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Parental Math Anxiety Is Associated With Negative Emotional Activation During Hypothetical Health Decision Making

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Abstract

Dealing with numbers is an inherent aspect of interpreting health statistics, and negative emotions may interfere with medical decision making. One emotionally charged decision-making context is parents making medical decisions for their children. Knowing which factors–such as anxiety specific to math contexts–are associated with parents' negative emotions during the decision-making process may inform ways to better support families as they make critical medical decisions. The current study involved secondary data analyses of an experiment with 249 parents. Participants were randomly assigned to make hypothetical health decisions for themselves, their child, or a stranger. We examined which domain-specific math (e.g., math anxiety), domain general (i.e., need for cognition), and demographic variables (e.g., parents' health-care coverage) were associated with ratings of negative emotional activation immediately after making the decisions. Results indicated that two factors were significantly associated with parents' ratings of negative emotional activation: (1) the person they were making decisions about (i.e., higher negative emotion activation if they were randomly assigned to make hypothetical health decisions about their child versus themselves or a stranger), and (2) parents' ratings of their own math anxiety (i.e., parents with higher self-reported math anxiety also reported higher negative emotional activation). Future research may further consider the joint roles of emotional activation and math anxiety in how parents make health decisions for their children. Further, understanding how much math anxiety causally contributes to people's overall negative emotional activation could lead to a more nuanced understanding of negative emotional activation in health decision making.

Keywords

math anxiety, parents, health decision making

Non-Technical Summary

Background

Health information often includes numerical information, and no two health contexts are exactly the same. Parents' negative feelings about health decision making may be partially caused by their anxiety about math. Parents' feelings about math would ideally not be related to their medical decisions, but evidence suggests that math anxiety and emotional activation affect medical decisions. The mechanism underlying emotional activation during risk estimation tasks that involve numerical information is currently an open question.

Why was this study done?

The current study aims to increase understanding of potential underlying variables that may be involved with negative emotional activation in health decision making.

What did the researchers do and find?

In the current pre-registered study consisting of secondary data analyses, we explored whether mathematical and non-mathematical factors were associated with caregivers' negative affect (henceforth labeled "negative emotional activation" for consistency with prior research; Zikmund-Fisher et al., 2006, https://doi.org/10.1111/j.1525-1497.2006.00410.x) during hypothetical medical decision making. Two factors were found to be significantly associated with the participants' ratings of negative emotional activation: the person they were making the hypothetical health decisions for, and their ratings of their own math anxiety.

What do these findings mean?

The findings of the current study bring awareness to variables that could influence the health decisions made by parents in real-life scenarios.

Highlights

- Parents' health-related decisions may be affected by who they are making the decision about (e.g., themselves, their children, or others).
- Math anxiety is related to negative emotional activation during health decision making.
- Many factors affect emotions during health decision making, including factors related to math (e.g., math anxiety).
- Individual differences exist in how people perceive health information: Each decision-making context is different, and parents' perceptions and decisions are informed by their pre-existing factors (e.g., parent math anxiety).

Math and Health

How people think and feel about numbers and math is highly relevant to health contexts (Rolison et al., 2020). Medical information is often communicated as rational numbers, such as fractions (e.g., 1/4), percentages (e.g., 25%), or whole number frequencies (e.g., 1 in 4) (Gigerenzer et al., 2007; Scheibe et al., 2022; Thompson et al., 2023; Waters et al., 2006). These numbers are often disliked (Mielicki et al., 2022; Sidney et al., 2021) and anxiety provoking (Mielicki et al., 2022, 2023; Necka et al., 2015). Therefore, when people are presented with health statistics in medical contexts in the form of rational numbers, one reason they may experience negative state-like emotions (e.g., anxiety) in the moment that they are evaluating health statistics could be due to having to attempt to decipher mathematical information.

Substantial research has shown that math skills have important implications for health-related outcomes (Peters, 2020; Peters et al., 2019; Reyna & Brainerd, 2007; Thompson et al., 2023). Further, there is increasing evidence that math anxiety influences health decision making and health outcomes (Peters & Bjalkebring, 2015). For example, math anxiety is correlated with worse understanding of health information (Rolison et al., 2016). Math anxiety refers to the unpleasant feelings or tension that many people experience while performing or thinking about math (Ashcraft, 2002; Hembree, 1990; O'Leary et al., 2017; Richardson & Suinn, 1972). Higher math anxiety is associated with more negative perceptions about one's math abilities (Ashcraft, 2002), higher test anxiety and generalized anxiety (Dowker et al., 2016; Hembree, 1990), more math avoidance behaviors (Ashcraft, 2002; Ashcraft & Krause, 2007), lower need for cognition (Maloney & Retanal, 2020), and lower accuracy on assessments of mathematical performance (Sidney et al., 2019; Thompson, Taber, Fitzsimmons, & Sidney, 2021). Although extensive research has been conducted on the role of math anxiety in educational contexts, less is known about how math anxiety may function in health contexts, such as the one illustrated above. Additionally, whether anxiety about math may contribute uniquely to negative emotions during health decision making is an open question, as well as whether estimating hypothetical health risks with visual displays will elicit negative emotional activation.

Emotion and Health

Medical settings can be "emotionally-laden contexts" (Ferrer & Mendes, 2018; p. 1), such that negative emotions are frequently experienced. In general, the affective states people experience influence their medical decision making (Kahneman, 2011; Loewenstein, 2005). Negative emotions can lead to negative health outcomes; for example, more state anxiety was associated with lower engagement in health behaviors among a sample of pregnant women (Nicoloro-SantaBarbara et al., 2017). Thus, it is important to understand *who* is most likely to experience negative emotions in health contexts, such as individuals higher in math anxiety.

Caregivers may be especially likely to experience negative emotions in medical settings or find medical decision making for children stressful. However, more is known about caregiver emotions when children are experiencing more serious medical situations (see for example a review of decision making relative to children with medical complexity, Jonas et al., 2022) than about emotions when caregivers are making relatively routine health decisions for their children. In one study conducted with respect to medical decision making for children generally, participants were randomly assigned to make health decisions as themselves, as a parent deciding for their (hypothetical) child, as a doctor deciding for a patient, or as a medical director designing treatment guidelines (Zikmund-Fisher et al., 2006). Participants in the parent role reported the highest negative emotional activation scores. While the internet sample collected by Zikmund-Fisher and colleagues was demographically diverse, it is important to note that not all participants were parents. Therefore, some participants assigned to the parent role likely needed to imagine that they were a parent, whereas others were actually parents. In the current study, all participants were parents, which allowed us to replicate the finding that people would experience more negative emotional activation when making decisions about a child than about themself. Furthermore, parents in our study could also be randomly assigned to make hypothetical decisions about someone else (i.e., a stranger), which might a less emotionally charged situation (as in Zikmund-Fisher & colleagues' [2006] conditions when people were making hypothetical decisions as a medical director or a physician). Establishing the role of parental status on emotional activation during health decisions is important because self-reported emotional activation can influence participants' hypothetical treatment choices (Zikmund-Fisher et al., 2006).

The Current Study

The main goal of the current study was to investigate which factors were associated with negative emotional activation experienced while parents made (hypothetical) health decisions for themselves, their child, or an unrelated stranger. More specifically, we examined whether math traits (i.e., math anxiety, subjective numeracy), non-math traits (i.e., need for cognition, who the parent was making the hypothetical medical decision about), and demographic variables (i.e., parents' gender, parents' level of educational attainment, parents' health-care coverage), were associated with parents' ratings of negative emotional activation as they made hypothetical medical decisions. We did not make directional hypotheses and only aimed to explore which mathematical and non-mathematical factors were related to negative emotional activation by conducting regression analyses. For the sake of avoiding HARKing, we want to be clear that even though we pre-registered an analysis plan, we did not make specific directional hypotheses prior to conducting the data analyses.

In addition to assessing whether math anxiety was associated with negative emotional activation, we also measured parents' subjective numeracy–their perceived ability to accurately assess mathematical information and preferences for math (Fagerlin et al., 2007; "How good are you at calculating a 15% tip?")–because higher subjective numeracy is positively related to objective math performance and negatively related to math anxiety (Thompson, Taber, Fitzsimmons, & Sidney, 2021).

Furthermore, we measured parents' need for cognition, which is a domain-general measure of how much someone engages with and enjoys thinking and problem solving (Cacioppo et al., 1984). Recent research found that higher need for cognition was related to lower math anxiety in a national sample of U.S. adults (Thompson, Taber, Sidney, et al., 2021) and that math anxiety may mediate a relation between need for cognition and math achievement (Maloney & Retanal, 2020). Note that none of the questions in the need for cognition measure are inherently mathematical, although they do include phrases like "solutions to problems" and "problems," which participants could interpret as mathematical. Although we did not have any directional hypotheses about the role of need for cognition on emotional activation, we reasoned that individual differences in whether one tends to engage in or enjoy deeper thinking and problem solving (i.e., more cognitive focus) might matter for whether a task elicits more emotional activation. Therefore, higher need for cognition might be related to lower negative emotional activation, as math anxiety and negative emotional activation are likely positively related.

We also included gender in our statistical models because women tend to be more math anxious (Sidney et al., 2021) and less confident in their math performance than men (Rivers et al., 2021; Scheibe et al., 2022), and mothers are often more involved than fathers in their family's healthcare decisions (Zvara et al., 2013). For example, teens self-reported that their mothers helped more with Type-1 diabetes care than did fathers (King et al., 2014; Palmer et al., 2011), and in a small sample of dual-earner families, couples reported that mothers alone were more likely to take their child to the doctor than fathers alone (Ehrenberg et al., 2001).

Finally, we included parental educational attainment in our models as a proxy for general math understanding; we included health-care coverage as a possible predictor of emotional activation because a lack of healthcare coverage may lead to greater stress while thinking about making healthcare decisions for one's children (see Lentz et al. [2019] for a review of financial toxicity, or the negative impact of financial burden on well-being after a cancer diagnosis). In summary, we included subjective numeracy, parent's gender and educational attainment, and need for cognition in our models to control for these variables of interest as we assessed the association between math anxiety and negative emotional activation.

Method

Fitzsimmons and colleagues (2023) implemented a fully crossed 3 (visual display: number line, icon array, Arabic numerals) x 3 (person medical decisions were made for: self, child, stranger) factorial design. The primary aim of Fitzsimmons et al. was to assess which one of three visual displays presented to participants – who were all parents/guardians (henceforth, "parents") – led to the most mathematically accurate responses pertaining to hypothetical health decisions (see Figure 1).

In the current study, we conducted preregistered (Meanor et al., 2022S) secondary data analyses to determine mathematical and non-mathematical factors that accounted for variance in negative emotions as reported immediately after participants completed all trials in the hypothetical decision-making task.

Participants

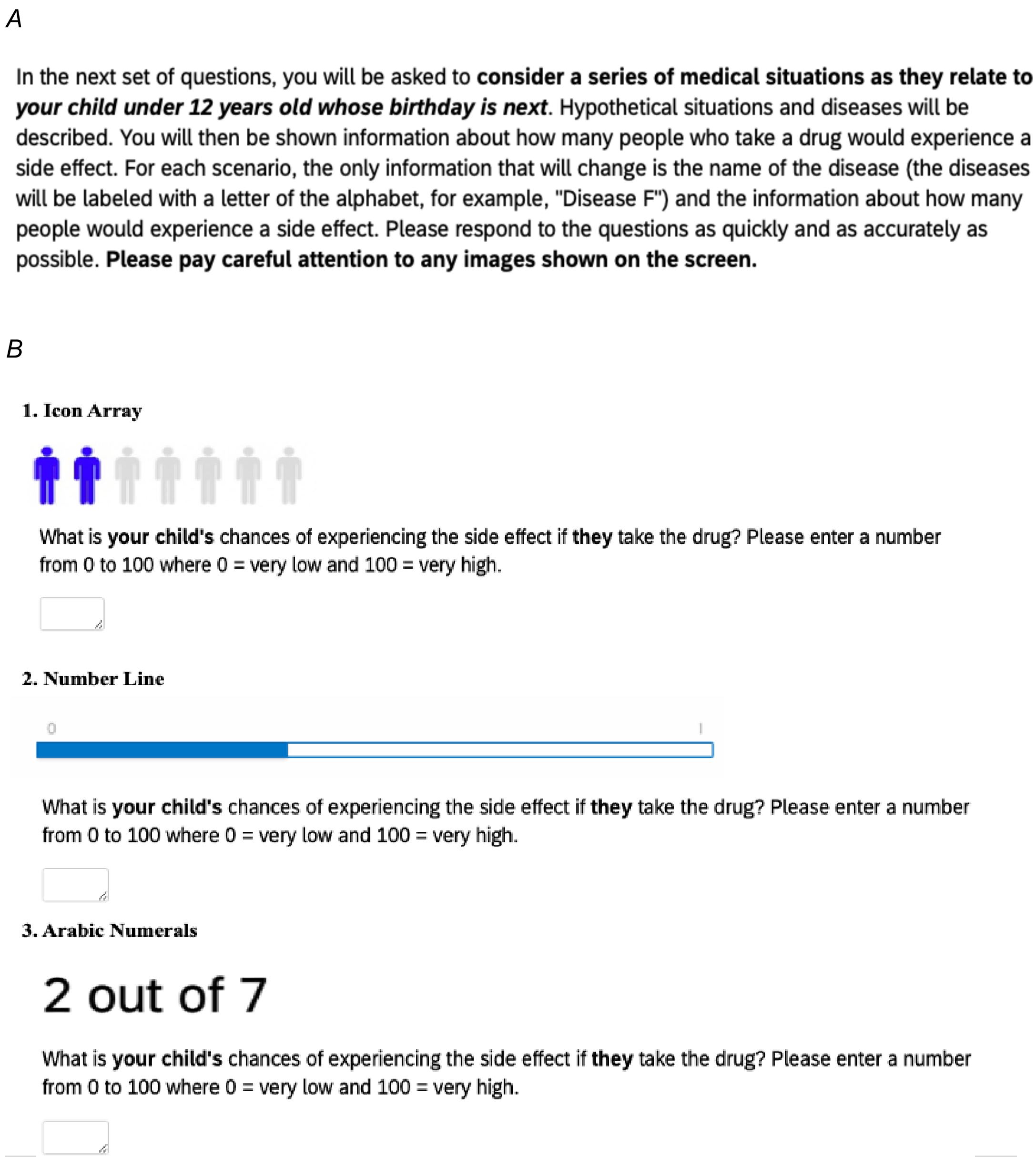
Participants provided informed consent and completed the online experiment through Amazon's Mechanical Turk. Inclusion criteria required that all participants had a child between 0 and 11 years of age, spoke English fluently, and were residents of the United States. Fitzsimmons et al. (2023) excluded 58 participants: 22 for completing the survey too quickly (<12 minutes); five for gibberish, nonsensical, or non-language based open-ended responses, 27 for incorrectly answering one or both manipulation check items, and 10 for invariably responding on the pretest number line estimation task. Some participants overlapped in multiple exclusionary categories, and 4 participants were excluded based on invariable responses to the number-line task alone. We excluded an additional participant who did not report their race, gender, or college education. We chose to exclude this participant because we included gender and education in our primary analyses. The final analytic sample included 249 participants. See Table 1 for participant demographic information.

Procedure

Prior to responding to the hypothetical medical questions, participants who were randomly assigned to the child conditions were instructed to think about their child whose birthday was next in the calendar year to encourage parents to think about one child in particular. Participants in the self and stranger conditions were not given these instructions.

Figure 1

Examples of the Prompts (A) and Visual Displays (B) Shown to Participants Depending on Randomly Assigned Condition



Note. In the example prompt, the phrase “as they relate to your child” (i.e., child condition) was interchanged with “as they relate to yourself” (i.e., self condition), and “as they relate to someone you do not know” (i.e., stranger condition). All participants viewed the example prompt; participants saw only one of the three visual displays depending on their randomly assigned condition.

Table 1

Participant Demographics

Variable	***N***	**Percent**
Race and Ethnicity		
White	203	81.2
Black or African American	17	6.8
Hispanic or Latino	4	1.6
American Indian or Alaska Native	1	0.4
Asian	15	6.0
Native Hawaiian or Pacific Islander	0	0.0
Other	1	0.4
Did not report	2	0.8
Multiple	6	2.4
Gender		
Male	105	42.0
Female	138	55.2
Non-binary	1	0.4
Different identity	0	0.0
Did not report	5	2.0
Employment		
Employed for wages	189	75.6
Self-employed	21	8.4
Out of work for more than 1 year	1	0.4
Out of work for less than 1 year	7	2.8
Homemaker	24	9.6
Student	2	0.8
Retired	0	0.0
Did not report	5	2.0
Education		
Less than a high school diploma	0	0.0
High school diploma	22	8.8
Some college (no degree)	39	15.6
Associate's Degree	29	11.6
Bachelor's Degree	114	45.6
Graduate Degree	45	18.0
Household Income		
$0 to $9,999	5	2.0
$10,000 to $14,999	2	0.8
$15,000 to $19,999	5	2.0
$20,000 to $34,999	15	6.0
$35,000 to $49,999	38	15.2
$50,000 to $74,999	56	22.4
$75,000 to $99,999	53	21.2
$100,000 to $199,999	59	23.6
$200,000 or more	12	4.8
Did not report	4	1.6
Health Insurance		
Currently Covered	230	92.0
Not Currently Covered	16	6.4
Does Not Know If Covered	0	0.0
Did not report	3	1.2
Number of Math Courses Taken	**(*SD*)**	**Range**
	4.94	0-10
Sum of Math Courses (max of 10)	(2.46)	

Participants completed the following tasks in this order: (a) risk estimation accuracy on hypothetical medical decisions concerning side effects in which parents were randomly assigned to the 3 (visual display) x 3 (person decision was about) experimental design, (b) negative emotional activation, (c) need for cognition, (d) math anxiety, and (e) subjective numeracy. The need for cognition scale was in its own block, which was counterbalanced with the math anxiety and subjective numeracy measure. At the end of the study, parents indicated their demographic information (gender, educational attainment, and status of health insurance) as well as child demographic information (child's gender, age, race, and presence of medical issues). Note that when parents were asked about their child's demographics, all participants, regardless of whether they had previously been asked to think about making health decisions for their child, were told to think about their child who had the next upcoming birthday. The full survey is posted on OSF (Meanor et al., 2024S).

Measures and Outcomes

Risk Estimation Accuracy

Participants estimated the risk of experiencing side effects (adapted from Waters et al., 2006) from 12 different magnitudes of risk by typing a number between 0 and 100 in a textbox. Each problem started with a vignette: "Imagine [your doctor, your child's doctor, a doctor] says [you, your child, this person] has a very high risk of getting disease C in the future. A new drug would substantially cut [your, your child's, this person's] risk of developing Disease C. But the drug has a side effect that impacts some people who take the drug. The information immediately below indicates how many people who take the drug will experience the side effect." Below this text was a visual model or Arabic numeral depending on randomly assigned condition, and participants typed their estimate into a textbox. Fitzsimmons et al. (2023) operationalized risk estimation accuracy as percent of absolute error(|actual risk estimate-parents' estimated risk|)/100 for each problem, and then averaged across all problems.

To avoid overlap with Fitzsimmons et al. (2023), our pre-registered secondary analyses did not involve risk estimation accuracy. However, to better interpret significant associations from the current study, we later conducted post-hoc explorations of how risk estimation accuracy related to negative emotional activation, need for cognition, math anxiety, and subjective numeracy.

Negative Emotional Activation

Immediately after completing the health risk estimation task in their randomly assigned visual display x person conditions, participants reported their level of negative emotional activation. Participants rated on a scale from 1 to 5 (1 = "*very slightly/not at all*," 5 = "*extremely*") the extent to which they felt each of ten emotions while answering the hypothetical medical scenarios (i.e., anxious, distressed, guilty, interested, conflicted, determined, uncomfortable, concerned, worried, and responsible; Watson et al., 1988; Zikmund-Fisher et al., 2006). As pre-registered, we averaged the seven negative emotions (i.e., anxious, distressed, guilty, conflicted, uncomfortable, concerned, and worried) to determine each participant's level of negative emotional activation during the health risk estimation task. The internal reliability of all 10 emotion words was weaker (α = .85) than the internal reliability after omitting the items that did not express negative emotional valence: responsible, interested, and determined (α = .91).

Need for Cognition

Due to limited time with participants, we administered a condensed, previously validated measure of need for cognition (Lins de Holanda Coelho et al., 2020) to assess how this variable related to negative emotional activation. Participants answered six questions (e.g., "I really enjoy a task that involves coming up with new solutions to problems") on a 5-point Likert-type scale ranging from "*Extremely uncharacteristic*" to "*Extremely characteristic*" (Cacioppo et al., 1984). We averaged participants' responses across items so that higher scores reflected greater need for cognition.

Math Anxiety

Participants rated their trait math anxiety for four specific number types: whole numbers, whole number frequencies, fractions, and percentages (Thompson, Taber, Sidney, et al., 2021). Participants also responded to the single-item math anxiety rating scale (i.e., On a scale of 1 to 10 with 10 being the most anxious, how anxious are you?) to assess their math anxiety for math in general (Ashcraft, 2002). Ashcraft reports that the one-item measure is strongly correlated in several samples with longer measures of math anxiety (*r*s between .49 and .85). This claim is supported by several other recent studies (e.g., Scheibe et al., 2024) in which the SIMA strongly correlated (*r*s between .67 and .81) with several different, longer math anxiety scales. In the current study, we assessed whether greater math anxiety (averaged across the 5 items about math in general and specific types of math) was related to participants' greater negative emotional activation scores. We expected math anxiety to correlate with negative emotional activation because math anxious individuals are more likely to be generally anxious as well (Ashcraft, 2002; Hembree, 1990). Note however that we did not expect trait math anxiety to be redundant with negative emotional activation during the health risk estimation task.

Subjective Numeracy

Participants completed the 8-item subjective numeracy scale (Fagerlin et al., 2007; Zikmund-Fisher et al., 2007) in which they answered questions about their math ability (e.g., "How good are you at working with percentages?") and preferences for numbers (e.g., "How often do you find numerical information to be useful?") on 6-point Likert-like scales. Scores were averaged across the eight items, and higher scores indicated higher subjective numeracy.

Results

Preliminary Analyses

Prior to assessing whether mathematical and non-mathematical factors predicted negative emotional activation, we first determined whether we should include the experimental conditions from the parent study in our regression analysis. In the parent study (Fitzsimmons et al., 2023), there were two between-subjects conditions (person the medical decision was made about and visual display) with three levels each. A 3 (person condition) x 3 (visual display) between-subjects ANOVA indicated that those who made hypothetical decisions about their child reported higher negative emotional activation (M = 2.37, SD = 1.01) than those who made hypothetical decisions about themselves (M = 1.71, SD = 0.81) or others (M = 1.77, SD = 0.84), which did not differ from each other, $F(2, 240) = 13.36$, $p < .001$, $\eta_p^2 = .10$. However, there was no effect of visual display, $F(2, 240) = 0.15$, $p = .858$, nor an interaction between visual display and person condition, $F(4, 240) = 0.16$, $p = .961$. Therefore, we only included the person condition in the regression analysis reported in Table 2.

We rechecked that random assignment to condition was successful for the sub-set of variables included in our secondary data analyses. Given that Zikmund-Fisher et al. (2006) noted that ratings of emotional activation were the most negative when participants took on the role of parents during hypothetical medical-decision making, and that we included person condition in our primary regression analyses, we checked whether random assignment to person condition (i.e., child, self, stranger) was successful. Additionally, we reasoned that parents' emotional activation may vary depending on characteristics of their child, so we checked whether child characteristics differed by condition. Indeed, parent-reported child demographic information revealed no differences by person condition in the age ($p = .475$) and gender of the child ($p = .294$).

We first examined correlations among the five main continuous study variables: need for cognition, math anxiety, subjective numeracy, negative emotional activation, and risk estimation accuracy (operationalized as percent absolute error). Of note, as shown in Table 3, negative emotional activation was positively correlated with math anxiety ($r = .29$, $p < .001$), but was not significantly correlated with need for cognition ($r = -.07$, $p = .304$), subjective numeracy ($r = -.12$, $p = .054$), or risk estimation accuracy ($r = .10$, $p = .111$).

Table 2

Regression Predicting Negative Emotional Activation

Predictor	*B*	*SE*	β	*t*	*p*
Condition[a]					
Child (0) vs. Other (1)	-0.56	0.14		-4.14	< .001
Child (0) vs. Self (1)	-0.64	0.13		-4.78	< .001
Need for Cognition	0.02	0.05	.03	0.44	.663
Math Anxiety	0.13	0.03	.32	4.17	< .001
Subjective Numeracy	0.10	0.09	.10	1.21	.229
Gender[b]	-0.06	0.12	-.03	-0.50	.621
Educational Attainment[c]	0.03	0.12	.02	0.29	.775
Have insurance[d]	-0.28	0.21	-.08	-1.35	.178
	R	***R*²**	***Adj R*²**	***F***	***p***
Model fit	.44	.19	.16	7.05	< .001

[a]The child group was used as the referent. Gender, educational attainment, and whether participants reported having insurance were all coded as binary options. [b]Self-identified male participants were coded as 1; all other responses were coded as 0. [c]Participants reporting having a 4-year degree or more were coded as 1; all other responses were coded as 0. We also recoded educational attainment as a continuous variable and conducted checks for multicollinearity with other variables in the model represented in Table 2; however, all VIF values were less than 2.0 (between 1.03 and 1.88) so we concluded that multicollinearity was likely not a significant problem in this model. [d]Participants reporting having insurance were coded as 1; all other responses were coded as 0. The negative emotional activation score was right skewed. However, when this dependent variable was log-transformed, because the assumption of normality was violated, results did not differ from the reported analyses above.

Table 3

Correlations Among Study Variables and Scale Reliability, Means, and Standard Deviations

Variable	Scale Range	*M* (*SD*)	1	2	3	4	5
1. Need for cognition	1-5	3.50 (1.10)	α = .94				
2. Math anxiety	1-10	3.84 (2.27)	-.35*	α = .92			
3. Subjective numeracy	1-6	4.68 (0.88)	.37*	-.64*	α = .84		
4. Negative Emotional activation	1-5	1.96 (0.94)	-.07	.29*	-.12	α = .91	
5. Risk[a] estimation error	0-100	4.90 (5.37)	-.02	.25*	-.23*	.10	α = .89

Note. n = 249 for all variables included in this matrix. Scale reliabilities are provided on the main diagonal. Educational attainment was not included in Table 3 because it was coded as a categorical variable given that a majority of participants earned a four-year degree or more (see Table 1).
[a]Risk estimation accuracy was operationalized as PAE meaning that higher PAE values indicated more error and less accurate estimation.
*p < .001.

What Factors Are Associated With Negative Emotional Activation?

To examine which mathematical and non-mathematical factors predicted negative emotional activation, we regressed negative emotional activation on condition (person: dummy coded with child as the referent), need for cognition, math anxiety, subjective numeracy, gender, educational attainment, and having insurance. As shown in Table 2, the model explained 19% of the variance in emotional activation, and the overall model fit was significant, $F(8, 240) = 7.05$, $p < .001$. Even when we accounted for mathematical and non-mathematical factors, an effect of condition indicated that participants reported higher negative emotional activation when making decisions about their child than when deciding for another person or themselves (Table 2). In addition to condition (person), math anxiety also significantly predicted negative emotional activation, $\beta = .32$, $t = 4.17$, $p < .001$. No other variables were statistically significant.

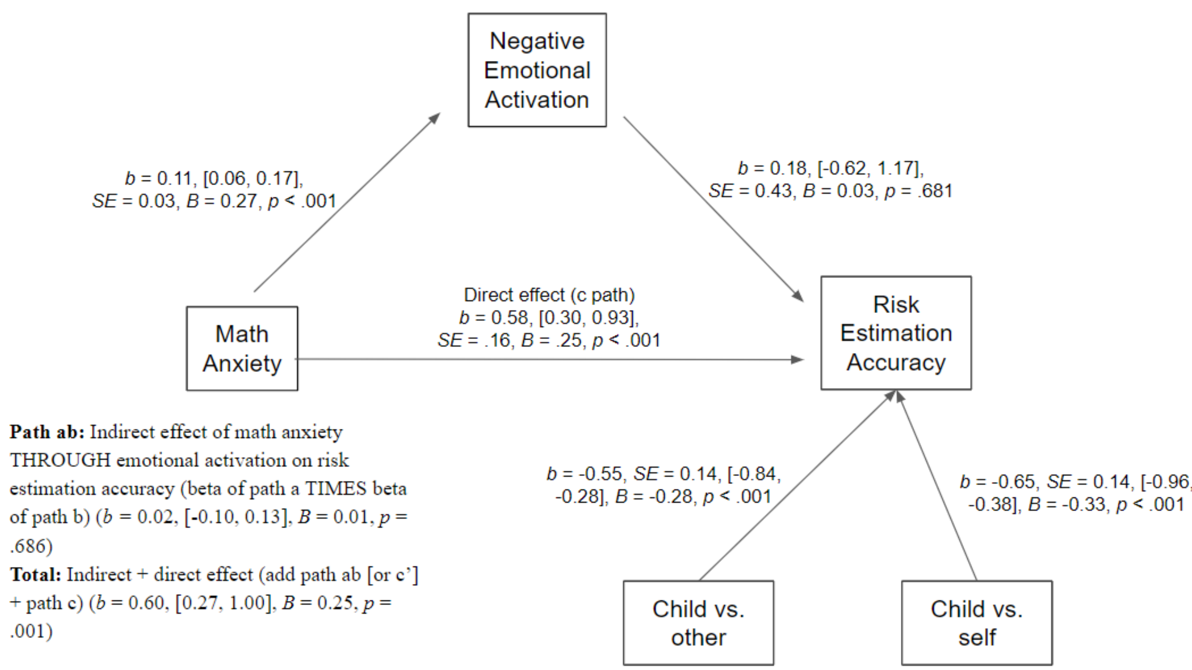
Was There an Indirect Effect of Math Anxiety on Risk Estimation Accuracy Through Negative Emotional Activation?

As shown in Table 3, participants who reported higher math anxiety estimated health risk less accurately and reported more negative emotional activation. The relations among these variables in addition to one proposed theory of math anxiety–the disruption account (see Ramirez et al., 2018 for a review of various theories of math anxiety), which suggests that math anxiety causes poor math performance because people experience negative emotions about math, which overwhelms their working memory and depletes cognitive resources needed to solve math problems–prompted us to conduct a post-hoc mediation analysis. In this mediation analysis, we assessed whether math anxiety might have an indirect effect on risk-estimation accuracy through emotional activation, but there was not a significant indirect effect (see Meanor et al., 2024S). It is possible that the hypothetical health decisions in the current study–deciding whether to take or recommend someone else should take a drug based on its side effects–did not elicit a high amount of negative emotional activation. In fact, negative emotional activation was right skewed in this study. Future work should consider more negative affect-inducing scenarios.

We predicted risk estimation accuracy from math anxiety, and tested whether there was an indirect effect of math anxiety on risk estimation accuracy through emotion activation while controlling for person condition. Person condition was entered as a dummy variable with child as the referent level. We fit our model using the *lavaan* package (Rosseel, 2012) as implemented in R (version 4.2.0) using 500 bootstrap estimates. Results indicated significant effects of math anxiety on emotional activation (b = .11, p < .001) and risk-estimation accuracy (b = .58, p < .001; see Figure 2). However, results indicated no indirect effect of math anxiety on risk estimation accuracy through emotional activation because emotional activation did not predict risk estimation accuracy in the model (b = .18, p = .681).

Figure 2

No Indirect Effect of Math Anxiety on Risk Estimation Through Emotional Activation



Note. Values within brackets are 95% confidence intervals for the unstandardized effect.

Additional Pre-Registered Exploratory Analyses

The current study included two additional pre-registered exploratory analyses. The first assessed which of the same seven independent variables (person condition, subjective numeracy, math anxiety, need for cognition, gender, educational attainment, and status of insurance) predicted participants' "anxious" rating (i.e., the item in the negative emotional activation measure that had the most obvious face validity with math anxiety). Similar to the regression on negative emotional activation reported above, both the person the decision was about (p's < .01) and math anxiety (p < .001) were related to the "anxious" rating.

The other secondary analysis investigated whether the child demographic information (i.e., age, gender, race, presence of medical condition) related to the parents' ratings of negative emotional activation. None of these variables accounted for significant variance in negative emotional activation, which was unexpected; see the discussion for a possible explanation. Additional details pertaining to the secondary analyses can be found in Meanor et al., 2024S.

Discussion

We explored which variables related to parents' ratings of negative emotional activation immediately after they made hypothetical medical decisions about themselves, their child, or a stranger. Making hypothetical decisions for one's child (relative to making decisions for oneself or a stranger) was significantly related to more negative emotional activation, as was higher levels of math anxiety. Results of the current study are consistent with research indicating that making a health decision for a child is anxiety provoking, and further demonstrate that math anxiety is associated with negative emotional activation following hypothetical decision making involving numbers. It is well-established that many people experience anxiety when engaging in math tasks (see Barroso et al., 2021 for a recent meta analysis), but the topic of math anxiety has been underexplored within the applied context of parents making medical decisions for their children.

Is Math Anxiety Separable From Anxiety Related to Non-Numerical Contextual Factors?

People make decisions daily that involve numerical information. For example, calculating an 18% tip, determining which line to stand in based on an estimation of how many people are waiting, or whether to take a medication based on side-effect statistics. In such real-life situations, what is the underlying source of negative emotional activation experienced during decision making: is it math anxiety, other sources of negative affect (e.g., poor mood), or both? Consider a caregiver making a decision about a child regarding whether to administer a doctor-recommended medication. The doctor presents numerical and visual information to the caregiver (see Figure 1 for an example). Not only does the caregiver have to correctly evaluate the numerical information, but they are ultimately tasked with making a decision regarding their child's well-being. Differentiating between anxiety related specifically to interacting with numerical information (i.e., math anxiety) and context-specific anxiety could be an important distinction to make when helping patients make informed health decisions (see Figure 3).

Figure 3

Modeling Causes of Negative Emotional Activation During Health Risk Estimation

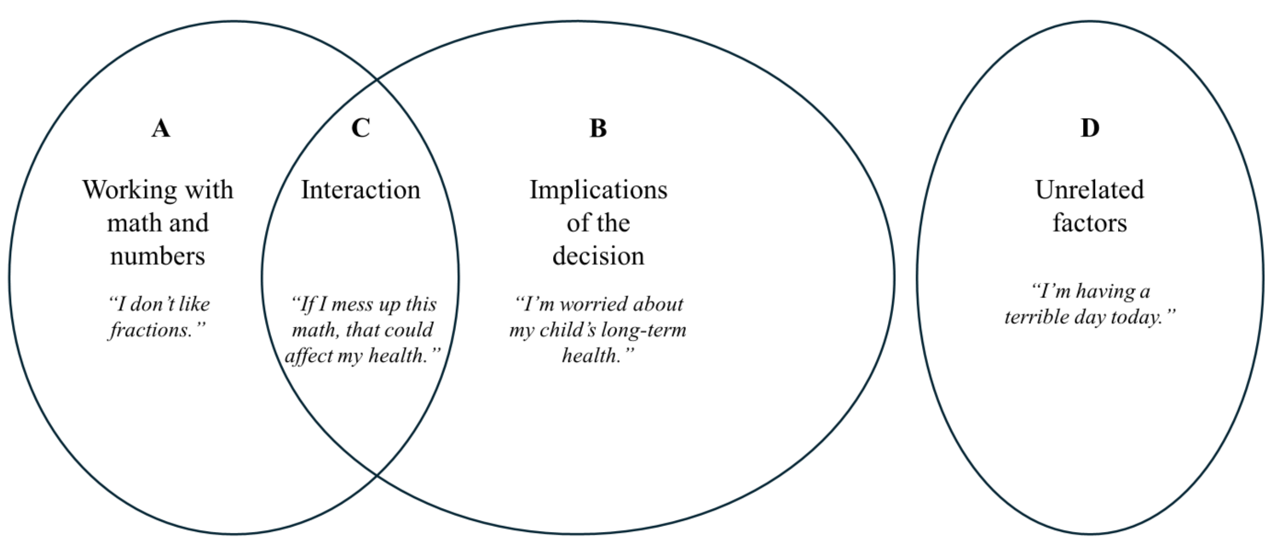


Figure 3 models proposed causes of negative emotional activation during health risk estimation including working with math and numbers (i.e., math anxiety), implications of the decision, an interaction between math anxiety and implications, and unrelated factors (e.g., mood). Intuitively, people experiencing higher math anxiety should experience more negative emotional activation during a math-related task, but as Figure 3 models, that is not guaranteed to be the case. Our findings indicate that parents' ratings of their own math anxiety is associated with their overall negative emotional activation. Math anxiety may make it more difficult for parents to interpret health statistics accurately and to make mathematically-informed health decisions, given that math anxiety is correlated with less mathematical accuracy (Sidney et al., 2019; Thompson, Taber, Fitzsimmons, & Sidney, 2021). Of note, in the present study, greater math anxiety was also associated with less mathematical accuracy (i.e., risk perception accuracy), but negative emotional activation was *not* associated with mathematical accuracy, possibly because the hypothetical scenarios did not induce high levels of negative emotional activation on average (i.e., M = 1.96 on a scale from 1 to 5). Future work could examine risk estimation accuracy in scenarios that elicit greater negative emotional activation–in both hypothetical and real health decisions.

How Might Math Anxiety Interfere With Informed Medical Decision Making?

We identified one factor – math anxiety – that relates to negative emotional activation as parents make hypothetical health decisions. Research has already highlighted that math anxiety is related to a host of other negative outcomes including negative perceptions about one's math abilities (Ashcraft, 2002), higher test anxiety (Hembree, 1990; Zettle & Raines, 2000), math avoidance (Dowker et al., 2016), decreased understanding of health information (Rolison et al., 2016), and lower accuracy on tests assessing mathematical ability (Sidney et al., 2019; Thompson, Taber, Fitzsimmons, & Sidney, 2021). Misunderstanding mathematical information in the context of healthcare puts those who are less numerate at a distinct disadvantage (Peters, 2020). Increasing one's mathematical understanding may help adults more accurately solve health-related problems (Thompson, Taber, Sidney, et al., 2021; Thompson et al., 2023). However, math anxiety may be a potential barrier to patients' accurate understanding of relevant health statistics, subsequently making it very difficult for adults to accurately incorporate health statistics into their medical decisions. If possible, parents' math anxiety could be considered when medical professionals are sharing health statistics and engaging them in shared decision making.

Limitations and Future Directions

Our study had some limitations which we believe create some exciting opportunities for future research. First, the medical scenarios and risks were hypothetical. Participants likely did not feel as engaged with our experiment as they would if their child was actually ill, reducing the generalizability of the findings. Assigning participants to hypothetical situations is common in medical decision-making research (Bogardus et al., 1999; Tait et al., 2010; Thompson, Taber, Fitzsimmons, & Sidney, 2021; Zikmund-Fisher et al., 2006) and allows for initial testing of ideas without burdening patient samples. Emotional activation was also assessed with self-report, rather than through more objective measures, such as physiological arousal. Future research could profitably assess whether emotional activation is influenced by math and non-math factors in medical settings using patient samples.

Another limitation of the current study was that, to increase experimental control, participants viewed medical information that was very limited in nature. Participants were only shown the likelihood that patients could experience a side effect from the new drug; they were not provided with a disease name or the nature of the side effects. In a real-life scenario, this information would likely be readily available. As noted, this decision was intentional to reduce the impact of participants' prior experiences with, and knowledge of, specific diseases, but has the corresponding limitation of reducing generalizability (Thompson, Taber, Fitzsimmons, & Sidney, 2021). Future research should manipulate the simplicity of the risk estimation tasks. For example, future research could manipulate the severity of side effects to examine how severity may be related to negative emotional activation. A related note on generalizability is that our MTurk sample was composed predominantly of White, highly educated participants, who likely had high technological sophistication given they were willing to engage in online research studies. Despite aspects of the current experiment that reduce generalizability, it is noteworthy that variables from the current study were related in ways previously reported in the literature. For instance, subjective numeracy and math anxiety were negatively correlated (r = -.64, p < .001; see also Choi et al., 2020; Thompson, Taber, Sidney, et al., 2021). Furthermore, math anxiety was negatively related to need for cognition, r = -.35, p < .001 (see also Thompson, Taber, Sidney, et al., 2021).

Finally, math anxiety is correlated with trait anxiety (Hembree, 1990; Scheibe et al., 2022), but trait anxiety was not measured in the parent study. Therefore, we cannot definitively say that math anxiety was related to negative emotional activation when controlling for trait anxiety or other indicators of negative affect, such as neuroticism. It is possible that participants' self-reported trait math anxiety may have been strongly correlated with self-reports of trait general anxiety or other forms of anxiety. However, previous research (Scheibe et al., 2022) gives us reason to suspect that math anxiety predicts health-related problem-solving accuracy even controlling for trait anxiety, and math anxiety predicts risk perceptions controlling for generalized anxiety (Rolison et al., 2020). Future research could address these open questions.

Concluding Remarks

Results from the current study suggest that parents' own math anxiety may contribute to their experience of negative emotions as they make hypothetical medical decisions for their children. There are practical implications for these findings that should be investigated in future research. For example, medical decision aids could be tailored to patients' levels of math anxiety, or brief interventions could be developed and tested to reduce math anxiety before patients are provided with health statistics.

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Author Contributions: AM: Conceptualization, first draft writing, revisions; DAS: Conceptualization, analyses, first draft writing, revisions; CJF: Conceptualization, analyses, revisions; JMT: Conceptualization, revisions, supervision; LHW: Conceptualization, data collection from the parent project; CAT: Conceptualization, first draft writing, revisions, supervision

Data Availability: For this article, a data set is publicly available (Meanor et al., 2024S).

Supplementary Materials

The Supplementary Materials contain the following information:

- The preregistration for the study (Meanor et al., 2022S)
- The anonymized research data (Meanor et al., 2024S)
- The full survey (Meanor et al., 2024S)
- Supplemental analyses (Meanor et al., 2024S)
  - Relation among child demographics and emotional activation
  - Factors predicting anxious rating
  - Regression predicting anxious rating (Table S1)

Index of Supplementary Materials

Meanor, A., Thompson, C. A., & Scheibe, D. A. (2022S). *Mathematical and non-mathematical factors that affect parental emotions during hypothetical medical decision-making* [Preregistration]. OSF Registries. https://doi.org/10.17605/OSF.IO/3P9H8

Meanor, A., Thompson, C. A., Scheibe, D. A., Taber, J. M., & Fitzsimmons, C. J. (2024S). *Mathematical and non-mathematical factors that affect parental emotions during hypothetical medical decision-making* [Anonymized research data, full survey and supplemental analyses]. OSF. https://osf.io/3z97p

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