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Math anxiety is associated with skipping problems and less help-seeking behavior after error commission

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A R T I C L E I N F O

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A B S T R A C T

Math anxiety is a significant barrier to STEM participation and success. This study investigates the influence of math anxiety and autonomy support on students' post-error problem-solving behaviors. 111 participants participated in this study. Autonomy support was manipulated by randomly assigning participants to choice and no-choice group. Math anxiety was assessed using a questionnaire. Participants had three options after making an error in a math task: skipping the problem (avoidance), asking for a hint (help-seeking), or solving the question by oneself (self-reliance). Structural Equation Modeling results revealed that higher levels of math anxiety were associated with increased skipping of problems and decreased help-seeking behaviors after an error. Autonomy support showed no significant effects on post-error behaviors. These findings suggest math avoidance after error commission in high math anxious adults and highlight the need to develop interventions targeting more adaptive post-error behaviors in these individuals.

Education relevance and implications: This study highlights the significant impact of math anxiety on students' problem-solving behaviors after making errors. Specifically, it reveals that individuals with high math anxiety are more likely to skip problems and less likely to seek help, which can hinder their learning and perpetuate a cycle of poor performance. These findings underscore the importance of developing educational interventions that encourage perseverance and help-seeking behaviors, helping students overcome math anxiety and improve their math skills. Such interventions could ultimately enhance students' engagement and success in STEM fields.

1. Introduction

It is imperative to have a workforce trained in Science, Technology, Engineering, and Mathematics (STEM) to drive innovation and secure a prosperous future. Being skilled in mathematics is crucial in today's complex technological society, not only for everyday life, but also for professional development (Gross et al., 2009), future economic success (Ritchie & Bates, 2013; Rose, 2006), and general quality of life (Rivera-Batiz, 1992). Math anxiety, defined as the feelings of tension, apprehension, or fear toward math (Ashcraft, 2002), constitutes a barrier to STEM participation (Ahmed, 2018) and success, even after controlling for math ability (Daker et al., 2021). A study showed that most adults in the United States have mild to moderate levels of math anxiety (Hart & Ganley, 2019) and at least one in three students across all the Organization for Economic Co-operation and Development (OECD) countries expressed worry about their math performance (OECD, 2015).

Several meta-analyses have found small-to-moderate negative correlations ($r = -0.28$) between math anxiety and math achievement (e.g. Barroso et al., 2021; Hembree, 1990; Ma, 1999), which is consistent across several countries (Foley et al., 2017; Lau et al., 2022). This detrimental effect of math anxiety on performance has been shown at the elementary (Ramirez et al., 2013), high school (Pizzie & Kraemer, 2023), and university (Núñez-Peña et al., 2013) levels. Several studies have shown that math anxiety can significantly impact brain function, as shown by event-related potentials (Suárez-Pellicioni et al., 2016) and functional magnetic resonance imaging (fMRI) studies (Lyons & Beilock, 2012a, 2012b; Young et al., 2012).

Several mechanisms have been suggested to explain the negative effects of anxiety on performance, such as the competition for working memory resources (Kirk & Ashcraft, 2001) or attentional control deficit (Hopko et al., 1998; Li & Fan, 2022; Suárez-Pelliccioni et al., 2014; Suárez-Pellicioni et al., 2015), but probably the most basic negative consequence of math anxiety is that high math anxious individuals avoid math whenever possible (Ashcraft & Krause, 2007), which makes them

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gain less practice with math. A meta-analysis showed a negative correlation between math anxiety and student's intention to take more mathematics in high school and college ($r = -0.31$; Hembree, 1990). Research has shown that students with higher levels of math anxiety avoided degrees with moderate to high math content (Núñez-Peña et al., 2013) and that math anxiety predicted avoidance of STEM courses and underperformance in these fields throughout university, independently of math ability (Daker et al., 2021). Studies have also shown that this avoidance of math content also happens inside the classroom and in everyday situations. Quintero et al. (2022), for example, found that high math anxious students showed less classroom engagement in math, and that this avoidance partially explained high math anxious individuals' underperformance in math. Song et al. (2023) found that higher levels of math anxiety was associated with avoidance of participation in math-related extracurricular activities and with more negative homework behaviors. These avoidant behaviors in everyday learning in the after-school setting, in turn, mediated the relationship between math anxiety and poor math achievement. This avoidance tendency is also shown in high math anxious individuals' characteristic patterns of responding quickly to problems to avoid the uncomfortable situation of doing math, called local avoidance (Faust, 1996).

Whereas the negative consequences of math anxiety on math performance are well-documented, we know less about how math anxiety affects student's problem-solving behaviors. Previous research has shown that math anxiety is associated with the reliance on less advanced strategies and effort avoidance. Ramirez et al. (2016) found that, among children with higher working memory capacity, those with high levels of math anxiety avoided the use of more advanced memory-based strategies (e.g. retrieval) to solve arithmetic, which are associated with higher math performance. This less frequent use of more advanced strategies mediated between math anxiety and math achievement. Another study showed that math anxiety was associated with less planned engagement with effortful problem-solving (i.e. effortful strategy) when studying for a math exam (Jenifer et al., 2022). Choe et al. (2019) found that high math anxious individuals preferred to solve easy problems over harder ones, even when they could receive higher rewards by solving the hard ones. This avoidance of math could potentially impact high math-anxious individuals' help-seeking behavior (Federici et al., 2015) although, to the best of our knowledge, no study to date has found this association (e.g. Iannacchione et al., 2023).

High math-anxious individuals' preference for less advanced strategies and easy problems could be associated with their avoidance of errors and how they respond to them. Using event-related potentials, Suárez-Pellicioni et al. (2013a, 2013b) found that high math-anxious individuals showed an error-related negativity (ERN) component of enhanced amplitude for errors committed in a numeric task as compared to a control task, while no such effect was found for those with low levels of math anxiety. This finding was interpreted as high math anxious individuals showing a greater emotional response to self-committed errors in a task involving what they are anxious about, numbers. Another study showed that high math-anxious individuals were more accurate when they were required to repeat the same response associated with an error in the previous trial, suggesting that errors cause a reactive inhibition of erroneous responses in high math anxious individuals (Núñez-Peña et al., 2017).

To summarize, not only that math anxiety is associated with differences in error processing (Suárez-Pellicioni et al., 2013a, 2013b), but also with post-error (Núñez-Peña et al., 2017) and math avoidant behaviors (Fioriti et al., 2025). To the best of our knowledge, the literature has not yet informed how high levels of math anxiety can influence individuals' problem-solving behaviors *after* they make an error in math, which constitutes the first objective of this study. Specifically, we studied to which extent high math anxious individuals would rely on skipping a problem (i.e. avoidant behavior), asking for a hint to try to solve it (i.e. help-seeking behavior), or trying to solve it without any external help (i.e. self-reliance behavior) after they solved a math problem incorrectly. This is important, as it could inform on high math-anxious individuals' perseverance when they encounter errors and on how they learn from them (Alvidrez et al., 2024).

Research has suggested that the extent to which the learner has the choice to engage in a given task or not is important for learning. Providing a choice is, according to the Self-Determination Theory (Deci & Ryan, 1985), a good way to support a person's experience of autonomy, which should result in positive motivational outcomes. Providing a choice has been shown to lead to increased motivation, liking, and interest in a task (Cordova & Lepper, 1996; Iyengar & Lepper, 1999; Wang et al., 2024). In other words, people would be more intrinsically motivated to persist at a given task when they chose to get involved in it as compared to when they did not have such a choice (Patall et al., 2008). To the best of our knowledge, no study has investigated the impact that having the choice to do math would or not would have on post-error behaviors in a math task. Addressing this gap in the literature constitutes the second objective of this study. Given that some research has shown that giving excessive or irrelevant choices can be suboptimal, leading to decision fatigue, reduced motivation and lower performance (Vansteenkiste et al., 2004), we explored this question addressing only one simple choice: doing or not doing math.

Regarding the first aim of the study, and based on the extensive evidence associating math anxiety and math avoidance (e.g. Ashcraft & Krause, 2007; Faust, 1996), we predicted that high math anxious individuals would show a math avoidant behavior, skipping more math problems and avoiding help-seeking behaviors by not asking for a hint, trying to move through the task as fast as possible (i.e. local avoidance). Besides local avoidance, high math anxious individuals may not seek help out of a fear of negative judgment (Newman, 2002), or a perceived lack of competence (Ryan et al., 1998). Regarding the second aim of the study and considering the impact of choice on motivation (Patall et al., 2010), we expected that students assigned to the choice condition would persevere more after an error (i.e. self-reliance behavior) than those assigned to the non-choice condition.

2. Method

2.1. Participants

All experimental procedures were approved by the Institutional Review Board at a large southern public university. One hundred and eleven college students from a large public university in the southern U.S. participated in this online study. Participants mean age was 24 years old (age range 18–57, SD = 5.37). The majority of the participants were females ($n = 106$; 95.5 %). 82.9 % of the participants were White, 11.7 % were Black, 0.9 % were Asian and 4.5 % were from other racial groups. A Power Analysis based on the root mean squared error of approximation (RMSEA) in Structural Equation Modeling determined that the required minimum sample size for model misfit detection was 71. Participants completed the study as part of a research credit requirement for their Educational Psychology undergraduate and graduate courses, which aims to help students become familiar with research. Even though the study itself did not simulate the high-stakes pressures of classroom exams or assessments, students knew they were accountable for completing the experiment, as the experimenter would confirm their participation and report this information to the course instructor for credits.

The sample was randomly divided into a group of participants who were given the chance to choose between solving a math or a literacy task (choice group; $n = 89$) and a group who was not given this choice and was automatically assigned to solve a math task (no-choice group; $n = 88$). For more information about this, see the *Experiment* Section and a previous study (Wang et al., 2021). Only data from participants who chose the math task were included in the main analyses, as we aimed to study post-error behavior in math-specific contexts. Of the 89 participants in the choice condition, 64 (71.9 %) chose the math task, while 26

(28.1 %) chose the literacy task. Of the 88 participants in the no-choice condition, 47 (53.4 %) were assigned to the math task, while 41 (46.6 %) were assigned to the literacy task. Thus, 111 participants were used in the analysis: 64 participants who chose to do math in the choice condition and 47 participants who were assigned to do math in the non-choice condition. According to Welch *t*-test and Pearson's χ^2 tests, these two groups did not differ in age ($t = -0.93$, df $= 94.85$, $p = 0.353$), gender ($\chi^2 = 0$, df $= 1$, $p = 1$), race ($\chi^2 = 6.37$, df $= 5$, $p = 0.272$), math anxiety ($t = -0.32$, df $= 100.41$, $p = 0.749$), like math or not ($t = -2.00$, df $= 103.1$, $p = 0.048$), accuracy ($t = -1.38$, df $= 104.31$, $p = 0.170$), or average response times ($t = -0.50$, df $= 102.94$, $p = 0.616$) in the experimental task.

2.2. Instrument

Participants started their participation in the study by completing an online Qualtrics form including demographic questions such as participant's age, gender, or race.

2.2.1. Math anxiety

The online version of the Abbreviated Math Anxiety Scale (AMAS) was used to measure math anxiety (Vahedi & Farrokhi, 2011). The scale had nine 5-point Likert-type items, ranging from 1 (*low anxiety*) to 5 (*high anxiety*). Scores in this test range from 9 to 45. The items asked the participant to rate the statement regarding how anxious they would feel during different situations such as “*Having to use the tables in the back of a math book*.”. The reliability of AMAS was 0.82.

2.2.2. Controlling factors

This study also introduced several controlling factors suggested by previous literature which could potentially influence math anxiety and math problem-solving behaviors, including gender (Van Mier et al., 2019), liking of math (Akin & Kurbanoglu, 2011), or math performance (measured as accuracy and response times in the math task; Luttenberger et al., 2018). These controlling variables were collected either as part of the pre-task demographic survey (like of math or not and gender) or during the experimental task (math performance). By including these controls, we aimed to isolate the effects of math anxiety on post-error problem-solving behaviors.

Specifically, like math or not was measured using one question: “*Do you like math?*” and participants responded using a Likert scale with three response options including: “don't like”, “neither like nor don't like”, and “like” math. Math performance was assessed using accuracy and response times on the 25 items from the Cultural Fair Intelligence Test (CFIT, see below for details) that participants solved during the experimental task. Participant gender was included as a categorical variable based on self-reported data collected during the demographic survey.

2.3. Experiment

2.3.1. Math task

Both the experimental and control groups were asked to answer 25 questions (Appendix A). The questions were taken from the Cultural Fair Intelligence Test (CFIT) from the Genius Tests (Genius Tests, 2021). This test measures a wide range of math competencies including arithmetic processing (e.g. “*Ernie had $10 in cash, with which he purchased gum for $1.29, a candy bar for $1.49, and a beverage for $2.39. If he does not have to pay sales tax, how much change should he receive?*”), time/day calculations *(“Now, it's twice as long since noon as it was two hours ago. What time is it now?”*), distance calculations (*“Two women start at the same point. They walk in opposite directions for 3 meters, then turn right and walk another 4 meters. How far apart are they?”*), fraction calculations (“*Mike has eight pretzels. If Mike gives half his pretzels to Sandy and Sandy gives three quarters of those pretzels to Jason, how many pretzels does Mike have?”*), proportional reasoning (“*Three painters can paint three walls in three minutes. How many painters are needed to paint 27 walls in nine minutes?”*), algebraic reasoning (*“In four years, Phil will be half Tim's age. Two years ago, Tim was five times Phil's age. How old is Phil now?”),* and geometric reasoning (“*If a hexagon is 12, how many is a square?*”), among others. The CFIT was challenging enough to lead participants to make errors and was therefore an appropriate choice to study post-error problem solving behaviors.

2.3.2. Procedure

Participants signed up for the study through the university's data collection system, which assigned them a unique four-digit research ID number. They received a Zoom meeting link and instructions to temporarily change their Zoom ID to their research ID before the experiment to protect their privacy. Upon joining the Zoom meeting, the investigator sent the participant the consent form via the Zoom chat function. The participant e-signed the consent form, which included information about the experiment and emphasized that they could withdraw from the study at any time if they felt uncomfortable. Once participants signed the consent form, they received a link to the online survey and experimental task hosted on Qualtrics and a self-developed system repectively. Participants completed the task independently, with their video and microphone on. The experimenter was available in the Zoom session in case participants had questions or technical difficulties, but their video and microphone were off to avoid distractions. The experimenter was able to see whether the participant completed the task or not, but did not have access to the participants' responses during the task. Specifically, the experimenter could not see the participants' screen during the task session.

Participants in the choice group were asked to freely choose between a math or a literacy task. Participants in the no-choice group were asked to solve a math task without having a choice. More information about these two groups is given in Section 2.1. Participants were informed that the task consisted of 25 questions (see Appendix A) and was untimed. After assigning the participants to one of the groups, if they had no further questions about the task, the investigator muted their microphone and turned off their video to give the participants uninterrupted time to solve the 25 questions. We collected information on participants' accuracy and response times in the task, as well as the post-error choices they made.

Participants were asked to respond to each question by choosing one of 5 alternative response options. For example, for the question “*Ernie had $10 in cash, with which he purchased gum for $1.29, a candy bar for $1.49 and a beverage for $2.39. If he does not have to pay sales tax, how much change should he receive?”*, the 5 response options were: a) $ 4.83; b) $ 5.17, c) $5.83, d) $ 6.12, e) None. If participants responded correctly (option a), they moved to the following question. If the response was incorrect, they were given three options. (1) They could skip the question, in which case their answer would be considered incorrect, and they would move to the next question (i.e. avoidance). (2) They could request a hint (e.g. “*His cost was $1.29 + $ 1.49 + $2.39*”.) and attempt to answer the same question again (i.e. help-seeking). If the answer was correct, they would move to the following question. If the response was incorrect, they were given the 3 post-error options (i.e. skipping, asking for hint, continuing to think) again. (3) They could continue to think the response to the question by themselves without asking for a hint or skipping the question (i.e. self-reliance). If the response given was correct, they proceeded to the following question. If it was incorrect, the participant was given the same 3 post-error options again (i.e. skipping, asking for hint, continue to think).

2.4. Data analysis

2.4.1. Post-error behavior scoring

The frequency of post-error problem-solving behaviors was extracted from the data for every participant, following the rules summarized in

Table 1
Scoring rules for post-error problem-solving behaviors.

Post-error approach	Problem-solving behaviors	Hint	Skip
Avoidance	Skipping with no Hint	N	Y
	Skipping after Hint	Y	Y
Help seeking	Ask for Hint	Y	N
Self-reliance	Solving the Question by oneself	N	N

Note: The first two categories are both skipping behavior. **1. Skipping with no Hint**: The individual did not request a hint (**Hint** = **N**) and skipped the question (**Skip** = **Y**); **2. Skipping after Hint**: The individual requested a hint (**Hint** = **Y**) and skipped the question after receiving the hint (**Skip** = **Y**); **3. Ask for Hint**: The individual requested a hint (**Hint** = **Y**) and did not skip the question (**Skip** = **N**); **4. Solving the Question by Oneself**: The individual did not request a hint (**Hint** = **N**) and did not skip the question (**Skip** = **N**).

Table 1. Each row represents a specific behavior pattern characterized by combinations of actions related to hints, skipping, and attempts to solve a question. The columns indicate whether a hint was requested (Hint) and whether the question was skipped (Skip). Appendix B provides the actual screens that participants saw during the task.

Scores of dependent variables in this study were defined as the total number of items for which specific actions occur, which suggested how likely certain problem-solving behaviors were to happen after error commission. For example, pressing the "skip" button on 5 different items in total throughout the experiment resulted in a score of 5 in avoidant behaviors. Thus, all behavioral scores ranged from 0 to 25 (the total number of items). All behavioral scores were standardized for further data analysis.

2.4.2. *Structural equation modeling specifications*

To answer the two research questions of this study, a structural equation model (SEM) was fitted to test the effects of math anxiety on post-error problem-solving behavior controlling for all other variables. In SEM, the outcomes were frequency of help-seeking (i.e. asking for a hint), avoidant (i.e. skipping), and self-reliant behaviors. The group variable contained the choice and non-choice groups. Math anxiety was treated as a latent variable. Other controlling variables included gender, like math or not, and accuracy and average response time in the math task as indicators of math performance (see Fig. 1). RMSEA, Comparative Fit Index (*CFI*), Tucker-Lewis Index (*TLI*) were reported to examine the goodness-of-fit of SEM. *RMSEA* value close to or lower than 0.08 and *CFI* and *TLI* higher than 0.90 are acceptable (Hu & Bentler, 1999). SEM allows for the inclusion of latent variables that estimate post-error behaviors while accounting for individual variabilities. This approach ensures that the model accounts for both the frequency and nature of post-error decisions (i.e. help-seeking, avoidant, self-reliant) without disproportionately weighting data from low-accuracy participants. Additionally, math accuracy on the experimental task was included as a covariate to isolate the unique effects of math anxiety on post-error behaviors. While we recognize that low-accuracy participants contribute more post-error data points, our goal was not to compare high- and low-accuracy participants but rather to understand how math anxiety influences post-error behaviors regardless of accuracy. This approach allowed us to control for performance-related variability while focusing on the psychological and behavioral responses to errors.

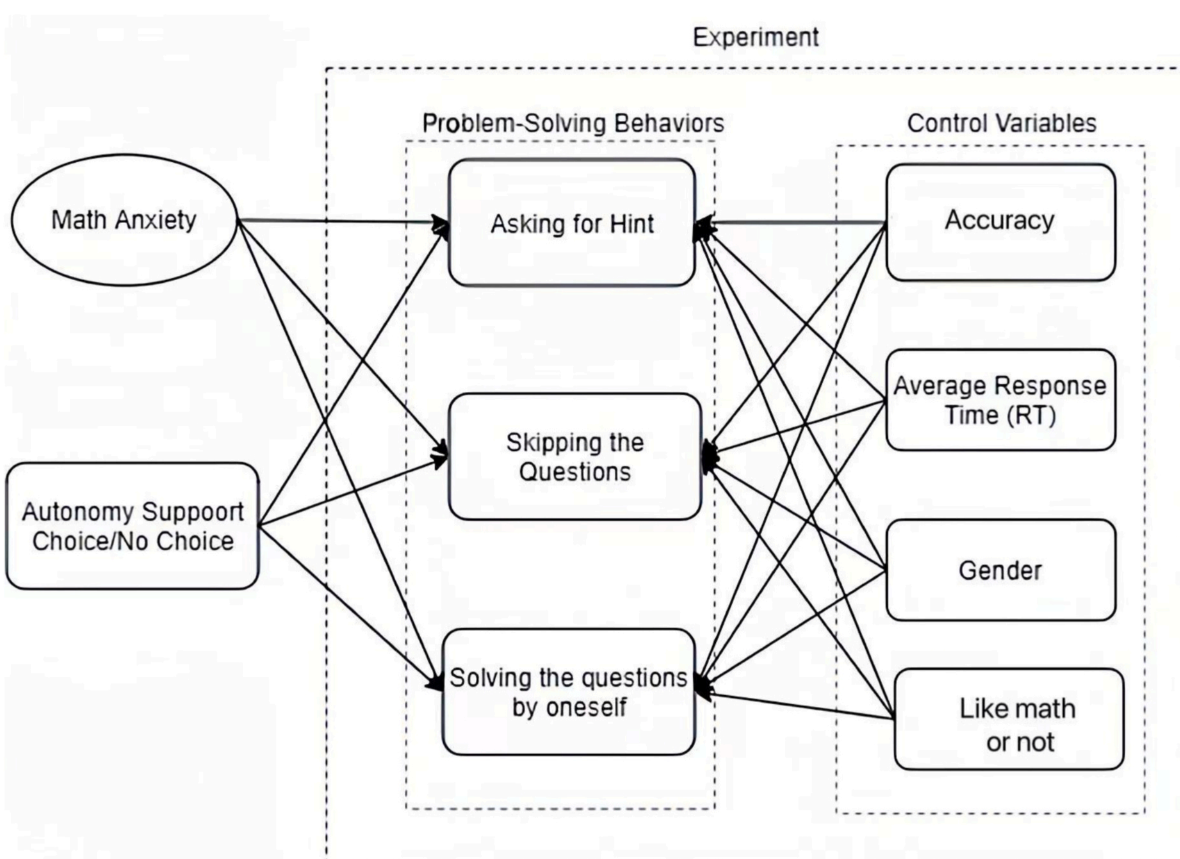

Fig. 1. Proposed experiment model.
Note. Illustration of the SEM carried out to study the role of math anxiety in explaining post-error problem solving behavior after accounting for autonomy support and control variables (aim 1) and to study the role of autonomy support in explaining post-error problem solving behavior after accounting for math anxiety and control variables (aim 2).

3. Results

3.1. Overall performance on the task and post-error behaviors: descriptive statistics

Of 25 questions, the average number of incorrectly answered items across participants was 10.7 (SD = 3.88). The minimum number of errors a participant made was 3 and the maximum number was 24. The average accuracy across participants was 14.6 (SD = 3.78), suggesting that on average, participants were able to answer approximately 60 % of items correctly (14.6 out of 25 questions).

The average number of clicking the "*Hint*" button across samples was 5.69 (SD = 3.66), the average number of clicking the "*Skip*" button across samples was 2.21 (SD = 3.00) and the average number of times participants "*Solving the question by oneself*" was 4.79 (SD = 3.91). Of 111 participants, 17 participants (15.3 %) had zero "*Solving the question by oneself*" behaviors, 12 participants (10.8 %) had zero "*Asking for hint*" behaviors and 42 participants (37.8 %) had zero "*Skipping the question*" behaviors.

3.2. Performance and post-error behavior based on choice

Table 2 provides the basic descriptive statistics and the results of the t/χ^2 tests carried out to compare the choice and no-choice groups. As shown in this table, the two groups did not differ in age ($t = -0.93$, $p = 0.353$), gender ($\chi^2 = 0.00$, $p = 1$), race ($\chi^2 = 6.37$, $p = 0.272$), like of math or not ($t = 3.11$, $p = 0.08$), accuracy ($t = -0.32$, $p = 0.749$), or response times ($t = -0.50$, $p = 0.616$) in the math task. The two groups, however, differed on math anxiety ($t = 2.538$, $p = 0.013$), with the no-choice group showing slightly higher math anxiety scores than the choice group.

3.3. Structural equation modeling results: math anxiety and post-error behaviors (aim 1)

As shown in Fig. 2, the SEM had an acceptable model fit (*CFI* = 0.944, *TLI* = 0.922, *RMSEA* = 0.066). The results of SEM showed that, after controlling for the effects of accuracy, response times, gender, and like math or not (i.e. control variables), math anxiety was significantly and negatively associated with asking for a hint behavior ($\beta = -0.222$, $p < 0.05$) and significantly and positively associated with skipping the questions ($\beta = 0.238$, $p < 0.05$). No significant association was found between math anxiety and self-reliance post-error behavior ($\beta = 0.022$, $p = 0.841$).

3.4. Structural equation modeling results: autonomy support and post-error behaviors (aim 2)

SEM results also informed us about the second aim of this study, which was to address the role of having the choice to do math or not (i.e., autonomy support) on post-error behaviors in a math task. The results, shown in Fig. 2, revealed that autonomy support is not associated with post-error problem-solving behaviors.

Note: The dotted line represents non-significant associations, while solid lines represent significant associations.

3.5. Post-error behaviors and math performance (accuracy)

In addition, asking for a hint behavior was found to have a significantly negative relationships with accuracy on the math task ($\beta = -0.290$, $p < 0.05$) and a positive relationship with average response time on the math task ($\beta = 0.624$, $p < 0.05$). The results suggested that the more participants asked for hints, the worse their performance was on the task and the slower they solved it. In other words, this suggests that overall, hints were not helpful to solve the problems correctly in this study.

The results also revealed a significant positive correlation between self-reliance and average response times ($\beta = 0.286$, $p < 0.05$, indicating that trying to solve the problems by oneself was a time-consuming process.

Finally, we found a significant negative effect between gender and self-reliance behavior ($\beta = -0.108$, $p < 0.05$). However, this result must be taken with caution given the small number of males in our sample (only 5; Strube, 1991). Future research should be carried out to study gender differences in post-error behavior.

4. Discussion

Previous studies have shown that high math anxious individuals show a different response to errors committed in a numeric task as compared to a non-numeric task (Suárez-Pellicioni et al., 2013a, 2013b) and that they adapt their responses based on previous errors in math (Núñez-Peña et al., 2017). However, no study to date has explored the association between math anxiety and post-error problem-solving behaviors. Addressing this gap constitutes the first objective of this study. In addition, according to Self-Determination Theory (Deci & Ryan, 1985), providing a choice supports autonomy and leads to positive motivational outcomes. Research shows that having a choice increases motivation, liking, and interest in a task (Cordova & Lepper, 1996; Iyengar & Lepper, 1999; Patall et al., 2008). However, no study has investigated the impact of having the choice to do math on post-error behaviors in a math task, which is the second objective of this study. To address these questions, we focused on help-seeking, avoidance, and

Table 2
Descriptive statistics and t/χ^2 Tests for the Choice and No-choice groups.

Variables	Levels	Range/Freq.	Mean (SD)/Prop.	Choice group		No-choice group		t/χ^2	*p*-value
				Mean	SD	Mean	SD		
Age		20–54	23.99 (5.37)	24.6	5.61	23.6	5.2	−0.933	0.353
Gender	Male	5	4.50 %	3	4.69 %	2	4.26 %	0.000	1.000
	Female	106	96.50 %	61	95.31 %	45	95.74 %		
Race	White	92	82.88 %	39	82.98 %	53	82.81 %	6.368	0.272
	Black or African American	14	12.61 %	5	17.67 %	9	25.94 %		
	American Indian or Alaska Native	3	2.70 %	1	1.78 %	2	3.47 %		
	Asian	2	1.80 %	2	2.89 %	0	0.00 %		
Math anxiety		9–45	22.27 (7.37)	20.3	6.46	23.7	7.71	2.538	0.013
Like Math or Not	Like	65	39.64 %	33	70.21 %	32	51.61 %	3.108	0.078
	Do not Like	44	58.59 %	14	29.79 %	30	49.39 %		
	Missing	2	1.80 %						
Accuracy		24	14.32 (3.88)	14.4	3.85	14.2	3.94	−0.321	0.749
Response Time		19.24–90.36	44.22 (13.39)	45	12.9	43.7	13.9	−0.502	0.616

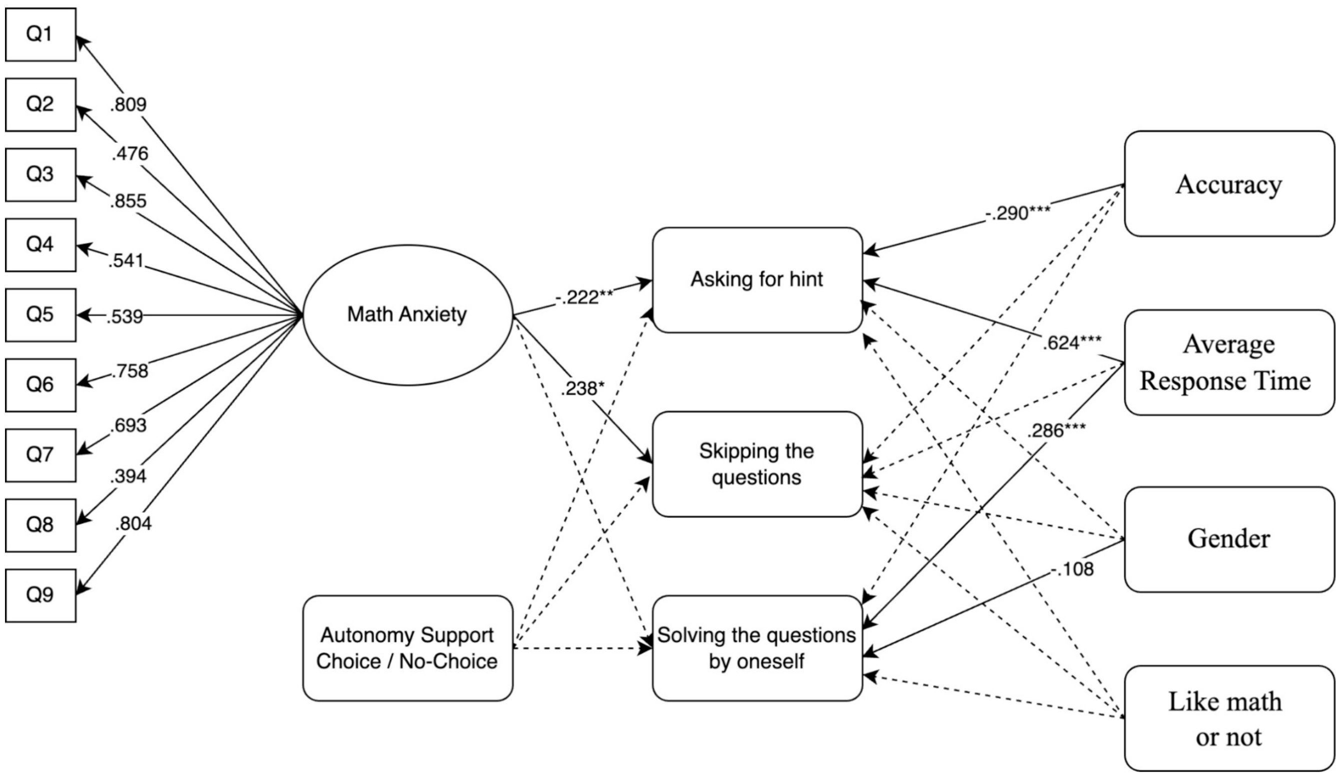

Fig. 2. Structural equation modeling results.

self-reliance behaviors after a math error.

4.1. Math anxiety and post-error behaviors in math

Our study found that, after making an error in math, high math anxious individuals skip problems and do not ask for help. The reluctance to seek help after making an error may stem from a fear of negative judgment (Newman, 2002), a perceived lack of competence (Ryan et al., 1998) or the simple desire to avoid doing math as much as possible (Faust, 1996). Overall, these findings support previous literature showing high math anxious individuals' avoidance of math (Daker et al., 2021; Hembree, 1990; Núñez-Peña et al., 2013). Our findings are also consistent with previous research showing high math anxious individuals' disengagement from math (Quintero et al., 2022), less math participation (Song et al., 2023), lack of effort (Jenifer et al., 2022) and preference for less challenging math tasks (Choe et al., 2019, Daker et al., 2021).

Avoidance of effortful tasks prevents high math anxious individuals from gaining the necessary practice and mastery of mathematical concepts, which may play a critical role in perpetuating their poor math performance and in turn, their math anxiety. This cycle of avoidance and underperformance has been well-documented in the literature (Ashcraft & Krause, 2007; Faust, 1996). By skipping problems and not seeking help after making errors, high math anxious individuals miss out on critical learning opportunities that could help them improve their math skills and overcome their math anxiety. Previous studies have indeed proved that avoidant behaviors actually mediate between math anxiety and poor math achievement (Quintero et al., 2022; Song et al., 2023). In other words, high math anxious individuals prioritize the immediate relief from anxiety over the potential long-term benefits of persevering in math, such as learning more advanced math content and improving math competence.

Overall, our findings contribute to a deeper understanding of the specific behaviors exhibited by high math anxious individuals in response to errors. These findings underscore the importance of developing targeted interventions that address these avoidant behaviors. Encouraging perseverance and help-seeking in the face of challenges could be key for breaking the cycle of math anxiety and poor performance (Ramirez et al., 2016).

Interestingly, the study did not find a significant relationship between math anxiety and self-reliance behaviors. This suggests that math-anxious individuals do not necessarily compensate for their help-seeking avoidance by increasing their efforts to solve problems independently. Instead, our findings suggest that high levels of math anxiety may lead to a broader disengagement from math. This disengagement can have long-term negative effects on learning and performance, highlighting the need for targeted interventions to address math engagement in high math anxious individuals (Hembree, 1990).

Additionally, our results indicate that skipping math problems did not result in faster response times, suggesting that the intended goal of avoidance (i.e., minimizing time spent on the task) was not achieved. It is possible that we did not find skipping to result in faster response times because we categorized as skipping two specific behaviors: skipping without asking for a hint and skipping after asking for a hint (see Table 1). In other words, the fact that we considered skipping after asking for a hint as skipping can also explain the lack of the expected association between skipping and faster response times.

In addition to this, it is possible that the cognitive load created by ruminations about the possibility of skipping a problem or hesitancy in deciding among the post-error behaviors could have offset any time-saving benefits of skipping. Furthermore, this effect could be due to inefficiencies in decision-making processes among high math-anxious individuals. This would be consistent with research showing that math anxiety impairs processing efficiency (Suárez-Pellicioni et al., 2013a, 2013b) and attentional control (Hopko et al., 1998; Li et al., 2022; Suárez-Pellicioni et al., 2016), which could have contributed to longer decision times even when they decide to skip a problem. Overall, our study suggests that high math anxiety is associated with skipping behavior but that this skipping seems not to be automatic or impulsive.

4.2. Post-error behaviors are not affected by autonomy support

Contrary to our expectations, the provision of autonomy support, operationalized as the ability to choose between a math and a literacy task, did not significantly impact post-error problem-solving behaviors. This finding contrasts with previous evidence suggesting that autonomy support can enhance motivation (Deci & Ryan, 1985; Patall et al., 2008).

The lack of significant findings could be attributed to several factors. First, the type of choice provided might not have been meaningful or relevant enough to influence problem-solving behaviors. Previous research suggests that the quality and relevance of choices are crucial for autonomy support to be effective (Iyengar & Lepper, 1999). More nuanced and context-specific autonomy-supportive strategies should be explored to determine its association with post-error behavior. For instance, providing choices throughout the task or integrating student preferences into task design might yield different outcomes (Jang et al., 2010; Vansteenkiste et al., 2004).

Second, the timing and context of the choice might have played a role. The choice was given at the beginning of the task, which might not have been sufficient to sustain motivation and engagement throughout the task. Providing ongoing opportunities for choice and incorporating other autonomy-supportive strategies, such as offering positive feedback and encouraging self-regulation, might yield different results (Reeve, 2009).

Finally, individual differences in need for autonomy could influence the effectiveness of autonomy support. Some students might require more or different types of support to benefit from autonomy-enhancing strategies. Personalized approaches that consider individual differences in motivation might be more effective in promoting engagement and reducing avoidance behaviors (Patall et al., 2008).

4.3. Post-error behaviors and math performance

Our study revealed that asking for a hint (help-seeking) and solving questions by oneself (self-reliance) were significantly and positively associated with response times. The act of asking for a hint involves stopping to seek external assistance, which inherently takes time, and continuing to work on a problem independently without seeking help can also prolong the problem-solving process, especially if the individual is struggling to find a solution. This finding aligns with previous research indicating that both help-seeking and persistent problem-solving can be time-consuming processes (Newman, 2002; Ryan & Pintrich, 1997).

On the other hand, we found math scores to be negatively associated with asking for a hint. This finding is at odds with previous literature showing a positive association between help seeking behaviors and math achievement (e.g. Schenke et al., 2015). This discrepancy can be due to the specificity of our task or our sample. For example, it may be the case that the hints provided after an error in our study were not helpful for successfully completing the task. It might also be the case that this negative correlation is simply reflecting low math skilled individuals' tendency to ask for hints more frequently. Given the correlational nature of our study, we cannot determine the role of post-error help-seeking behavior in explaining high math anxious individuals' changes in math performance. Future studies should address this relevant question using longitudinal designs.

4.4. Implications for educational practice

Our study found that high math anxious individuals tend to skip math problems and avoid asking for help after making an error, suggesting a lack of effort and perseverance when faced with challenges or undesirable results. Addressing these behaviors in educational settings is crucial for improving math performance and reducing math anxiety.

First, it is essential to teach high math anxious individuals about the importance of errors as part of the learning process. Emphasizing that mistakes are a natural and valuable part of any learning can help reframe their perspective on errors. Interventions such as error management training, which encourages students to view errors as opportunities for learning and growth, can be particularly effective (Keith & Frese, 2008). Teachers can model positive attitudes toward errors and provide constructive feedback that focuses on effort and improvement rather than solely on correctness.

Second, fostering a supportive learning environment that encourages help-seeking behaviors may be crucial for these individuals. Teachers should emphasize the value of asking for help and create a classroom culture in which asking questions when needed is viewed positively (Karabenick & Berger, 2013). Structured opportunities for collaboration and peer support can promote help-seeking behaviors and reduce the stigma associated with asking for help (Newman, 2002). Peer support programs, where students work together to solve problems and support each other's learning, have been shown to be effective in encouraging help-seeking and reducing anxiety in educational settings (Pointon-Haas et al., 2023; Worley et al., 2023).

Additionally, providing targeted interventions that focus on building perseverance and resilience in the face of challenges can be beneficial. Strategies such as goal setting, self-regulation training, and developing a growth mindset may help students build the skills needed to persist through difficulties. For example, teaching students to set specific, achievable goals and to monitor their progress can increase their motivation and engagement (Zimmerman & Schunk, 2011). Promoting a growth mindset, where students believe that their abilities can improve with effort and practice, can also be helpful in reducing anxiety and improving performance (Dweck, 2006).

Furthermore, personalized approaches that consider individual differences in motivation and anxiety levels might be more effective in promoting engagement and reducing avoidance behaviors (Patall et al., 2008). Tailoring interventions to meet the specific needs of high math anxious individuals, such as providing more frequent and specific feedback or offering alternative problem-solving strategies, can help them feel more supported and capable (Núñez-Peña et al., 2015; Wang et al., 2021).

Finally, incorporating technology-based interventions, such as adaptive learning platforms and math-specific anxiety reduction programs, can provide additional support for high math anxious individuals (Öztop, 2023). These tools can offer personalized feedback, track progress, and provide practice opportunities in a low-stress environment. Studies have shown that technology-based interventions can effectively reduce math anxiety and improve performance by providing a safe space for practice and immediate feedback (Atoyebi & Atoyebi, 2022; Ersozlu, 2024).

In summary, the findings from this study highlight the importance of addressing post-error avoidant behaviors in high math anxious individuals. Our findings are consistent with previous evidence showing that overcoming avoidant behaviors and more frequent engagement with math is critical in helping high math anxious individuals overcome their math anxiety and its impact on performance (Pizzie & Kraemer, 2023).

4.5. Limitations

While this study provides important insights into the influence of math anxiety on post-error problem-solving behaviors, some limitations should be noted. First, in our study, some participants were allowed to choose to do math whereas others solved the math task without having the choice. This could have introduced a selection bias, as high math anxious participants may have opted out of the math task when given the choice, leading to participants in the non-choice task scoring higher in math anxiety as compared to those in the choice condition. Our results (Table 2) suggest that a selection bias could have been introduced in our study, as participants in the non-choice condition scored higher in math anxiety than those in the choice condition. Note, however, that the choice and non-choice groups did not differ in whether they like math or not. Future studies could consider implementing a paradigm that gives participants the illusion of choice but ultimately requires them all to complete the math task in order to preserve the sense of autonomy while reducing potential selection bias.

Also, the unequal number of data points generated by participants with varying accuracy levels could constitute another potential limitation. While SEM enables the inclusion of accuracy as a covariate, future studies could adopt alternative designs. For example, researchers could manipulate the difficulty of the task to ensure a more uniform distribution of incorrect responses across participants or could use adaptive algorithms, which dynamically adjust response times based on participants' performance to optimize error rates (Fielhler et al., 2005).

In addition, this study did not control for participants' test anxiety, so the results might partially reflect students' anxiety related to test-taking situations. However, the participants were aware that the experiment had no impact on their grades or academic records. Knowing that their performance in the experiment would not have any real-world consequences, in contrast to high-stakes testing, likely reduced any effects of test anxiety in our results. Future studies, however, should address this limitation by controlling for this type of anxiety.

Additionally, the current study relied on a single session and a specific task format, which may limit the generalizability of the findings. Future research could employ longitudinal designs to examine how post-error behaviors evolve over time or under different conditions, such as varying levels of task difficulty or autonomy support.

5. Future research directions

Building on our findings, future research should focus on several key areas to better support high math anxious individuals and improve their problem-solving behaviors. First, it is crucial to investigate the effectiveness of specific interventions designed to reduce avoidant behaviors and promote perseverance in math. Future studies could explore the impact of resilience training programs that teach students to persist through challenges and view errors as learning opportunities. These programs could be tested in different educational settings to determine their effectiveness in reducing math anxiety and improving performance.

Second, future research should examine the role of help-seeking behaviors in more detail. Understanding the specific reasons why high math anxious individuals avoid seeking for help can inform the development of targeted interventions. For instance, qualitative studies involving interviews or focus groups with high math anxious students could provide deeper insights into their reluctance to ask for help and unravel possible strategies to encourage more proactive help-seeking behaviors.

Future studies could explore item-level trends to provide more nuanced insights into students' problem-solving behaviors. For instance, examining how strategies evolve over the course of multiple test problems—such as fluctuations in help-seeking behaviors, self-reliance, or the tendency to skip questions—could reveal patterns influenced by fatigue, perceived difficulty, or the effectiveness of hints. Applying Item Response Theory (IRT) to estimate item parameters and analyze item-level statistics would be a rigorous approach to understanding these dynamics. Such fine-grained analyses could complement the test-level performance evaluations presented in this study, offering a deeper understanding of how individual item characteristics interact with problem-solving strategies.

Finally, future studies should aim to replicate this study in settings that better reflect classroom environments and their real-life pressures. For example, this could involve incorporating performance-based incentives, such as awarding bonuses for accuracy, providing real-time feedback on performance, or introducing peer comparison or time pressure, which are common in educational contexts. These modifications would enhance the ecological validity of the findings and provide a more comprehensive understanding of how math anxiety influences post-error behaviors in real-world situations.

In summary, future research should aim to develop and test targeted, evidence-based interventions that address the specific behaviors and challenges associated with high math anxiety. By focusing on reducing avoidance and promoting help-seeking researchers can contribute to more effective strategies for improving math engagement, effort, and learning from errors in high math anxious individuals.

6. Conclusion

Our study identified two post-error behaviors in high math anxious individuals: a tendency to skip problems and a reluctance to seek help after making errors in a math task. The act of skipping problems post-error reflects an avoidance strategy that prevents individuals from engaging with and mastering challenging material. This avoidance may prevent them to learn from errors and may reinforces a cycle of poor performance and increased anxiety. Similarly, the reluctance to seek help after encountering an error may suggest a lack of perseverance and a fear of negative judgment, further hindering learning and improvement in math.

By identifying these behaviors, our study underscores the importance of developing targeted interventions aimed at breaking this avoidance-performance cycle in math anxiety. Encouraging perseverance and fostering a supportive environment that normalizes help-seeking are essential strategies for educators to consider. Addressing these specific post-error behaviors can play a significant role in reducing math anxiety and improving overall math competence among high math anxious individuals. Future research should continue to explore effective interventions that promote resilience and adaptive problem-solving in the face of mathematical challenges. Future longitudinal studies should address the role of these post-error behaviors in the development of math anxiety in children.

CRediT authorship contribution statement

Yurou Wang: Writing – review & editing, Writing – original draft, Validation, Project administration, Methodology, Data curation, Conceptualization. **Jihong Zhang:** Writing – original draft, Methodology, Data curation. **Macarena Suárez Pellicioni:** Writing – review & editing, Writing – original draft, Validation.

Consent to participate

All participants signed the consent form.

Ethics approval

Approved by the University of Alabama Ethical Review Board (IRB). Protocol ID: 19-12-3088.

Code availability

The authors share the code on the Center of Open Science Website (https://osf.io/2mp9t/).

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On behalf of all authors, the corresponding author states that there is no conflict of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.lindif.2025.102681.

Data availability

The authors share the data on the Center of Open Science Website (https://osf.io/2mp9t/).

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