

Intergenerational Effects of Parents' Math Anxiety on Children's Math Achievement and Anxiety

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Abstract

A large field study of children in first and second grade explored how parents' anxiety about math relates to their children's math achievement. The goal of the study was to better understand why some students perform worse in math than others. We tested whether parents' math anxiety predicts their children's math achievement across the school year. We found that when parents are more math anxious, their children learn significantly less math over the school year and have more math anxiety by the school year's end—but only if math-anxious parents report providing frequent help with math homework. Notably, when parents reported helping with math homework less often, children's math achievement and attitudes were not related to parents' math anxiety. Parents' math anxiety did not predict children's reading achievement, which suggests that the effects of parents' math anxiety are specific to children's math achievement. These findings provide evidence of a mechanism for intergenerational transmission of low math achievement and high math anxiety.

Keywords

academic achievement, cognitive development, educational psychology, emotional development, mathematics achievement

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A core goal of the education system is to help students achieve at high levels, both while they are in school and later when they are in the workforce. Although the classroom is usually viewed as the primary vehicle for advancing academic achievement, parents also play an important role in students' academic success (Eccles, 2007). Parents are their children's first and most sustained teachers. But what if parents are themselves anxious about the material their children are learning, as is often the case with math?

Many people have a fear of math, termed *math anxiety* (Ashcraft, 2002; Maloney & Beilock, 2012). Worldwide, math anxiety is associated with decreased math achievement (Lee, 2009). Classroom and laboratory studies have revealed a great deal about the bidirectional link between an individual's math anxiety and his or her math performance. Yet very little is known about how one person's negative emotional responses toward math might relate to someone else's math achievement and attitudes—for example, how having a math-anxious parent or teacher might affect a child's mathematical success and math anxiety

(Beilock, Gunderson, Ramirez, & Levine, 2010). In the present study, we demonstrated that parents' math anxiety is linked to their children's math achievement and math anxiety, and we showed how intergenerational effects of low math achievement and high math anxiety may unfold.

Parents of young children widely believe that math education is primarily the function of schooling and that their role in their children's math achievement is not as important as their role in other subjects, such as reading (Cannon & Ginsburg, 2008). Nonetheless, children may turn to their parents for math help, teachers may ask parents to work with their children on homework, or both.

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We reasoned that if parents are math anxious, their help could backfire, negatively affecting their children's math learning and attitudes. This is a somewhat counterintuitive idea given that parent involvement in homework is generally believed to have positive effects on children's academic achievement. However, this positive relation holds more for verbal subject matter than for mathematics (Robinson, 2014). Indeed, parents' help on math homework is sometimes negatively linked with students' math achievement (Patall, Cooper, & Robinson, 2008; Robinson, 2014). Here, we considered the possibility that it is specifically parents with high math anxiety whose homework help is negatively related to their children's math achievement. These parents may have inadequate math-helping skills or rigidly use instructional strategies that conflict with those that teachers use in the classroom, which could confuse children and negatively affect their math learning. Frequent involvement of parents with high math anxiety in their children's math homework could also create opportunities to communicate their fears about math to their children.

To uncover the relation between parents' math anxiety and children's mathematical knowledge and attitudes, we assessed parents' reported math anxiety and frequency of math homework help as well as the math achievement and math anxiety of their first- and second-grade children at both the beginning and end of the school year. As a control, we also assessed children's reading achievement. Each child was tested individually within the first 3 months and within the last 2 months of the school year, with measures of math achievement and math anxiety administered on separate days. We focused on early elementary school because children as early as first-grade experience math anxiety, which is negatively related to their math achievement (Ramirez, Gunderson, Levine, & Beilock, 2013), and those students who start behind their peers in math skills tend to stay behind throughout schooling (Committee on Early Childhood Mathematics, 2009; Duncan et al., 2007).

Method

Participants

Children. We started with 868 children (469 girls, 399 boys), all of whom participated in a larger study assessing the relation between academic-related affective factors and school achievement. This was a convenience sample obtained by contacting schools during the Fall and recruiting from as many schools as feasible. We then tested every child whose parents gave consent and who was present at school on the days in which we tested. The first round of data collection ended after the first 12 weeks of the school year.

Of the children tested, we had data on parents' math anxiety and frequency of homework help from 529 children (289 girls, 240 boys), and thus we considered this our starting sample for the study. This subsample did not significantly differ from the full starting sample in terms of age, gender, or grade. Further, this sample was representative of the socioeconomic status (SES) distribution in the state of Illinois. The children for whom we had parent data (and thus were included in the analyses in this study) came from schools where, on average, 52% of children received free or reduced-price lunch (an indicator of low SES), and this is on par with what is typical for the state of Illinois (Illinois State Board of Education, 2014).

However, as is often the case in studies such as ours (Esbensen, Miller, Taylor, & Freng, 1999), the children whose parents chose to participate came from higher SES schools as opposed to lower SES schools (school-level SES was calculated as the percentage of children who received free or reduced-price lunch, with a higher percentage corresponding to lower SES). Children whose parents did not participate came from schools in which a mean of 67% of children received free or reduced-price lunch. Whereas the children in our sample whose parents participated had a statistically higher SES relative to all of the children that we tested, we nonetheless had child-parent participants from schools serving children from a wide range of SES backgrounds. Looking solely at the sample of children whose parents responded, the SES level of their children's schools ranged from 0% of the children receiving free or reduced-price lunch to 97% of the children receiving free or reduced-price lunch. Given this wide range and the fact that the SES for our sample was on par with statistics for the state of Illinois, we feel we captured a representative sample of children.

We removed children from the analysis who were uncooperative and did not complete tasks as asked ($n = 21$; 4.0%). We also removed students because of experimenter error during the administration of the Woodcock-Johnson test (i.e., basal criteria were not properly established or children did not get six problems in a row wrong; $n = 43$; an additional 8.1%).¹ We also removed children who did not complete the assessment of math anxiety in both the Fall and the Spring ($n = 27$). This left us with 438 children (243 girls, 195 boys; mean age = 7.21 years, $SD = 0.62$ years), 185 of whom were in first grade and 253 of whom were in second grade. The 438 children whose data were analyzed came from 90 separate classrooms in 29 different schools, including public (both charter and noncharter) and private schools in three states in the Midwest.

Parents. The primary caregivers of the children who were entered into our analyses all completed the relevant

tasks. For simplicity, we use the word “parents” to refer to primary caregivers. Of those who identified their relation to the child ($n = 133$), 97% stated that they were “parents.” The others indicated that they were foster parents (0.8%), grandparents (1.5%), or legal guardians (0.8%). Of those who answered the optional question about their gender ($n = 127$), 89.0% were female and 11.0% were male.

Teachers. To examine whether parents’ math anxiety and help with math homework were related to children’s learning above and beyond their classroom and schooling environment, we also assessed teachers’ math knowledge and math anxiety and gathered information about school-level SES. For all analyses involving teacher factors (i.e., teachers’ math anxiety or teachers’ math knowledge), we excluded 14 teachers (and their students) for the following reasons: 2 teachers did not teach their students math; 4 teachers taught only a subset of their students math, and this subset changed throughout the school year; 5 teachers did not complete the relevant measures or dropped out of the study; and 3 teachers cotaught their students. This left us with 76 teachers (73 females, 3 males) and 379 children (211 girls, 168 boys) from 27 different schools for analyses involving teachers. The subset of 379 children who were included in the analyses in which we controlled for teacher factors did not differ in SES from our starting sample of 529 children for whom we had parents’ math anxiety and homework-helping data.

Materials and procedure

Children’s tasks. Children completed measures of math achievement, reading achievement, and math anxiety as part of a larger study. All tasks were administered within the first 12 weeks of the school year and again within the final 8 weeks of the school year. Students were assessed at school during one-on-one sessions with an experimenter. The achievement and anxiety sessions were conducted on separate days, typically no more than a week apart, with the achievement-test session always administered first.

Math achievement was measured using the Applied Problems subtest of the Woodcock-Johnson III Tests of Achievement (Woodcock, McGrew, & Mather, 2001). This subtest consists of orally and visually presented word problems involving arithmetic calculations of increasing difficulty. Reading achievement was measured using the Letter-Word Identification subtest of the Woodcock-Johnson III. This subtest consists of visually presented letters and words of increasing difficulty. Children are asked to identify the letters and read the words aloud. For both the Applied Problems and

Letter-Word Identification subtests, a different version of the Woodcock-Johnson test was used for the Fall and Spring assessments (Version A and Version B, respectively). Each child was assessed at school during a one-on-one session with an experimenter. All analyses were performed on students’ W scores, which are obtained by transforming students’ raw scores into Rasch-scaled scores with equal intervals (a score of 500 is approximately the average performance of a 10-year-old). Because of its properties as an interval scale with a constant metric, the W score is recommended for use in studies of individual growth (Woodcock, 1999).

Math anxiety was assessed using a revised version of the Child Math Anxiety Questionnaire (C-MAQ; Ramirez et al., 2013; Suinn, Taylor, & Edwards, 1988). The revised CMAQ (CMAQ-R) was designed for first- and second-grade children and involves 16 items that ask children how nervous they would feel during various math-related situations. Some items directly addressed children’s feelings of nervousness while solving particular math problems (e.g., “There are 13 ducks in the water, there are 6 ducks in the grass, how many ducks are there in all?”), while other items addressed their nervousness using more general situations they would experience in the classroom during math lessons (e.g., “being called on by a teacher to explain a math problem on the board”). Children responded by pointing to one of five faces that corresponded to different states on an emotional gradient (1 = *not nervous at all*, 2 = *a little nervous*, 3 = *somewhat nervous*, 4 = *very nervous*, 5 = *very, very nervous*). Scores were averaged across the 16 questions. This scale had good reliability; Cronbach’s alpha was .84 in the Fall and .82 in the Spring.

Parents’ tasks. Parents were sent questionnaire packets, which they completed and returned by mail during the middle of the school year. As part of a larger battery of assessments, math anxiety was evaluated using the short Mathematics Anxiety Rating Scale (sMARS; Alexander & Martray, 1989), which is a 25-item version of the widely used 98-item Mathematics Anxiety Rating Scale (Richardson & Suinn, 1972). Parents responded to questions about how anxious they would feel during different situations (e.g., “reading a cash register receipt after you buy something,” “studying for a math test”) on a 5-point scale (1 = *not at all*, 2 = *a little*, 3 = *a fair amount*, 4 = *much*, 5 = *very much*). All analyses were performed on the average of the 25 items. Parents also completed an assessment of their homework-helping behavior using the question, “How often do you help your child with their math homework?” Answers were made on a 7-point scale (1 = *never*, 2 = *once a month*, 3 = *less than once a week*, 4 = *once a week*, 5 = *2–3 times a week*, 6 = *every day*, 7 = *more than once a day*).

To obtain a proxy for math achievement, we also asked parents to indicate their highest level of education obtained (from “less than high school” to “graduate degree”) and to indicate the number of high school and college-level math courses they had taken.

Teachers’ tasks. Teachers’ math anxiety and math knowledge were assessed during the middle of the school year. As with parents, math anxiety was assessed using the sMARS. All analyses were performed on the average of the 25 items. Teachers’ math knowledge was assessed using the Elementary Number Concepts and Operations subtest of the Content Knowledge for Teaching Mathematics (CKT-M) measure (Hill, Schilling, & Ball, 2004). This task measures teachers’ facility in using mathematics knowledge for classroom teaching, including the ability to explain mathematical rules, assess the validity of unusual algorithms produced by students, and illustrate mathematical equations using diagrams or word problems. The content areas included addition, subtraction, multiplication, and division with whole numbers and fractions. The task consists of 26 multiple-choice questions. Items left blank were considered incorrect. All analyses were performed on raw scores (the number of items correct of the 26 questions).

Results

Descriptive statistics

All 438 children completed the assessment of math achievement at both the beginning and end of the year. First graders’ *W* scores on the Applied Problems subtest at the beginning of the year ranged from 415 to 501 ($M = 456$, $SD = 16$) and at the end of the year ranged from 424 to 515 ($M = 469$, $SD = 20$). Second graders’ *W* scores on the Applied Problems subtest at the beginning of the year ranged from 411 to 542 ($M = 476$, $SD = 19$) and at the end of the year ranged from 439 to 581 ($M = 488$, $SD = 21$).

Four hundred thirty-seven children completed the assessment of reading achievement in both the beginning and end of the year. First graders’ *W* scores on the Letter-Word Identification subtest at the beginning of the year ranged from 354 to 511 ($M = 434$, $SD = 32$) and at the end of the year ranged from 389 to 533 ($M = 463$, $SD = 27$). Second graders’ *W* scores on the Letter-Word Identification subtest at the beginning of the year ranged from 384 to 539 ($M = 472$, $SD = 27$) and at the end of the year ranged from 401 to 533 ($M = 486$, $SD = 24$).

All 438 children completed the assessment of math anxiety in both the beginning and end of the year. Scores on the CMAQ-R at the beginning of the year ranged from 1 to 5 ($M = 2.6$, $SD = 0.8$), and scores on the CMAQ-R at the end of the year ranged from 1 to 4 ($M = 2.4$, $SD = 0.8$).

The correlation between beginning-of-year math anxiety and end-of-year math anxiety was $r(438) = .48$.

For parents, math-anxiety scores on the sMARS ranged from 1 to 5 out of a possible 5 ($M = 2.1$, $SD = 0.9$). Scores on the measure of the frequency of parents’ homework help ranged from 1 to 7 out of a possible 7 ($M = 5.3$, $SD = 1.3$). The median level of parents’ math help did not differ by children’s grade (6.0 for first graders; 6.0 for second graders). On average, parents completed “an associate’s degree or equivalent 2-year undergraduate degree.” A subset of parents ($n = 130$)² also indicated the number of high school or college-level math courses they had completed, which ranged from 0 to 9 ($M = 4.4$, $SD = 2.0$). In all analyses, scale variables were left as continuous. Because responses on the homework-help question were left-skewed, we transformed the responses by squaring them to normalize the distribution (Chambers, Cleveland, Kleiner, & Tukey, 1983). (For additional descriptive statistics, see the Supplemental Material available online.)

The effect of parents’ math anxiety at varying levels of parents’ homework help

We first asked whether parents’ math anxiety related to students’ end-of-year math achievement and whether this relation varied as a function of how frequently parents helped with math homework. Using PROCESS (Hayes, 2013), we tested the interaction between parents’ math anxiety and the frequency of parents’ homework help while controlling for students’ grade, gender, beginning-of-year math achievement, and beginning-of-year math anxiety.³ Overall, the frequency of parents’ homework help moderated the relation between parents’ math anxiety and children’s end-of-year math achievement, as the interaction term was significant, $F(1, 430) = 4.59$, $p = .033$. See Table 1 for the full model.

At 1 standard deviation below the mean of parents’ homework help, there was no relation between parents’ math anxiety and children’s end-of-year math achievement, 95% confidence interval (CI) = $[-1.82, 2.77]$, as indicated by the fact that the CI crossed zero. In contrast, at 1 standard deviation above the mean of parents’ homework help there was a significant relation between parents’ math anxiety and children’s end-of-year math achievement, 95% CI = $[-4.62, -1.05]$, as indicated by the fact that the CI did not cross zero (Fig. 1). For ease of interpretation, the dependent variable in Figure 1 is grade-equivalent change (end-of-year grade equivalent minus beginning-of-year grade equivalent). A grade-equivalent change of one unit represents the amount that an average child is expected to learn over the course of an academic year. Note that the figure plots model-estimated growth. Given the continuous nature

Table 1. Results of the Model Predicting Children's End-of-Year Math Achievement

Variable	<i>b</i>	95% confidence interval
Parents' homework help	-0.16*	[-0.29, -0.03]
Parents' math anxiety	-1.18	[-2.57, 0.21]
Parents' Homework Help × Parents' Math Anxiety	-0.16*	[-0.30, -0.01]
Gender (girl = 0, boy = 1)	2.18	[-0.30, 4.66]
Grade (Grade 1 = 0, Grade 2 = 1)	1.56	[-1.25, 4.36]
Children's beginning-of-year math achievement	0.84**	[0.77, 0.92]
Children's beginning-of-year math anxiety	-0.86	[-2.51, 0.79]

Note: The model had 7 and 430 degrees of freedom. The R^2 for the model was .68.

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

of our variables, we do not plot specific data points but instead show growth estimates as a function of ± 1 standard deviation in parents' math anxiety and homework help, respectively.

Notably, the moderation of the effect of parents' math anxiety on children's end-of-year math achievement by the frequency of parents' homework help was not driven by parents' level of math knowledge. Even after we controlled for parents' highest level of education (a proxy for parents' math knowledge), the pattern remained the same. At 1 standard deviation below the mean of parents' homework help, the relation between parents' math anxiety and children's end-of-year math achievement was not significant, 95% CI = [-2.61, 2.41]. However, at 1 standard deviation above the mean of parents' homework help, this relation was significant, 95% CI = [-3.90, -0.022]. Furthermore, even after we controlled for teacher and classroom factors (i.e., teachers' math anxiety and math

knowledge as well as school-level SES), the pattern remained the same. The relation between parents' math anxiety and children's end-of-year math achievement was not significant at 1 standard deviation below the mean of parents' math help, 95% CI = [-1.642, 3.776], but was significant at 1 standard deviation above the mean of parents' math help, 95% CI = [-4.874, -0.952].

Also important is the fact that we did not see the same interaction between parents' math anxiety and math-helping behavior when the dependent variable was the W score for end-of-year reading (rather than the W score for end-of-year math). We tested the interaction between parents' math anxiety and the frequency of parents' homework-helping behavior while controlling for students' grade, gender, beginning-of-year reading achievement, and beginning-of-year reading anxiety. Overall, the frequency of parents' math homework help did not moderate the relation between parents' math anxiety and children's end-of-year reading achievement, $F(1, 425) = 0.114$, $p = .736$, which indicates that this relation was specific to math achievement.

The relation of parents' math anxiety to children's math anxiety

We demonstrated that when parents frequently help their children with math homework, increased math anxiety in the parents leads to decreased end-of-year math achievement in their children. We further hypothesized that this decreased performance, in turn, would lead to increased math anxiety in the children. To test this hypothesis, we conducted a moderated mediation analysis using a bootstrapping approach. Specifically, we tested the strength of the indirect path from parents' math anxiety through children's end-of-year math achievement to children's end-of-year math anxiety at three levels of parents' homework-helping behavior (1 SD below the mean, the mean, and 1 SD above the mean) using 5,000 bootstrap samples. Overall, the mediation of parents' math anxiety and children's end-of-year math anxiety by children's

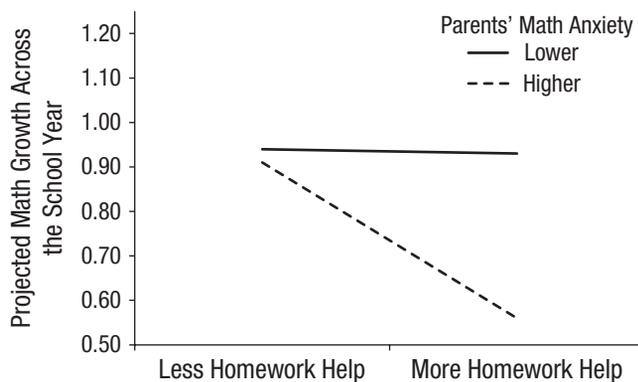


Fig. 1. Mean projected growth in math achievement across the school year as a function of the frequency of parents' homework help and parents' math anxiety. Growth was measured by a grade-equivalent change score (end-of-year grade equivalent minus beginning-of-year grade equivalent), with one grade-equivalent unit representing the amount that the average child is expected to learn across a school year. Lower math anxiety and less homework help each refer to a value 1 standard deviation below the mean; higher math anxiety and more homework help each refer to a value 1 standard deviation above the mean.

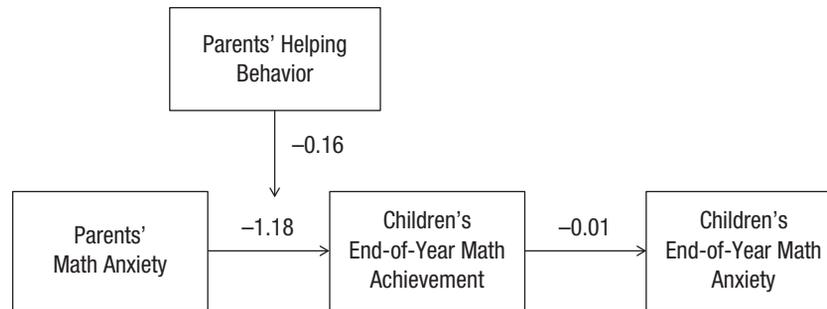


Fig. 2. Moderated mediation model showing the effect of parents' math anxiety on their children's end-of-year math anxiety, as mediated by children's end-of-year math achievement and moderated by parents' helping behavior. Values shown are unstandardized coefficients.

end-of-year math achievement was moderated by parents' homework-helping behavior, 95% CI = [0.000, 0.003], as indicated by the fact that the CI did not cross zero. The mediation was not significant at 1 standard deviation below the mean of parents' helping behavior, 95% CI = [-0.021, 0.009], but it was significant both at the mean, 95% CI = [-0.001, 0.021], and at 1 standard deviation above the mean, 95% CI = [0.002, 0.038]. In other words, when parents frequently helped their children with their math homework, parents' math anxiety was related to their children's end-of-year math anxiety, and this relation was mediated by the children's end-of-year math achievement (see Fig. 2 for the moderated mediation model; for additional analyses, see the Supplemental Material).

Discussion

In this large-scale field study, we demonstrated that parents' math anxiety is negatively related to their children's math learning across the school year—but only when parents frequently help their child with math homework. The negative impact of homework help by highly math-anxious parents was specific to children's math achievement, as there was no relation between highly math-anxious parents' homework help and children's reading achievement. We further showed that this effect persists even after controlling for parents' math knowledge and for school-level factors (i.e., teachers' math anxiety and math knowledge, and school-level SES). The fact that parents' math knowledge does not explain our effects is perhaps not surprising given that the math children learn in early elementary school is relatively easy (e.g., adding and subtracting under 20; working with basic shapes, time, and money). Most parents are likely competent in these basic skills and concepts. Nonetheless, even if parents' math ability is playing some role, our main point remains intact: When parents have a poor

relation with math and frequently help their children with their homework, their children learn less math.

Notably, even if parents are competent in the type of basic math that first- and second-grade children encounter, this does not preclude them from having feelings of anxiety when faced with their children's math homework. A case in point is that even reading aloud simple math problems can be anxiety inducing for highly math-anxious adults (Ashcraft & Ridley, 2005).

How might parents' math anxiety negatively relate to their children's math achievement across the school year? Previous research has shown that individuals with high math anxiety often express a variety of poor attitudes about math. They tend to believe that math is not useful and have low math self-efficacy and low motivation to succeed in math (Hembree, 1990). Expressing these beliefs could be demotivating to children, likely reducing the amount of effort they invest in math and reducing the amount of math they learn and remember. As a result of learning less math, these children may then become more math anxious.

Future studies are needed to investigate differences in the homework environment that is created by parents with higher versus lower math anxiety. It is possible that parents with high math anxiety convey a great deal of negativity when they help their child with math homework. For example, they may express frustration with their child for answering questions incorrectly or for struggling to learn a mathematical concept, and this frustration could be perceived by the child as punishment. Indeed, if the parents themselves have a high fear of failure in mathematics, then they may be more likely to express negativity when their child is struggling, which in turn could cause their children to also learn to fear failing in mathematics and to avoid engaging in challenging situations (Elliot & Thrash, 2004). It is also possible that parents with high math anxiety may have inflexible problem-solving strategies. If the strategies taught in the

classroom are different from those that parents were taught, then these parents may insist that the child use the strategies they learned long ago, which could lead to confusion and negative affect in the child. Though understanding the precise behaviors that account for the relation between parents' math anxiety and children's math learning across the school year is an important avenue for future research, the first step is to establish that a relation between parents' math anxiety and children's math achievement exists in the first place. To our knowledge, this study is the first to establish this relation.

Given that the large majority of the responding parents in this study were female, as were the majority of the teachers, these data do not afford us the statistical power needed to explore the role of parent-teacher gender in the reported effects. It is possible that the gender of the parent may play a role in the relation between parents' math anxiety and child's math achievement when parents frequently help with math homework. While more work is needed to explore this issue, it is important to note that the majority of early elementary teachers (> 90%) are female (National Education Association, 2001), and mothers are more likely than fathers to help with homework (Grolnick & Slowiaczek, 1994; Levin et al., 1997). Therefore, while it is an empirical question as to whether the gender of the teachers and parents play a role, we believe that the pattern reported here applies to the majority of children in this age range.

A consistent message that parents receive from teachers and schools is that their involvement in their children's academics is an important factor predicting their children's school success. However, in the absence of positive math attitudes, parents' homework involvement, though well-intentioned, may backfire, negatively affecting children's math growth across the school year and, in turn, children's math anxiety. The fact that this relation is present during the early elementary school grades is consistent with the possibility that the math-homework help provided by math-anxious parents may play an important but negative role in children's early math achievement and math anxiety, and in their long-term academic-achievement trajectories (Duncan et al., 2007).

Although it is possible that there is a genetic component to math anxiety (Wang et al., 2014), the fact that parents' math anxiety negatively affected children only when they frequently helped them with math homework points to the need for interventions focused on both decreasing parents' math anxiety and scaffolding their skills in homework help. Fortunately, adults' math anxiety can be changed (Hendel & Davis, 1978; Zettle, 2003). Past work demonstrates that adults are able to put aside their math fears to improve their own math achievement (Park, Ramirez, & Beilock, 2014). If decreasing parents' math anxiety can also translate into more effective

homework help, then this help could increase math achievement and decrease math anxiety in their children (Vukovic, Roberts, & Green Wright, 2013). While a conservative interpretation of these data would be that parents who are anxious about math simply should not help their children with math homework, another approach is to provide parents with tools to successfully help their children with math homework. These might include structured activities that allow parents to interact with their children around math in positive ways, which could be delivered in the form of math books, computer and traditional board games, or Internet apps. Parents' homework help could also be facilitated by providing tip sheets with general guidelines for math-homework help and through video models of effective math-homework help (Robinson, 2014). With support, parents with higher math anxiety may be less anxious while helping their children with math and be more equipped to positively affect their children's math achievement and math attitudes (Frenkel, 2013).

In sum, enhancing students' math performance will not be accomplished by solely focusing on teachers or curricula or by simply urging parents to be involved in their children's math homework. Indeed, even when math-anxious parents have good intentions, their homework help may backfire, decreasing children's math learning and increasing their math anxiety across the school year. These results shed new light on the importance of parents' math attitudes in their children's mathematical achievement and suggest that many parents need support to effectively help their children succeed in math.

Author Contributions

All authors designed the study. E. A. Maloney, G. Ramirez, and E. A. Gunderson collected the data. E. A. Maloney and S. L. Beilock analyzed the data, and all authors wrote the manuscript.

Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

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Supplemental Material

Additional supporting information can be found at <http://pss.sagepub.com/content/by/supplemental-data>

Notes

1. Furthermore, for 3% of included children, the ceiling criterion was not properly implemented. Proper administration of the test to ensure the child has reached ceiling is to stop at the end of the page after the child has incorrectly answered six problems in a row. For these 3% of children, testing stopped after they incorrectly answered six problems and did not continue until page completion. The likelihood that children would have answered any questions correctly after failing six is extremely low (2.2%) given our examination of the protocols that were correctly administered. Thus, we chose to include the data from these children in our analyses.
2. The question about course information was given to only 130 parents, as it was added to the end of the parent demographic questionnaire after some parents had already completed the material.
3. Our data were nested within classrooms and schools, and multilevel modeling techniques, such as hierarchical linear modeling, can address the nested nature of data such as these. However, in this particular case, our main analysis of interest—the moderated mediation—was conducted using a bootstrapping approach; to the best of our knowledge, hierarchical linear modeling is not an optimal means of conducting such analyses.

References

- Alexander, L., & Martray, C. R. (1989). The development of an abbreviated version of the Mathematics Anxiety Rating Scale. *Measurement and Evaluation in Counseling and Development, 22*, 143–150.
- Ashcraft, M. H. (2002). Math anxiety: Personal, educational, and cognitive consequences. *Current Directions in Psychological Science, 11*, 181–185.
- Ashcraft, M. H., & Ridley, K. S. (2005). Math anxiety and its cognitive consequences: A tutorial review. In J. I. D. Campbell (Ed.), *Handbook of mathematical cognition* (pp. 315–327). New York, NY: Psychology Press.
- Beilock, S. L., Gunderson, E. A., Ramirez, G., & Levine, S. C. (2010). Female teachers' math anxiety affects girls' math achievement. *Proceedings of the National Academy of Sciences, USA, 107*, 1860–1863.
- Cannon, J., & Ginsburg, H. P. (2008). "Doing the math": Maternal beliefs about early mathematics versus language learning. *Early Education and Development, 19*, 238–260.
- Chambers, J. M., Cleveland, W. S., Kleiner, B., & Tukey, P. A. (1983). *Graphical methods for data analysis*. Boston, MA: Wadsworth & Brooks/Cole Publishing.
- Committee on Early Childhood Mathematics. (2009). *Mathematics learning in early childhood: Paths toward excellence and equity*. Washington, DC: National Academies Press.
- Duncan, G. J., Dowsett, C. J., Claessens, A., Magnuson, K., Huston, A. C., Klebanov, P., . . . Japel, C. (2007). School readiness and later achievement. *Developmental Psychology, 43*, 1428–1446.
- Eccles, J. S. (2007). Families, schools, and developing achievement-related motivations and engagement. In J. E. Grusec & P. D. Hastings (Eds.), *Handbook of socialization* (pp. 665–691). New York, NY: The Guilford Press.
- Elliot, A. J., & Thrash, T. M. (2004). The intergenerational transmission of fear of failure. *Personality and Social Psychology Bulletin, 30*, 957–971.
- Esbensen, F. A., Miller, M. H., Taylor, T., He, N., & Freng, A. (1999). Differential attrition rates and active parental consent. *Evaluation Review, 23*, 316–335.
- Frenkel, E. (2013). *Love and math: The heart of hidden reality*. New York, NY: Basic Books.
- Grolnick, W. S., & Slowiaczek, M. L. (1994). Parents' involvement in children's schooling: A multidimensional conceptualization and motivational model. *Child Development, 65*, 237–252.
- Hayes, A. F. (2013). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach*. New York, NY: Guilford Press.
- Hembree, R. (1990). The nature, effects, and relief of mathematics anxiety. *Journal for Research in Mathematics Education, 21*, 33–46.
- Hendel, D. D., & Davis, S. O. (1978). Effectiveness of an intervention strategy for reducing mathematics anxiety. *Journal of Counseling Psychology, 25*, 429–434.
- Hill, H. C., Schilling, S. G., & Ball, D. L. (2004). Developing measures of teachers' mathematics knowledge for teaching. *The Elementary School Journal, 105*, 11–30.
- Illinois State Board of Education. (2014). *Illinois report card*. Springfield, IL: Author.
- Lee, J. (2009). Universals and specifics of math self-concept, math self-efficacy, and math anxiety across 41 PISA 2003 participating countries. *Learning and Individual Differences, 19*, 355–365.
- Levin, I., Levy-Shiff, R., Appelbaum-Peled, T., Katz, I., Komar, M., & Meiran, N. (1997). Antecedents and consequences of maternal involvement in children's homework: A longitudinal analysis. *Journal of Applied Developmental Psychology, 18*, 207–227.
- Maloney, E. A., & Beilock, S. L. (2012). Math anxiety: Who has it, why it develops, and how to guard against it. *Trends in Cognitive Sciences, 16*, 404–406.
- National Education Association. (2001). *Status of the American public school teacher 2000–2001*. Washington, DC: Author.
- Park, D., Ramirez, G., & Beilock, S. L. (2014). The role of expressive writing in math anxiety. *Journal of Experimental Psychology: Applied, 20*, 103–111.
- Patall, E. A., Cooper, H., & Robinson, J. C. (2008). Parent involvement in homework: A research synthesis. *Review of Educational Research, 78*, 1039–1101.
- Ramirez, G., Gunderson, E. A., Levine, S. C., & Beilock, S. L. (2013). Math anxiety, working memory, and math achievement in early elementary school. *Journal of Cognition and Development, 14*, 187–202.
- Richardson, F. C., & Suinn, R. M. (1972). The Mathematics Anxiety Rating Scale: Psychometric data. *Journal of Counseling Psychology, 19*, 551–554.
- Robinson, K. (2014). *The broken compass*. Cambridge, MA: Harvard University Press.
- Suinn, R. M., Taylor, S., & Edwards, R. W. (1988). Suinn Mathematics Anxiety Rating Scale for elementary school

- students (MARS-E): Psychometric and normative data. *Educational and Psychological Measurement*, *48*, 979–986.
- Vukovic, R. K., Roberts, S. O., & Green Wright, L. (2013). From parental involvement to children's mathematical performance: The role of mathematics anxiety. *Early Education & Development*, *24*, 446–467.
- Wang, Z., Hart, S. A., Kovas, Y., Lukowski, S., Soden, B., Thompson, L. A., . . . Petrill, S. A. (2014). Who is afraid of math? Two sources of genetic variance for mathematical anxiety. *Journal of Child Psychology and Psychiatry*, *55*, 1056–1064.
- Woodcock, R. W. (1999). What can Rasch-based scores convey about a person's test performance? In S. E. Embretson & S. L. Hershberger (Eds.), *The new rules of measurement: What every psychologist and educator should know* (pp. 105–127). New York, NY: Erlbaum.
- Woodcock, R. W., McGrew, K. S., & Mather, N. (2001). *Woodcock-Johnson Tests of Achievement*. Itasca, IL: Riverside.
- Zettle, R. D. (2003). Acceptance and commitment therapy (ACT) vs. systematic desensitization in treatment of mathematics anxiety. *The Psychological Record*, *53*, 197–215.