why high math-anxious (HMA) individuals have low achievement in math is that proposed by Ashcraft and colleagues (Ashcraft & Faust, 1994; Ashcraft & Kirk, 2001) and recently referred to as the *disruption account* (Ramirez et al., 2018). According to this account, when HMA individuals perform math tasks they have intrusive thoughts (i.e., worrying and ruminating about their poor performance, and fear of failure) which consume part of their working memory resources. Working memory (WM) is a cognitive system that integrates, computes, stores, and manipulates the information necessary to perform cognitive tasks, including math tasks (Baddeley, 1983). Given that WM has limited capacity, the worries experienced by HMA students would leave them with insufficient cognitive resources to perform the math task, and hence they would underperform in this type of task compared with their non-math-anxious peers. This is consistent with the findings of the recent meta-analysis by Zhang et al. (2019), who reported larger effects for the link

[1] Zhang et al. (2019) identified five factors that can modulate the relationship between math anxiety and performance: geographical region, grade level, measurement of math anxiety, measurement forms of math performance, and measurement aspects of math performance.

between math anxiety and math performance when math problem-solving skills were assessed (r = -0.33) than when calculation abilities were tested (r = -0.21). Solving math problems is expected to be more difficult and to require more cognitive resources than is the case with calculation (especially basic calculation; Lee & Cho, 2018).

Another personality factor that can affect academic achievement is perfectionism, defined as a multidimensional trait characterized by extremely high standards for performance and concern about making mistakes and the social costs of not being perfect (Frost, Marten, Lahart, & Rosenblate, 1990; Hewitt & Flett, 1991). Frost et al. (1990) proposed that perfectionism comprised six different aspects (i.e., high personal standards, preference for order and organization, excessive concern over mistakes, doubts about one's actions, perception of high parental expectations, and perception of high parental criticism) and they developed a tool — the Frost Multidimensional Perfectionism Scale (FMPS; Frost et al., 1990) — to measure them. Although some investigators have emphasized the negative aspects of perfectionism (e.g., Hollender, 1965; Pacht, 1984), others (e.g., Slade & Owens, 1998; Stoeber & Otto, 2006) have suggested that it may have two different forms. The first is an adaptive perfectionism consisting of perfectionistic strivings, in which emphasis is placed on setting and having high objectives and standards, while also accepting mistakes and resetting goals under certain circumstances (Stoeber & Otto, 2006). This type of perfectionism has been associated with positive affect and healthy psychological adjustment (Saboonchi & Lundh, 2003). The second form is a maladaptive perfectionism based on perfectionistic concerns and which is associated with setting unattainable high standards, a feeling of discrepancy between one's expectations and performance, concern over making mistakes, and fear of negative social evaluation (e.g., Comerchero, Fortugno, College, & York, 2013; Slaney, Rice, Mobley, Trippi, & Ashby, 2001). Maladaptive perfectionists experience more psychopathological problems (e.g., depression, obsessive-compulsive disorder, anxiety; see the meta-analysis by Limburg, Watson, Hagger, & Egan, 2017) and have lower self-confidence and self-efficacy (Akar, Dogan, & Üstüner, 2018). In terms of their responses to the FMPS, adaptive perfectionists usually score high on its *personal standards* and *organization* subscales, whereas maladaptive perfectionists score high on the *concern over mistakes*, *doubts about actions*, *parental expectations*, and *parental criticism* subscales (Stoeber & Otto, 2006).

In the context of education, these two higher-order dimensions of perfectionism have both been associated with academic achievement, but in opposing directions (Madigan, 2019; Stoeber, 2018). On the one hand, perfectionistic strivings are related to better performance, because enjoyment of striving can increase students' meticulosity and perseveration (Stoeber, 2012; Stoeber, Damian, & Madigan, 2018). By contrast, perfectionistic concerns, which include maladaptive cognitions such as worry, rumination, low self-esteem, and anxiety, are associated with worse academic achievement because they can make students more concerned with avoiding failure than with learning (Hewitt & Flett, 1991). Furthermore, the fear of making mistakes can lead students to procrastinate as a means of avoiding the possibility of failure (Madigan, 2019). Note that although perfectionism is often considered an antecedent of better or worse academic achievement, Damian, Stoeber, Negru-Subtirica, and Baban (2017) found that academic achievement can also be an antecedent of perfectionistic strivings or perfectionistic concerns and that academic efficacy (i.e., personal beliefs about one's capabilities to perform academic tasks) predicted increases in perfectionistic strivings.

Math anxiety and maladaptive perfectionism have one element in common, namely the fear of making mistakes. Two studies have examined the relationship between math anxiety and mistakes. Suárez-Pellicioni, Núñez-Peña, and Colomé (2013) investigated whether math anxiety was related to abnormal error monitoring processing using event-related brain potentials. They found an increase in error-related brain activity when HMA individuals solved a numerical task, but not when they solved a non-numerical task, leading them to conclude that HMA individuals could be "hypersensitive to self-generated errors in numerical tasks" (Suárez-Pellicioni et al., 2013, p. 15). More recently, Núñez-Peña, Tubau, and Suárez-Pellicioni (2017) studied post-error adjustment measures (post-error slowing and post-error accuracy) in HMA and low math-anxious (LMA) individuals while performing a multi-digit addition task. Group differences were found in post-error accuracy, showing that the HMA group was less accurate after having committed an error than were their LMA peers, although only when the response given in the previous trial needed to be repeated. The authors concluded that errors led HMA individuals to reactively inhibit their answer in the following item/question.

Fear of making mistakes can be particularly relevant when courses are assessed by means of multiple-choice exams. This approach to assessment is used by large numbers of teachers in the higher education context, due in part to large class sizes and a high teaching load. In a multiple-choice exam, students are presented with a series of questions followed by some possible answers (usually four), only one of which is correct. This type of test is usually scored by awarding one point for a correct answer, with one quarter or one third of a point being deducted for an incorrect answer (correction for guessing) and no points being given for a skipped question. Consequently, a student who is uncertain about how to answer has two options: skip the question and miss out on a possible point, or answer it and risk having points deducted. Baldiga (2014) found that when wrong answers were not penalized in a multiple-choice exam, men and women answered every question, but when they were penalized, women left more unanswered questions than did men (see also, Núñez-Peña, Suárez-Pellicioni, & Bono, 2016; Pekkarinen, 2015; Riener & Wagner, 2017). There is also evidence that women perform better in exams that do not involve multiple-choice questions (Walstad & Robson, 1997).

Differences in the way multiple-choice exams are answered may also be related to personality characteristics, such as perfectionism or, when assessing mathematical knowledge, math anxiety. In the case of HMA students, their ruminations about the consequences of failure and their low self-confidence in mathematical tasks (Ashcraft & Kirk, 2001; Ashcraft & Krause, 2007) could lead them to skip questions instead of guess if they do not have complete confidence in their response. This could put them at a disadvantage compared with their LMA course mates. As for perfectionism, perfectionistic concerns could lead students to be more concerned over making mistakes and to have more doubts about their own actions, such that they leave more questions unanswered. It should be noted that concerns were expressed some time ago about the exclusive use of multiple-choice exams, since they might put some students at a disadvantage (Bridgeman & Lewis, 1994).

The main objective of the present study was to examine the relationships between math anxiety, perfectionism, and academic achievement in undergraduate students enrolled in a course with high mathematical content. To our knowledge, only one study has examined the relationships between these variables (Tsui & Mazzocco, 2006), and the sample was comprised solely of children identified as gifted in mathematics[2]. Consequently, the relationships between these variables in other populations remain unknown. Furthermore, no study to date has investigated the way in which these

[2] In the context of foreign language learning, Yurtseven and Akpur (2018) found that perfectionism, foreign language anxiety, and procrastination predicted academic achievement in English as a foreign language (EFL).

personality characteristics might affect students' pattern of responses in multiple-choice exams in which errors are penalized. Hence, our second aim in this study was to evaluate to what extent differences in the way of answering in the face of uncertainty may depend on the level of both math anxiety and perfectionism.

In order to address these aims, levels of math anxiety and perfectionism were measured in a large sample of undergraduate students, with their academic achievement being assessed through a multiple-choice exam. In this exam, students' statistical problem-solving skills were evaluated by presenting them with practical cases and the corresponding data they had to use to answer the questions. We expected, first, that HMA students would achieve lower grades than their LMA peers, as reported previously (Núñez-Peña & Bono, 2019; Núñez-Peña, Suárez-Pellicioni, & Bono, 2013), and also that they would have higher levels of maladaptive perfectionism (i.e., concern over errors and doubts about actions). Second, and regarding differences in the way HMA and LMA students answered their multiple-choice exams, we expected to find that the former would have fewer hits and would leave more unanswered questions than would the latter group. Third, we explored whether the relationship between math anxiety and the number of unanswered questions might be mediated by the 'concern over errors' and 'doubts about actions' dimensions of perfectionism. Finally, we explored possible gender differences in math anxiety, perfectionism, and all measures of academic performance (i.e., number of hits, errors, and unanswered questions). Here we expected to reproduce previous findings of higher levels of math anxiety among female students (e.g., Else-Quest, Hyde, & Linn, 2010) and we also predicted that female students would skip more questions in their multiple-choice exam (Núñez-Peña et al., 2016).

Methods

Participants

Participants were 251 psychology undergraduates enrolled in a Research Design course at the University of Barcelona during either the 2016-2017 or 2018-2019 academic year (134 and 117 students respectively). They were selected on the basis of their availability and willingness to take part in the study. The sample comprised 210 females (83.7%; mean age 21.74 years, standard error of the mean, SEM = .35) and 41 males (16.3%; mean age 21.08 years, SEM = .49). They were all informed about the study procedure and gave consent to participate before data collection.

Materials

Students were administered the following questionnaires:

Shortened Math Anxiety Rating Scale *(sMARS*; Alexander & Martray, 1989). This is a 25-item scale on which each item describes a situation that may cause math anxiety. Respondents must indicate the level of anxiety that each situation would cause them by using a five-point Likert scale (1: no anxiety; 5: high anxiety), and thus the total score range is 25-125. The sMARS measures three dimensions of math anxiety, two of them related to anxiety that is experienced in academic contexts and one that refers to anxiety in other settings: Math test anxiety (MTA; i.e., worry when sitting a math exam or about math exam grades), numerical task anxiety (NTA; i.e., worry when performing numerical operations), and math course anxiety (MCA; i.e., worry during math courses). The Spanish version of the sMARS (Núñez-Peña, Suárez-Pellicioni, Guilera, & Mercadé-Carranza, 2013) that was used in the present study has shown good psychometric properties (Cronbach’s alpha of .94 for total scale scores).

Frost Multidimensional Perfectionism Scale (*FMPS;* Frost, Marten, Lahart, & Rosemblate, 1990). The FMPS assesses perfectionism by means of six subscales, only four of which were used in the present study: (1) Personal standards (FMPS-PS), which measures the tendency to set high standards for evaluation; (2) Concern over mistakes (FMPS-CM), which assess the predisposition to react negatively to errors; (3) Organization (FMPS-O), which measures the importance given to orderliness; and (4) Doubts about actions (FMPS-DA), which evaluates the tendency to doubt one's own ability. Each of these scales comprises a series of statements with which respondents must indicate their degree of agreement or disagreement using a 5-point Likert scale. The Spanish version of the FMPS used in the present study (Gelabert et al., 2011) has shown satisfactory psychometric properties (Cronbach's alpha of .93 for total scale scores).

Multiple-choice exam. Students enrolled in the Research Design course sat a multiple-choice exam at the end of the academic year. This course is a compulsory component of the Psychology degree at the University of Barcelona and it is high in mathematical content, focusing mainly on the statistical techniques most commonly used in psychology. For the exam, students were given some practical cases and the corresponding data, and were asked to solve problems by performing statistical analyses using SPSS. The questions they had to answer concerned the type of analyses performed and the interpretation of results. The exam included a total of 30 questions, each with four possible answers, and errors were penalized 0.33 points in order to correct for guessing.

Procedure

Questionnaires (sMARS and FMPS) were administered as a voluntary activity at the end of a Research Design class at the beginning of the academic year. Completion of both measures required about 15 minutes. At the end of the course, students were assessed with the multiple-choice exam. Only those students who both completed the questionnaires and sat the final exam were included in the present study.

Data Analysis

Data analysis was first performed by considering students with extreme (high vs. low) math anxiety scores, and subsequently with the whole sample. For the first analysis, extreme groups were formed based on students' overall math anxiety scores, using the first and third quartiles as cutoffs. To this end, we first computed sMARS quartiles for the whole sample and then assigned participants with extreme scores to either the HMA group (score above the third quartile on the sMARS, ≥ 79) or the LMA group (score below the first quartile, ≤ 54). The LMA group included 65 students and the HMA group 67. Group differences were examined by means of independent samples t-tests, considering all perfectionism scores (i.e., total and subscale scores) and students' final exam performance (i.e., grade and number of hits, errors, and unanswered questions) as dependent variables. Effect sizes were calculated using Cohen's *d* statistic.

The remaining three analyses were carried out with the whole sample. First, a correlational analysis (Spearman correlations) was carried out to study the relationships between scores on the sMARS and FMPS and students' exam performance. Second, a mediation model was constructed to explore whether perfectionism had a mediating effect on the relationship between math anxiety and students' performance. Finally, possible gender differences were investigated by means of independent samples t-tests for all questionnaire scores and all measures of students' performance. Due to the unequal number of men and women in our sample, we used Welch's t-test for unequal variances in the event that the data did not meet the homogeneity of variance assumption, and the Student's t-test otherwise.

The mediation analysis was performed using the PROCESS Macro 3.4 for SPSS (Hayes, 2018). This involved performing 10,000 bootstrap iterations to generate 95% confidence intervals (CI) for the indirect effect. The other statistical analyses were performed using SPSS 25.

Results

Group Differences: Extreme Math Anxiety Groups

Regarding perfectionism, total scores on the FMPS indicated that students in the HMA group were more perfectionist than their LMA peers ($t(130) = 3.97$, $p < .001$, $d = .69$). They also reported more concern over mistakes ($t(130) = 4.20$, $p < .001$, $d = .73$) and more doubts about their own actions ($t(130) = 5.37$, $p < .001$, $d = .94$) than did students in the LMA group. No group differences were found on either the personal standards ($t(130) = 1.54$, $p = .127$, $d = .27$) or organization scales ($t(130) = .27$, $p = .789$, $d = .05$) of the FMPS. Table 1 shows means and SEM for the HMA and LMA groups on all these variables.

Insert Table1 approximately here

Concerning academic achievement, HMA students obtained lower grades in the multiple-choice exam ($t(130) = 1.98$, $p = .05$, $d = .34$), achieving fewer hits ($t(130) = 2.15$, $p = .034$, , $d = .38$) and leaving more questions unanswered (*t*(130) = 2.24, *p* = .027, *d* = .39) in comparison with their LMA peers. No group differences were found in the number of errors (*t*(130) = 1.21, *p* = .228, *d* = .21). We subsequently calculated the number of hits per answered questions and again found no difference between the groups. Table 2 shows means and SEM for the HMA and LMA groups on all the exam performance measures.

Insert Table 2 approximately here

Relationships between Math Anxiety and Perfectionism: Correlational Analysis

Table 3 shows Spearman correlation coefficients for the relationships between anxiety and perfectionism scores, considering both total and subscale scores on the corresponding measures. The results showed that in addition to the expected correlations between the total and subscale scores on the sMARS, math anxiety was also positively related to perfectionism (*r* = .205, *p* = .001 for total sMARS scores; *r* = .195, *p* = .002 for MTA scores; and *r* = .179, *p* = .005 for MCA scores). Furthermore, the higher the math anxiety, the greater the concern over mistakes and the more doubts about one's own actions. These positive relationships were found for both the total sMARS score (*r* = .239, *p* < .001 for FMPS-CM, and *r* = .341, *p* < .001 for FMPS-DA) and sMARS subscale scores: MTA (*r* = .220, *p* < .001 for FMPS-CM, and *r* = .315, *p* < .001 for FMPS-DA), NTA (*r* = .184, *p* = .003 for FMPS-CM, and *r* = .190, *p* =.003 for FMPS-DA), and MCA (*r* = .205, *p* = .001 for FMPS-CM, and *r* = .286, *p* < .001 for FMPS-DA). Note that although the correlations for the NTA subscale scores were significant, the strength of these associations was weak.

Insert Table 3 approximately here

Relationships between Students' Exam Performance, Math Anxiety, and Perfectionism: Correlational Analysis

Table 4 shows Spearman correlation coefficients between students' performance on the multiple-choice exam (grade, number of hits, errors, unanswered questions, and hits per answered questions) and their levels of math anxiety and perfectionism. Students' grades were negatively related to their doubts about their own actions (r = -.203, p = .001). Importantly, the number of unanswered questions was positively related to math anxiety, as measured by the total sMARS score (r = .168, p = .008) and its three subscale scores (r = .135, p = .035 for MTA; r = .142, p = .025 for NTA; and r = .173, p = .006 for MCA). The number of unanswered questions was also negatively related to personal standards scores (r = -.156, p = .013) and positively related to doubts about one's own actions (r = .169, p = .007). As for the number of hits per answered questions, this was negatively correlated with doubts about one's own actions (r = -.168, p = .008). Although all these correlations were significant, the strength of the association between the variables was weak.

Insert Table 4 approximately here

Mediation Analysis

In order to study the relationship between math anxiety and the number of unanswered questions in more detail, we conducted a mediation analysis to explore whether this association was mediated by both concern over errors and doubts about actions.

Figure 1 shows the mediation model in which the two FMPS factors (FMPS-CM and FMPS-DA) act as mediators between the MCA factor and the number of unanswered questions. In the first regression step, the total effect (path c) indicated that MCA was positively associated with the number of unanswered questions (p = .021). In the second regression step (paths a_1 and a_2), MCA was positively related to FMPS-CM and FMPS-DA ($p < .001$). In the third regression step (paths b_1 and b_2), FMPS-CM was negatively related ($p = .007$) and FMPS-DA was positively related ($p = .014$) to the number of unanswered questions. However, when mediator variables were included in the model (direct effect, path c'), the regression coefficient became positive ($p = .0265$). In the final confirmatory step, the indirect effects (a_1*b_1 and a_2*b_2) and the Sobel test were significant ($p = .028$ and $p = .034$), confirming that both FMPS factors (concern over mistakes and doubts about actions) act as mediators, 95% CI [-.062, -.008] and [.009, .059].

Insert Figure 1 approximately here

The results of the mediation analysis showed no mediating effect of FMPS components on the relationship between the other two dimensions of math anxiety (MTA and NTA) and the number of unanswered questions.

Gender Differences

Female students reported being more math-anxious than did their male peers ($t(249) = 2.24$, $p = .026$, $d = .38$ for total sMARS scores, and $t(249) = 2.81$, $p = .005$, $d = .48$ for MTA subscale scores). They also tended to score higher on the MCA subscale than did males, $t(249) = 1.73$, $p = .086$, $d = .31$. Regarding perfectionism, gender differences were only found on the Organization subscale, with female students scoring higher than their male counterparts, $t(248) = 2.29$, $p = .023$, $d = .40$. Finally, concerning exam performance, there were no gender differences in course grades, but female undergraduates did leave more questions unanswered, $t(107.368) = 2.85$, $p = .005$, $d = .39$, and tended to achieve fewer hits in comparison with their male peers, $t(249) = 1.78$, $p = .076$, $d = .30$. Means and SEM for all variables, by gender, are shown in Tables 5 and 6.

Insert Tables 5 and 6 approximately here

Discussion

The primary aim of this study was to examine the relationships between math anxiety, perfectionism, and academic achievement in a course with high mathematical content, focusing particularly on two aspects of maladaptive perfectionism (i.e., concern over errors and doubts about actions) that can negatively affect students' performance. A second aim was to assess whether the pattern of responses in multiple-choice exams in this type of course is influenced by math anxiety and perfectionism. Specifically, we sought to determine whether undergraduates with these personality characteristics might be at a disadvantage when they are assessed with this type of exam.

In line with previous findings, students high in math anxiety obtained lower grades in the final multiple-choice exam than did their low math-anxious course mates (Núñez-Peña & Bono, 2019; Núñez-Peña et al., 2013). Importantly, a more detailed look at the pattern of exam responses among HMA students showed that they achieved fewer hits and skipped more questions than did their peers. However, the two groups did not differ in the number of errors. This is an interesting finding because the strategy of skipping questions has been shown to be detrimental (Baldiga, 2014), and hence students high in math anxiety might be particularly disadvantaged by doing so. Previous studies suggested that the lower grades obtained by HMA students in math courses could be due to the fact that their ruminations would occupy a considerable portion of their working memory, leaving them with insufficient cognitive resources to carry out the math task successfully (e.g., Núñez-Peña & Bono, 2019; but see other possible explanations of the relationship between math anxiety and math performance in Suárez-Pellicioni et al., 2016). This explanation is based on the account of math anxiety proposed by Ashcraft and colleagues (Ashcraft & Faust, 1994; Ashcraft & Krause, 2007). The present results extend this proposal, suggesting that when HMA students are faced with a multiple-choice math exam, they may obtain a low grade not only because their anxieties about math leave them with insufficient cognitive resources to perform the task but also because their fear about making mistakes leads them to avoid answering in the face of uncertainty, thereby lowering their final grade due to points being lost for unanswered questions. Previous studies have shown that highly math anxious individuals are hypersensitive to self-generated error in numerical tasks (Suárez-Pellicioni et al., 2013) and that they reactively inhibit their answers in this type of task after having committed an error (Núñez-Peña et al., 2017).

Taken together, our findings suggest that mistakes and the fear of making them could affect the behavior of HMA individuals when faced with a math task, a fact that might be aggravated in multiple-choice exams in which errors are penalized. In this respect, another noteworthy result of the present study is that HMA students also had more perfectionistic concerns. Specifically, they reported greater concern over their mistakes and had more doubts about their actions (i.e., maladaptive perfectionism) than did their LMA peers. No group differences were found in either personal standards or organization (i.e., adaptive perfectionism). Our results therefore replicate those of Tsui and Mazzocco (2006), extending them to the adult population. These authors reported that although perfectionism and math anxiety were positively correlated in terms of total scores, a more detailed analysis showed that math anxiety was only positively correlated with scores on three subscales of perfectionism, namely concern over mistakes, doubts about actions, and parental criticism. Thus, as in the present study, Tsui and Mazzocco (2006) found no relationship between math anxiety and either personal standards or organization (i.e., perfectionistic strivings). Our correlational analyses confirmed these results by showing a positive association between math anxiety and perfectionism: specifically, the higher the math anxiety (in terms of both total and subscale scores) the greater the concern over mistakes and doubts about actions. It is worth noting here that math anxiety has been widely shown to be negatively related with self-efficacy in math (i.e., low level of confidence in one's own math abilities; e.g., Jain & Dowson, 2009), a fact that might increase HMA individuals' doubts about their own actions and their fear of failure in math tests. In this respect, our findings suggest that because HMA students are more indecisive about their actions and more concerned about making mistakes, they try to avoid errors, and hence they tend, when uncertain, to skip more questions in multiple-choice tests than do their LMA peers.

In the present study, perfectionism was also related to academic achievement. Although this relationship has been reported previously, for both perfectionistic strivings and perfectionistic concerns (Madigan, 2019; Stoeber, 2018), no study to date has, to the best of our knowledge, examined the relationship between the pattern of responses in multiple-choice exams and this personality trait. Here we found that students who had more doubts about their own actions obtained lower grades. In addition, the number of unanswered questions was positively related to doubts about actions and negatively related to personal standards. Given the relationships between math anxiety, perfectionism, and the number of unanswered questions, we subsequently performed a mediation analysis, which showed that the relationship between math course anxiety and the number of unanswered questions was mediated by two dimensions of perfectionistic concerns: doubts about actions and concern over errors. This result provides further support for our previous proposal regarding the important impact that the fear of making mistakes can have on HMA students' achievement in math courses. Thus, although one might initially think that HMA students skipped more questions because they have a poorer understanding of the subject than do their LMA peers, the fact that they had more doubts about their own actions and were more concerned about their mistakes plausibly suggests that their worse performance may also be explained by their anxiety.

A final question of interest was to examine gender differences in math anxiety, perfectionism, and academic performance. Previous studies have shown that female students skip more questions in multiple-choice exams than do their male peers (Baldiga, 20104; Núñez-Peña et al., 2016; Pekkarinen, 2015; Riener & Wagner, 2017), probably because the latter are more willing to take risks. In a similar vein, other studies have reported higher levels of math anxiety among females (e.g., Else-Quest, Hyde, & Linn, 2010; Ma & Cartwright, 2003). It should be noted that our study replicated previous findings. First, our female students tended to achieve fewer hits in the multiple-choice exam and they skipped more questions than did their male classmates (Núñez-Peña et al., 2016). Second, concerning gender differences in math anxiety, our results showed that female students were more math-anxious than were males, although, as previously stated, this higher level of math anxiety did not lead female students to obtain lower grades in the course (Else-Quest et al., 2010; Hyde, Lindberg, Linn, Ellis, & Williams, 2008).

To sum up, the results of this study suggest that HMA students may skip more questions than their LMA peers in multiple-choice exams because they are more worried about making mistakes and have more doubts about their own actions. Skipping questions would disadvantage HMA students with respect to their LMA peers as it increases the likelihood of their obtaining lower test scores. This result highlights a potentially important issue to consider when using multiple-choice tests in this student population.

Recommendations

If multiple-choice assessments may put some students at a disadvantage, as we observed here for HMA students sitting a math test, then educators should not rely exclusively on this type of exam to assess their students' learning. Concern about the exclusive use of multiple-choice tests for this purpose has been previously reported (Bridgeman & Lewis, 1994; Bridgeman & Morgan, 1996), and it has been recommended that short-answer items should be included alongside multiple-choice questions. In the specific case of research methods courses, however, Bleske-Rechek, Zeug, and Webb (2007) recommended using open-question as opposed to closed-question tests, since the former are better able to assess the type of content featured in these courses; examples of open assessment include data analysis assignments and critical thinking exercises.

Limitations and Future Directions

The present study does have certain limitations that need to be considered. First, although some predictions have been made based on the mediation analysis, this remains a correlational study and hence it is impossible to make causal inferences regarding the relationship between variables (i.e., between math anxiety and a particular behavior in answering multiple-choice tests). However, this is a limitation common to the majority of studies dealing with math anxiety or other personality constructs, because, as stable personal characteristics, they cannot be experimentally manipulated. Second, this was a cross-sectional study with a sample comprised solely of psychology undergraduates at the University of Barcelona who were selected on the basis of their availability and willingness to take part. Thus, our sample was not representative of all higher education students and it remains to be seen whether our results can be replicated and extended to other populations in different contexts, and especially to different geographical regions (i.e., outside the Spanish higher education system). The meta-analysis by Zhang et al. (2019) reported that the strongest negative math-anxiety-performance link was found in studies that involved Asian students and the weakest in studies with European students. Future studies might therefore wish to examine whether the effects we report here are stronger in samples of Asian as opposed to European students.

Another related limitation of our study is that because women are overrepresented in Psychology faculties, our sample included more female than male students. It would therefore be useful to confirm that the relationship between math anxiety and the number of unanswered questions in multiple-choice exams holds in other university faculties where men and women are equally represented. Similarly, future studies might also examine the pattern of responses of HMA students in other types of tests, including multiple-choice exams without correction for guessing.

Conclusion

Notwithstanding these limitations, the present findings provide further evidence of the detrimental impact that math anxiety has on learners' performance in courses with mathematical content. More specifically, the results call into question the use of multiple-choice exams for assessing highly math-anxious students on this type of course, since doing so may further disadvantage them with respect to their LMA peers. When sitting a multiple-choice exam in which errors are penalized, students high in math anxiety may obtain lower test scores even if their knowledge of the course material is, in fact, comparable with that of their LMA peers. This is because concerns about errors and doubts about their own actions may lead them to skip questions.

Educators should consider the use of other kinds of assessment for this type of student, for example, those based on short-answer questions or essay items.

Acknowledgments

This research was supported by the Consolidated Group for Innovation in Teaching GINDOC-UB/099 at the University of Barcelona and by grants 2017PID-UB/01 from the University of Barcelona and PSI2015-69915-R (MINECO/FEDER) from the Spanish Ministry of Economy and Competitiveness and the European Regional Development Fund.

References

Akar, H., Dogan, Y. B., & Üstüner, M. (2018). The problems of contemporary education: The relationships between positive and negative perfectionisms, self-handicapping, self-efficacy and academic achievement. *European Journal of Contemporary Education*, *7*(1), 7–20. https://doi.org/10.13187/ejced.2018.1.7

Alexander, L., & Martray, C. (1989). The development of an abbreviated version of the Mathematics Anxiety Rating Scale. *Measurement and Evaluation in Counseling and Development.*, *22*(3), 143-150. https://doi.org/10.1080/07481756.1989.12022923

Ashcraft, M. H., & Faust, M. W. (1994). Mathematics anxiety and mental arithmetic performance: An exploratory investigation. *Cognition & Emotion*, *8*(2), 97–125. https://doi.org/10.1080/02699939408408931

Ashcraft, M. H., & Kirk, E. P. (2001). The relationships among working memory, math anxiety, and performance. *Journal of Experimental Psychology: General*, *130*(2), 224–237. https://doi.org/10.1037/0096-3445.130.2.224

Ashcraft, M. H., & Krause, J. A. (2007). Working memory, math performance, and math anxiety. *Psychonomic Bulletin & Review*, *14*(2), 243–248.

Baddeley, A. D. (1983). Working memory. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences, 302*, 311–324. https://doi.org/10.1098/rstb.1983.0057

Baldiga, K. (2014). Gender differences in willingness to guess. *Management Science, 60* (2), 434–448. https://doi.org/10.1287/mnsc.2013.1776

Beilock, S. L., & Willingham, D. T. (2014). Math anxiety: Can teachers help students reduce it? *American Educator, 38*(2), 28–32.

Bleske-Rechek, A., Zeug, N., & Webb, R. M. (2007). Discrepant performance on multiple-choice and short answer assessments and the relation of performance to general scholastic aptitude. *Assessment and Evaluation in Higher Education, 32*(2), 89-105. https://doi.org/10.1080/02602930600800763

Bridgeman, B., & Lewis, C. (1994). The relationship of essay and multiple-choice scores with grades in college courses. *Journal of Educational Measurement, 31*(1)*,* 37-50. https://doi.org/10.1111/j.1745-3984.1994.tb00433.x

Bridgeman, B., & Morgan, R. (1996). Success in college for students with discrepancies between performance on multiple-choice and essay tests. *Journal of Educational Psychology, 88*(2)*,* 333–340. https://doi.org/10.1037/0022-0663.88.2.333

Chang, H., & Beilock, S. L. (2016). The math anxiety-math performance link and its relation to individual and environmental factors: A review of current behavioral and psychophysiological research. *Current Opinion in Behavioral Sciences*, *10*, 33–38. https://doi.org/10.1016/j.cobeha.2016.04.011

Comerchero, V., Fortugno, D., College, T., & York, N. (2013). Adaptive perfectionism, maladaptive perfectionism and statistics anxiety in graduate psychology students. *Psychology Learning and Teaching*, *12*(1), 4–11. https://doi.org/10.2304/plat.2013.12.1.4

Damian, L. E., Stoeber, J., Negru-Subtirica, O., & Baban, A. (2017). On the development of perfectionism: The longitudinal role of academic achievement and academic efficacy. *Journal of Personality, 85*(4), 565-577. https://doi.org/10.1111/jopy.12261

Else-Quest, N. M., Hyde, J. S., & Linn, M. C. (2010). Cross-national patterns of gender differences in mathematics: A meta-analysis. *Psychological Bulletin, 136*(1), 103–127. https://doi.org/10.1037/a0018053

Foley, A. E., Herts, J. B., Borgonovi, F., Guerriero, S., Levine, S. C., & Beilock, S. L. (2017). The math anxiety-performance link. *Current Directions in Psychological Science*, *26*(1), 52–58. https://doi.org/10.1177/0963721416672463

Frost, R.O., Marten, P., Lahart, C., & Rosemblate, R. (1990). The dimensions of perfectionism. *Cognitive Therapy and Research, 14*(5), 449-468. https://doi.org/10.1007/BF01172967

Gelabert, E., García-Esteve, L., Martín-Santos, R., Gutiérrez, F., Torres, A., & Subirà, S. (2011). Psychometric properties of the Spanish version of the Frost Multidimensional Perfectionism Scale in women. *Psicothema, 23*(1), 133-139.

Hayes, A. F. (2018). *Introduction to mediation, moderation, and conditional process analysis* (2nd ed.). New York, NY: The Guilford Press.

Hewitt, P., & Flett, G. (1991). Perfectionism in the self and social contexts. *Journal of Personality and Social Psychology*, *60*(3), 456–470. https://doi.org/10.1037/0022-3514.60.3.456

Hoffman, B. (2010). “I think I can, but I’m afraid to try”: The role of self-efficacy beliefs and mathematics anxiety in mathematics problem-solving efficiency. *Learning and Individual Differences*, *20*(3), 276–283. https://doi.org/10.1016/j.lindif.2010.02.001

Hollender, M. H. (1965). Perfectionism. *Comprehensive Psychiatry, 6*(2), 94–103. https://doi.org/10.1016/S0010-440X(65)80016-5

Hyde, J. S., Lindberg, S. M., Linn, M. C., Ellis, A. B., & Williams, C. C. (2008). Gender similarities characterize math performance. *Science, 321*(5888), 494–495. https://doi.org/10.1126/science.1160364

Jain, S., & Dowson, M. (2009). Mathematics anxiety as a function of multidimensional self-regulation and self-efficacy. *Contemporary Educational Psychology, 34*(3), 240-249. https://doi.org/10.1016/j.cedpsych.2009.05.004

Limburg, K., Watson, H. J., Hagger, M. S., & Egan, S. J. (2017). The relationship between perfectionism and psychopathology: A meta-analysis. *Journal of Clinical Psychology, 73*(10), 1301–1326. https://doi.org/10.1002/jclp.22435

Ma, X., & Cartwright, F. (2003). A longitudinal analysis of gender differences in affective outcomes in mathematics during middle and high school. *School Effectiveness and School Improvement, 14*(4), 413–439.

Madigan, D. J. (2019). A meta-analysis of perfectionism and academic achievement. *Educational Psychology Review, 31*, 967–989. https://doi.org/10.1007/s10648-019-09484-2

Núñez-Peña, M.I., & Bono, R. (2019). Academic anxieties: Which type contributes the most to low achievement in methodological courses? *Educational Psychology*, *39*(6), 797–814. https://doi.org/10.1080/01443410.2019.1582756

Núñez-Peña, M.I., Suárez-Pellicioni, M., & Bono, R. (2013). Effects of math anxiety on student success in higher education. *International Journal of Educational*

Research, *58*, 36–43. https://doi.org/10.1016/j.ijer.2012.12.004

Núñez-Peña, M. I., Suárez-Pellicioni, M., & Bono, R. (2016). Gender differences in test anxiety and their impact on higher education students' academic achievement. *Procedia - Social and Behavioral Sciences*, *228*, 154–160. https://doi.org/10.1016/j.sbspro.2016.07.023

Núñez-Peña, M. I., Suárez-Pellicioni, M., Guilera, G., & Mercadé-Carranza, C. (2013). A Spanish version of the short Mathematics Anxiety Rating Scale (sMARS). *Learning and Individual Differences*, *24*, 204–210. https://doi.org/10.1016/j.lindif.2012.12.009

Núñez-Peña, M. I., Tubau, E., & Suárez-Pellicioni, M. (2017). Post-error response inhibition in high math-anxious individuals: Evidence from a multi-digit addition task. *Acta Psychologica*, *177*, 17–22. https://doi.org/10.1016/j.actpsy.2017.04.002

Pacht, A. R. (1984). Reflections on perfection. *American Psychologist, 39*(4), 386–390. https://doi.org/10.1037/0003-066X.39.4.386

Pekkarinen, T. (2015). Gender differences in behaviour under competitive pressure: Evidence on omission patterns in university entrance examinations. *Journal of Economic Behavior & Organization, 115*, 94–110. https://doi.org/10.1016/j.jebo.2014.08.007

Ramirez, G., Shaw, S. T., & Maloney, E. A. (2018). Math anxiety: Past research, promising interventions, and a new interpretation framework. *Educational Psychologist*, *53*(3), 145–164. https://doi.org/10.1080/00461520.2018.1447384

Richardson, M., Abraham, C., & Bond, R. (2012). Psychological correlates of university students' academic performance: A systematic review and meta-analysis. *Psychological Bulletin*, *138*(2), 353–387. https://doi.org/10.1037/a0026838

Riener, G., & Wagner, V. (2017). Shying away from demanding tasks? Experimental evidence on gender differences in answering multiple-choice questions. *Economics of Education Review, 59*(C), 43–62. https://doi.org/10.1016/j.econedurev.2017.06.005

Saboonchi, F., & Lundh, L. (2003). Perfectionism, anger, somatic health, and positive affect. *Personality and Individual Differences, 35*(7), 1585-1599. https://doi.org/10.1016/S0191-8869(02)00382-3

Slade, P. D., & Owens, R. G. (1998). A dual process model of perfectionism based on reinforcement theory. *Behavior Modification, 22*(3), 372-390. https://doi.org/10.1177/01454455980223010

Slaney, R. B., Rice, K. G., Mobley, M., Trippi, J., & Ashby, J. S. (2001). The Revised Almost Perfect Scale. *Measurement and Evaluation in Counseling and Development, 34*(3), 130–145. https://doi.org/10.1080/07481756.2002.12069030

Stoeber, J. (2012). Perfectionism and performance. In S. M. Murphy (Ed.), *The Oxford handbook of sport and performance psychology* (pp. 294–306). New York, NY: Oxford University Press.

Stoeber, J. (2018). *The psychology of perfectionism: Theory, research, and applications*. London, UK: Routledge.

Stoeber, J., Damian, L. E., & Madigan, D. J. (2018). Perfectionism: A motivational perspective. In J. Stoeber (Ed.), *The psychology of perfectionism: theory, research, and applications*. London, UK: Routledge.

Stoeber, J., & Otto, K. (2006). Positive conceptions of perfectionism. *Personality and Social Psychology Review*, *10*(4), 295–319. https://doi.org/10.1207/s15327957pspr1004_2

Suárez-Pellicioni, M., Núñez-Peña, M. I., & Colomé, À. (2013). Abnormal error monitoring in math-anxious individuals: Evidence from error-related brain potentials. *PloS One*, *8*(11), e81143. https://doi.org/10.1371/journal.pone.0081143

Suárez-Pellicioni, M., Núñez-Peña, M. I., & Colomé, À. (2016). Math anxiety: A review of its cognitive consequences, psychophysiological correlates, and brain bases. *Cognitive, Affective & Behavioural Neuroscience*, *16*(1), 3–22. https://doi.org/10.3758/s13415-015-0370-7

Tsui, J. M., & Mazzocco, M. M. M. (2006). Effects of math anxiety and perfectionism on timed versus untimed math testing in mathematically gifted sixth graders. *Roeper Review, 29*(2), 132-139. https://doi.org/10.1080/02783190709554397

Walstad, W., & Robson, D. (1997). Differential item functioning and male-female differences on multiple-choice tests in economics. *Journal of Economics Education, 28*(2), 155-171.

Yurtseven, N., & Akpur, U. (2018). Perfectionism, anxiety, and procrastination as predictors of EFL academic achievement: A mixed methods study. *Novitas-ROYAL, 12*(2). 96-115.

Zhang, J., Zhao, N., & Ping Kong, Q. (2019). The relationship between math anxiety and math performance: A meta-analytic investigation. *Frontiers in Psychology, 10, 1613.* https://doi.org/10.3389/fpsyg.2019.01613

Figure 1. Mediation model with parameter estimation testing the mediating effect of the Concern over Mistakes factor (FMPS-CM) and the Doubts about Actions factor (FMPS-DA) on the relationship between the Math Course Anxiety factor (MCA) and the number of unanswered questions. **p < .01, *p < .05.

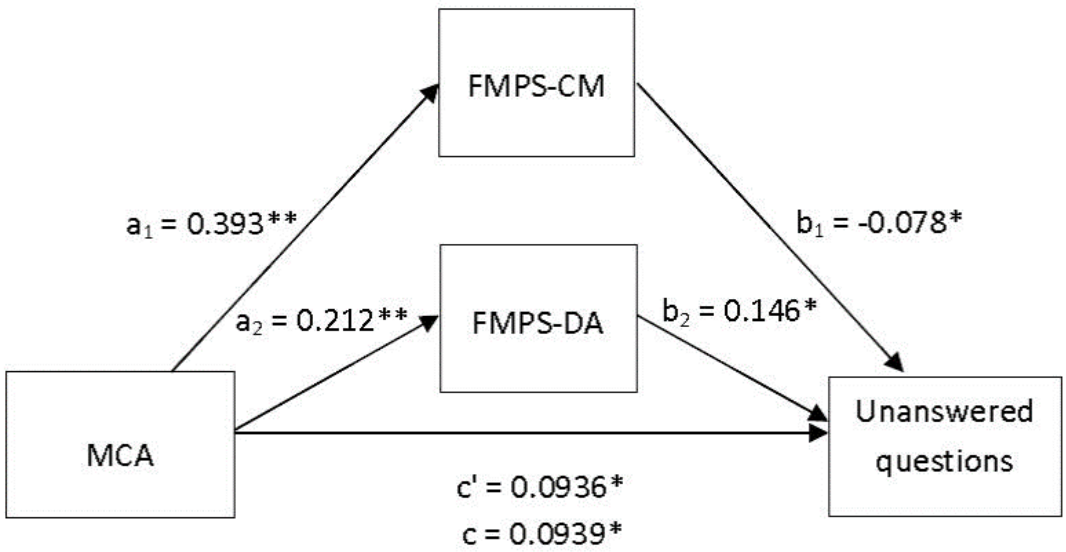

Table 1. Means and SEM (in brackets) for the LMA and HMA groups on the two questionnaires (total and subscale scores).

	sMARS	MTA	NTA	MCA	FMPS	FMPS -PS	FMPS -CM	FMPS -O	FMPS -DA
LMA	46.00 (.81)	34.37 (.74)	5.83 (.18)	5.8 (.17)	70.82 (1.73)	20.92 (.64)	17.88 (.87)	22.08 (.62)	9.95 (.41)
HMA	90.07 (1.18)	62.28 (.64)	12.79 (.57)	15 (.48)	80.73 (1.80)	22.28 (.62)	23.48 (1)	21.84 (.65)	13.13 (.42)

Note. sMARS: Shortened Math Anxiety Rating Scale; MTA: Math test anxiety subscale; NTA: Numerical task anxiety subscale; MCA: Math course anxiety subscale; FMPS: Frost Multidimensional Perfectionism Scale; FMPS-PS: Personal standards subscale; FMPS-CM: Concern over mistakes subscale; FMPS-O: Organization subscale; FMPS-DA: Doubts about actions subscale.

Table 2. Means and SEM (in brackets) for the LMA and HMA groups on all the performance measures.

	Grade	Hits	Errors	Unanswered questions	Hits per answered questions
LMA	6.44 (.20)	23.71 (.50)	4.18 (.34)	2.11 (.31)	.85 (.10)
HMA	5.87 (.21)	22.13 (.53)	4.79 (.37)	3.07 (.31)	.82 (.12)

Table 3. Spearman correlation coefficients for relationships between anxiety and perfectionism scores.

	1	2	3	4	5	6	7	8
1. sMARS	-							
2. MTA	.949**	-						
3. NTA	.665**	.493**	-					
4. MCA	.824**	.687**	.508**	-				
5. FMPS	.205**	.195**	.119	.179**	-			
6. FMPS-PS	.045	.048	.045	.059	.719**	-		
7. FMPS-CM	.239**	.220**	.184**	.205**	.835**	.501**	-	
8. FMPS-O	-.009	-.009	-.072	.009	.408**	.141*	.037	-
9. FMPS-DA	.341**	.315**	.190*	.286*	.593**	.219**	.501**	.039

* $p < .05$; ** $p < .001$

Note. sMARS: Shortened Math Anxiety Rating Scale; MTA: Math test anxiety subscale; NTA: Numerical task anxiety subscale; MCA: Math course anxiety subscale; FMPS: Frost Multidimensional Perfectionism Scale; FMPS-PS: Personal standards subscale; FMPS-CM: Concern over mistakes subscale; FMPS-O: Organization subscale; FMPS-DA: Doubts about actions subscale.

Table 4. Spearman correlation coefficients for relationships between exam performance measures and scores on the two questionnaires.

	sMARS	MTA	NTA	MCA	FMPS	FMPS -PS	FMPS -CM	FMPS -O	FMPS -DA
Grade	-.091	-.081	-.080	-.064	-.029	.090	.005	-.024	-.203**
Hits	-.103	-.089	-.088	-.084	-014	.104	.013	-.016	-.202**
Errors	.038	.043	.047	-.006	.067	-.021	.028	.027	.161*
Unanswered	.168*	.135*	.142*	.173**	-.055	-.156*	-.082	-.022	.169**
Hits per answered questions	-.058	-.054	-.058	-.031	-.037	.057	-.014	-.011	-.168**

* $p < .05$; ** $p < .001$

Note. sMARS: Shortened Math Anxiety Rating Scale; MTA: Math test anxiety subscale; NTA: Numerical task anxiety subscale; MCA: Math course anxiety subscale; FMPS: Frost Multidimensional Perfectionism Scale; FMPS-PS: Personal standards subscale; FMPS-CM: Concern over mistakes subscale; FMPS-O: Organization subscale; FMPS-DA: Doubts about actions subscale.

Table 5. Means and SEM (in brackets) for male and female students on the two questionnaires (total and subscale scores).

	sMARS	MTA	NTA	MCA	FMPS	FMPS -PS	FMPS -CM	FMPS -O	FMPS -DA
Male	62.05 (2.77)	44.90 (1.79)	8.71 (.71)	8.44 (.61)	73.63 (2.24)	22.00 (.79)	20.37 (1.18)	20.46 (.73)	10.80 (.60)
Female	68.75 (1.21)	50.37 (.78)	8.61 (.28)	9.78 (.32)	74.37 (.99)	20.82 (.33)	19.96 (.50)	22.43 (.35)	11.28 (.24)

Note. sMARS: Shortened Math Anxiety Rating Scale; MTA: Math test anxiety subscale; NTA: Numerical task anxiety subscale; MCA: Math course anxiety subscale; FMPS: Frost Multidimensional Perfectionism Scale; FMPS-PS: Personal standards subscale; FMPS-CM: Concern over mistakes subscale; FMPS-O: Organization subscale; FMPS-DA: Doubts about actions subscale.

Table 6. Means and SEM (in brackets) for male and female students on all the exam performance measures.

	Grade	Hits	Errors	Unanswered questions
Male	6.56 (.26)	24.05 (.63)	4.15 (.51)	1.80 (.26)
Female	6.10 (.12)	22.68 (.32)	4.56 (.21)	2.76 (.22)