

# Do Parental Attitudes Really Matter to Children's Mathematics Anxiety? A Meta-Analysis

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*Received January 6, 2020; Revised March 28, 2020; Accepted April 19, 2020*

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**Abstract** Parental attitudes toward mathematics are a potentially easy and effective intervention for lessening students' mathematics anxiety. In this study, we examine the relationship between parental attitudes toward mathematics and their students' mathematics anxiety. The goal is to provide empirical support for the development and proliferation of interventions to increase positive parental attitudes toward mathematics to achieve a decrease in students' mathematics anxiety. Seventy-four abstracts of studies were identified through the electronic databases. Following review, we excluded 67 studies that did not meet all inclusion criteria. Therefore, the 7 studies in this meta-analysis consist of five peer-reviewed published studies and two dissertations. Of the 7 studies used for this meta-analysis, a total of 20 correlation coefficients were extracted. We found that the average correlation for the relationship between students' mathematics anxiety and parents' attitudes toward mathematics was -0.26, a small, though statistically significant, correlation. The inverse relationship indicates that as parents' positive attitudes toward mathematics increase, their children's anxiety decreases. Moreover, elementary and middle school students are much more affected by parents' attitudes toward mathematics than are college students. Therefore, positive parental attitudes toward mathematics appear to have a positive influence on students' mathematics anxiety and this provides a clue for how to involve parents in mathematics anxiety interventions.

**Keywords** Meta-Analysis, Mathematics Education, Mathematics Anxiety, Parental Attitudes

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## 1. Introduction

Skills in and knowledge of mathematics are becoming increasingly more important in the labor market, and

research suggests that there is a direct relationship between increased math course completion and increased earnings (Goodman, 2012). Even though the importance of mathematics ability in society is well established, some students develop anxieties toward mathematics, and those students are likely to avoid math coursework in middle and high school, as well as avoid college majors and career paths that require strong math or quantitative skills (Ashcraft, 2002). Mathematics anxiety involves negative thoughts and reactions to situations involving math (Ashcroft & Moore, 2009) and includes "feelings of tension and anxiety that hinder the manipulation of numbers and the solving of mathematical problems in a wide variety of everyday life and academic situations" (Richardson & Suinn, 1972). Previous research suggests that many factors potentially contribute to mathematics anxiety, including gender, low social economic status, minority status, and the presence of learning disabilities (Beasley & Fisher, 2012; Devine, Fawcett, Szűcs & Dowker, 2012; Elsse-Quest, Hyde & Linn, 2010; Goetz, Bieg, Lüdtke, Pekrun & Hall, 2013; Rubinsten & Tannock, 2010; Vukovic, Roberts & Green, 2013). Although each of these factors can help teachers identify students at heightened risk, most factors are static, limiting targeted intervention and support. One factor that may also be related to increased risk and could potentially be directly targeted for intervention is parent's involvement in their children's learning of mathematics. Particularly, parental attitudes toward mathematics are a potentially easy and effective intervention for lessening students' mathematics anxiety (Gunderson, Ramirez Levine & Beilock, 2012; Maloney, Ramirez, Gunderson Levine & Beilock, 2015; Muller, 1998; Shaver & Walls 1998). Therefore, it is necessary to examine the relationship between parental attitudes toward mathematics and their children's mathematics anxiety with regard to lowering students' mathematics anxiety. The purpose of this study is to provide empirical support for the development and

proliferation of interventions to increase positive parental attitudes toward mathematics to achieve a decrease in student mathematics anxiety.

## 2. Previous Research

Mathematics anxiety has been broadly studied during the last six decades. At first, mathematics anxiety was not regarded as distinct from general anxiety. However, Dreger and Aiken (1957) found that their students had certain kinds of anxiety toward mathematics that were distinct from general anxiety. This anxiety seemed to influence their students' reactions to numbers and mathematics. To ascertain the difference between number anxiety and general anxiety, Dreger and Aiken employed the Taylor Manifest Anxiety Scale, substituting three items to measure anxiety about numbers. By using the scale, Dreger and Aiken concluded that some students have anxiety specifically toward numbers and mathematics. In a follow-up study (Aiken & Dreger, 1961), the authors developed their own Math Attitude Scale to predict final mathematics grades for a sample of 67 females and 60 male college students.

### 2.1. Mathematics Anxiety Rating Scale (MARS)

Following the recognition of its existence (Dreger & Aiken, 1957; Gough, 1954), many other researchers have tried to develop a tool to measure Mathematics Anxiety. The most significant progress was made after Richardson and Suinn's (1972) development of the Mathematics Anxiety Rating Scale (MARS). MARS consists of a 98-item scale, and each item is assigned a value from 1 to 5, depending on the level of anxiety participants experience in a variety of everyday situations. Each item is composed of brief descriptions of behavioral situations involving numbers and mathematics.

### 2.2. Development of Mathematics Anxiety Scale

Since MARS was originally developed to measure

college students' anxiety toward mathematics, Suinn and Edwards (1982) developed modified versions of MARS: The Mathematics Anxiety Rating Scale for Adolescents (MARS-A), used to measure junior and senior high school students' mathematics anxiety, and the Mathematics Anxiety Rating Scale for Elementary School Students (MARS-E; Suinn & Edwards, 1982; Suinn, Talyor, & Edwards, 1988), used to measure mathematics anxiety in elementary school students. Fennema and Sherman (1976) also included mathematics anxiety as one of the main factors in learning mathematics and employed 12 items in their famous Fennema-Sherman Mathematics Attitude Scale. Plake and Parker (1982) suggested a shortened version of MARS (MARS-R) for measuring statistics or mathematics course-related anxiety. Instead of 98 items, the MARS-R has only 24 items and is highly related to the 98-item MARS (with a correlation of .97). Another shortened version of MARS (sMARS) was suggested by Alexander and Martray (1989). The sMARS, which has 25 items, measures mathematics anxiety from the following three perspectives: Math Test Anxiety, Numerical Anxiety, and Math Course Anxiety. Hopko, Mahadevan, Bare, and Hunt (2003) designed the Abbreviated Math Anxiety Scale (AMAS). The AMAS has only nine items and uses a 5-point Likert-type scale, ranging from 1 (low anxiety) to 5 (high anxiety), with the total score representing a summation of the following nine items:

1. Having to use the tables in the back of a math book.
2. Thinking about an upcoming math test 1 day before.
3. Watching a teacher work an algebraic equation on the blackboard.
4. Taking an examination in a math course.
5. Being given a homework assignment with many difficult problems that is due the next class meeting.
6. Listening to a lecture in math class.
7. Listening to another student explain a math formula.
8. Being given a "pop" quiz in math class.
9. Starting a new chapter in a math book.

**Table 1.** Instruments for Measuring Mathematics Anxiety

Author	Name of Instrument	Subject	Number of Items
Richardson and Suinn (1972)	MARS	College	98
Plake and Parker (1982)	MARS-R	College	24
Suinn and Edwards (1982)	MARS-A	High school	98
Suinn, Talyor, and Edwards (1988)	MARS-E	Elementary	26
Wigfield and Meece (1988)	MAQ	Grade 4-6	11
Alexander and Martray (1989)	sMARS	College	25
Fennema-Sherman Mathematics Attitude Scale (1976)	FSMAS	High school	12
Hopko, Mahadevan, Bare, and Hunt (2003)	AMAS	High School	9

### 2.3. Mathematics Anxiety and Achievement

It is well known that there exists a negative relationship between mathematics anxiety and mathematics achievement (Ashcraft & Moore, 2009; Ramirez, Gunderson, Levine & Beilock, 2013; Wu, Amin, Barth & Malcarne & Menon, 2012). That is, low anxiety students perform better in mathematics than high anxiety students. Ma's (1999) and Hembree's (1990) meta-analyses showed that significant correlation (-0.27 and -0.61) existed between mathematics anxiety and achievement. Ma (1999) examined 26 studies involving students in grades 4 through 12, though the author did not examine studies involving college students. Hembree (1990) examined 161 studies that had been conducted on students in grades 5 through 12 as well as on college students. In their studies, mathematics anxiety and achievement in mathematics showed significant relationships across all grades. Neither study, however, found any evidence of a difference between males and females regarding the relationship between mathematics anxiety and mathematics achievement. Hembree found only that in all grades female students had more mathematics anxiety than male students and that student mathematics anxiety in Female seemed not to be expressed as anxiety behaviors like avoidance or low performance. Hembree argued that female students are prone to discussing their anxiety or are good at controlling it.

No studies included in Ma's (1999) and Hembree's (1990) meta-analysis were conducted on Kindergarten through Grade 3 students, not because young students do not experience anxiety but because of the absence of an instrument for measuring mathematics anxiety among young students. Jackson and Leffingwell (1999) did interesting research that can serve as evidence of mathematics anxiety among young students. Jackson and Leffingwell asked 157 students who gathered at a senior-level elementary mathematics class to describe "your worst or most challenging mathematics experience from kindergarten through college." Sixteen percent of students experienced their first anxiety toward mathematics in Grade 3 or 4, and the factor that caused their anxiety could be categorized as one of four types: difficulty of material, hostile instructor behavior, gender bias, and perception of instructors. Most anxiety-producing factors were related to an instructor's overt or covert statements and behaviors. It is worth pointing out that some students responded that their worst mathematics experience took place in kindergarten or Grade 1 and had occurred more than 10 years prior.

The difficulty of developing measures for mathematics anxiety in early age pertains to students' reading ability. Because students in kindergarten to Grade 3 have low reading ability, a written questionnaire is not suitable for such students. Thus, determining when young students develop mathematics anxiety and how it emerges requires greater innovation in gaining insight into students' thoughts and feelings.

### 2.4. Parent's Attitudes

Family factors like social economic status (SES) and parents' level of education are important in predicting children's academic achievement (Christenson, Rounds & Gorney, 1992; Chiu, 2010; Smith & Hausafus, 1998; Yan & Lin 2005). However, we focus on parents' attitudes rather than on their level of education because their attitudes can work as mediators of socioeconomics (Guo & Harris, 2000) and can be changed and guided by a program and treatment. Furthermore, students spend a significant amount of time with their parents as they grow up and interact with their parents' thoughts and beliefs. Thus, parents' negative attitudes toward mathematics or mathematics anxiety can be transmitted to their children (Maloney & Beilock, 2012; Maloney, Ramirez, Gunderson, Levine, & Beliock, 2015). For example, if parents believe that doing well in mathematics is important only for boys, female students may be affected by their parents' thoughts and may believe that they are not good at mathematics because they are girls. Although, during adolescence, students are more greatly affected by their teachers and peers than by their parents, the parents' role in the initial status of mathematics anxiety development is enormous. Therefore, determining the kind of parental attitudes that affect children's mathematics anxiety if those attitudes positively or negatively affect that anxiety is important.

Parents' mathematics anxiety also affects their children's mathematics achievement. Maloney et al. (2015) found that the transmission of parents' mathematics anxiety to their children depends on the frequency of math homework help. The relationship between parents' mathematics anxiety and their children's math achievement is not significant when parents' do not frequently provide homework help. Interestingly, parents' level of math knowledge has no significant effect on children's achievement.

Most research on the relationship between parent's attitudes and student anxiety has been conducted as a form of research that showed the relationship between parent's mathematics anxiety and student anxiety toward mathematics or achievement in mathematics (Casad, Hale, & Wachs, 2015; He, 2007; Maloney, Gerardo, Gunderson, Susan, & Beilock, 2015). However, the positive influence of parents' attitude on student mathematics anxiety is rarely researched or has been researched as one part of the affective factors influencing mathematics anxiety. To examine the critical point of parents' attitudes, it is necessary to know how parents' influence changes according to the age of their children.

## 3. Methods

### 3.1. Search Procedures

To obtain the studies for the meta-analysis, we conducted a search of Education Resources Information

Center (ERIC), the National Technical Information Service (NTIS) Database in ProQuest, and Dissertations and Theses Global in ProQuest to locate studies examining the relationship between parent's attitude towards mathematics and students' mathematics anxiety from pre-kindergarten through college. We used the same Boolean search procure for all databases with the following terms: math OR mathematics AND anxiety AND paternal OR maternal OR parent. The titles and abstracts of the studies identified were assessed using the following inclusion criteria: (a) the abstract indicates that the study is about mathematics anxiety; (b) the abstract indicates that the study is empirical, (c) the study measures student's mathematics anxiety and parent's attitude toward mathematics; and (d) the study appears to analyze the relationship between students' mathematics anxiety and parent's attitude toward mathematics. Seventy-four abstracts were identified through the electronic databases. Following review, we excluded 63 studies that did not meet all four inclusion criteria, and retained 11 studies for full text coding.

### 3.2. Coding of Selected Studies

We collected full-text copies of the 11 studies meeting our inclusion criteria, and conducted full text coding for the meta-analysis. For each study, we extracted and coded the following information: (a) type of publication (i.e., peer-reviewed or dissertation); (b) the number of students; (c) grade-level of the students; (d) student gender; (e) the parent or parents whose attitude was measured; (f) the instrument used to measure students' mathematics anxiety, and (g) the instrument used to measure parental attitudes towards mathematics. In order to conduct the meta-analysis, we extracted all available correlation coefficients ( $r$ ) for all combinations of students and parents. For example, if a study provided  $r$  values for males and mothers and females and mothers separately, we extracted both effect sizes for analysis. Unfortunately, four studies did not provide enough information to extract effect sizes, therefore the final sample size was seven studies ( $k = 7$ ).

**Table 2.** Descriptive Information of Studies on the Relationship Between Mathematics Anxiety and Parents

Name	Type	Grade	Gender	Perceived Attitude of	Effect Size	$n$
Rosenberg (1980)	Dissertation	College	Female	Mother	-0.51	51
			Female	Father	-0.63	51
			Male	Mother	-0.56	18
			Male	Father	-0.20	18
De Bronac-Meade & Brown (1982)	Report	College	Mixed	Mother	-0.30	44
			Mixed	Father	-0.17	44
Cooper & Robinson (1991)	Journal	College	Mixed	Parents	-0.06	290
Coates (1997)	Dissertation	College	Mixed	Father (1995)	-0.02	53
			Mixed	Father (1996)	-0.00	55
			Mixed	Mother (1995)	0.02	68
			Mixed	Mother (1996)	-0.13	77
			Mixed	Parents (1995)	0.03	46
			Mixed	Parents (1996)	-0.09	53
Haynes, Mullins & Stein (2010)	Journal	College	Male	Parents	-0.05	80
			Female	Parents	-0.01	79
Birgin et al. (2010)	Journal	6	Mixed	Parents	-0.44	73
		7	Mixed	Parents	-0.63	73
		8	Mixed	Parents	-0.55	74
Vukovic, Roberts & Wright (2013)	Journal	2	Mixed	Parents	-0.12	78
		2	Mixed	Parents	-0.27	78

**3.3. Statistical Procedure**

All extracted correlation coefficients were transformed into Fisher’s z scores for meta-analytic calculations because the variance of *r* depends greatly on the size of *r* (Borenstein et al., 2009). We transformed all *r* values using the following formula:

$$Fisher's\ z: Z = 0.5 \times \ln\left(\frac{1 + r}{1 - r}\right)$$

where ln is the natural logarithm. The variance of Fisher’s z was calculated as follows:

$$V_z = \frac{1}{n - 3}$$

Among the included study, there were three parent groups with available, independent correlation coefficients between parental attitudes toward mathematics and students’ mathematics anxiety. Specifically, the following three associations were available: (a) father’s attitude toward mathematics; (b) mother’s attitude toward mathematics; and (c) parents’ attitude toward mathematics. Some studies reported values for all three groups. To maintain independence, we did not include the combined parent *r* if separate values were provided for mothers and fathers.

Once all effect sizes were extracted and converted, we estimated a random-effects meta-analysis model. Random effects were used because we assumed that the effect sizes identified via our search procedures may not represent the population of effect sizes between the variables of interest and study characteristics (e.g., age of students) moderate individual effect sizes, thus we assume that the studies were drawn from populations that differ from another and those differences impact the effect size (Borenstein et al., 2009). Our model estimated the heterogeneity (i.e., differences across effect sizes) within and between the three parent groups. Specifically, we calculated the *Q* and *I*<sup>2</sup> statistics. The *Q* statistic is the weighted sum of squares on a standardized scale, and if *Q* statistic is significant,

heterogeneity is present across the effect size. However, the *Q* statistic does not describe how much heterogeneity is present. Therefore, we calculated the *I*<sup>2</sup> statistics, which is the ratio of true heterogeneity to the total variation in observed effect (Borenstein et al., 2009). *I*<sup>2</sup> is bound between 0% and 100% and interpreted as follows: if *I*<sup>2</sup> is less than 25%, the heterogeneity can be interpreted as small; an *I*<sup>2</sup> between 25% and 75% means a medium level of heterogeneity; and an *I*<sup>2</sup> over 75% means a high level of heterogeneity (Borenstein et al., 2009). Lastly, we conducted a subgroup analysis to estimate whether or not the association between parental attitudes towards mathematics and students’ mathematics anxiety was different in student age groups. All analyses were conducted using the metafor package (Viechtbauer, 2010) in R (R Development Core Team, 2017).

**4. Result**

The studies in this meta-analysis consist of five peer-reviewed published studies and two dissertations. Among the seven studies, five were conducted with college students, one was conducted with middle school students, and one was conducted with elementary school students (see Table 2).

Table 3 describes the instruments used to assess student mathematics anxiety and parental attitudes towards mathematics. Three studies used the Mathematics Anxiety Rating Scale (MARS; Richardson & Suinn, 1972); two used the Fennema-Sherman Mathematics Attitude Scale (MAS; Fennema & Sherman, 1977); one used the Mathematics Anxiety Scale for Elementary School Students (MASESS; Bindak, 2005) and one used questionnaire that the researcher had developed for that study. Among the selected studies, Vukovic, Roberts, and Wright (2013) measured parents’ attitude toward mathematics according to the parents. The other studies measured the parents’ attitude as perceived by students.

**Table 3.** Instrument for measuring Mathematics Anxiety and Parents Attitude

Study	Mathematics Anxiety	Parents Attitude
Rosenberg (1980)	MARS	Fennema-Sherman Mother and Father Scale
De Bronac-Meade& Brown (1982)	MARS	Item invented by researcher
Cooper& Robinson (1991)	MAS	Item invented by researcher
Coates (1997)	MARS	Item invented by researcher
Haynes, Mullins & Stein (2010)	MAS	Item invented by researcher
Birgin et al. (2010)	MASESS	Item invented by researcher
Vukovic, Roberts & Wright (2013)	Researcher developed	Hoover-Dempsey and Sandler

Of the 7 studies used for this meta-analysis, a total of 20 correlation coefficients were extracted as most studies had multiple correlation coefficients by gender and grade (see Table 2). Most studies reported the correlation between students' mathematics anxiety and parent's attitude. However, Haynes, Mullins, and Stein's (2010) analyzed the relationship between mathematics anxiety and parent's attitude using the multiple regression. Hence, they calculated beta coefficient instead of correlation coefficients score. However, beta coefficient can be interpreted as correlation coefficients during meta-analysis if beta coefficient resided in the interval  $\pm .50$  (Peterson & Brown, 2005). So, we included the study's beta coefficient values because they resided in the interval  $\pm .50$  and coded the beta coefficient as the correlation coefficient between students' mathematics anxiety and parents' attitude.

### 4.1. Overall Effect

Across all seven studies, the random effects weighted average effect size was  $r = -0.26$  ( $p < 0.001$ ), with a 95% confidence interval of  $r = -0.38$  to  $r = -0.14$ . ( $Q = 79.77, p < 0.001, I^2 = 78.7\%$ ) The random effects weighted average effect size on father's attitude was  $r = -0.22$  ( $p < 0.01$ ), with a 95% confidence interval of  $r = -0.48$  to  $r = -0.07$ . ( $Q = 18.88, p < 0.001, I^2 = 77.2\%$ ) The random effects weighted average effect size on mother's attitude was  $r = -0.28$  ( $p < 0.01$ ), with a 95% confidence interval of  $r = -0.48$  to  $r = -0.05$  ( $Q = 11.28, p = 0.0236, I^2 = 68.7\%$ ). The random effects weighted average effect size on parents' attitude was  $r = -0.28$  ( $p < 0.0001$ ), with a 95% confidence interval of  $r = -0.44$  to  $r = -0.09$ . ( $Q = 49.31, p < 0.0001, I^2 = 85.8\%$ ). Overall, there was no significant difference between the three groups ( $Q(2) = 0.16, p = 0.923$ ).

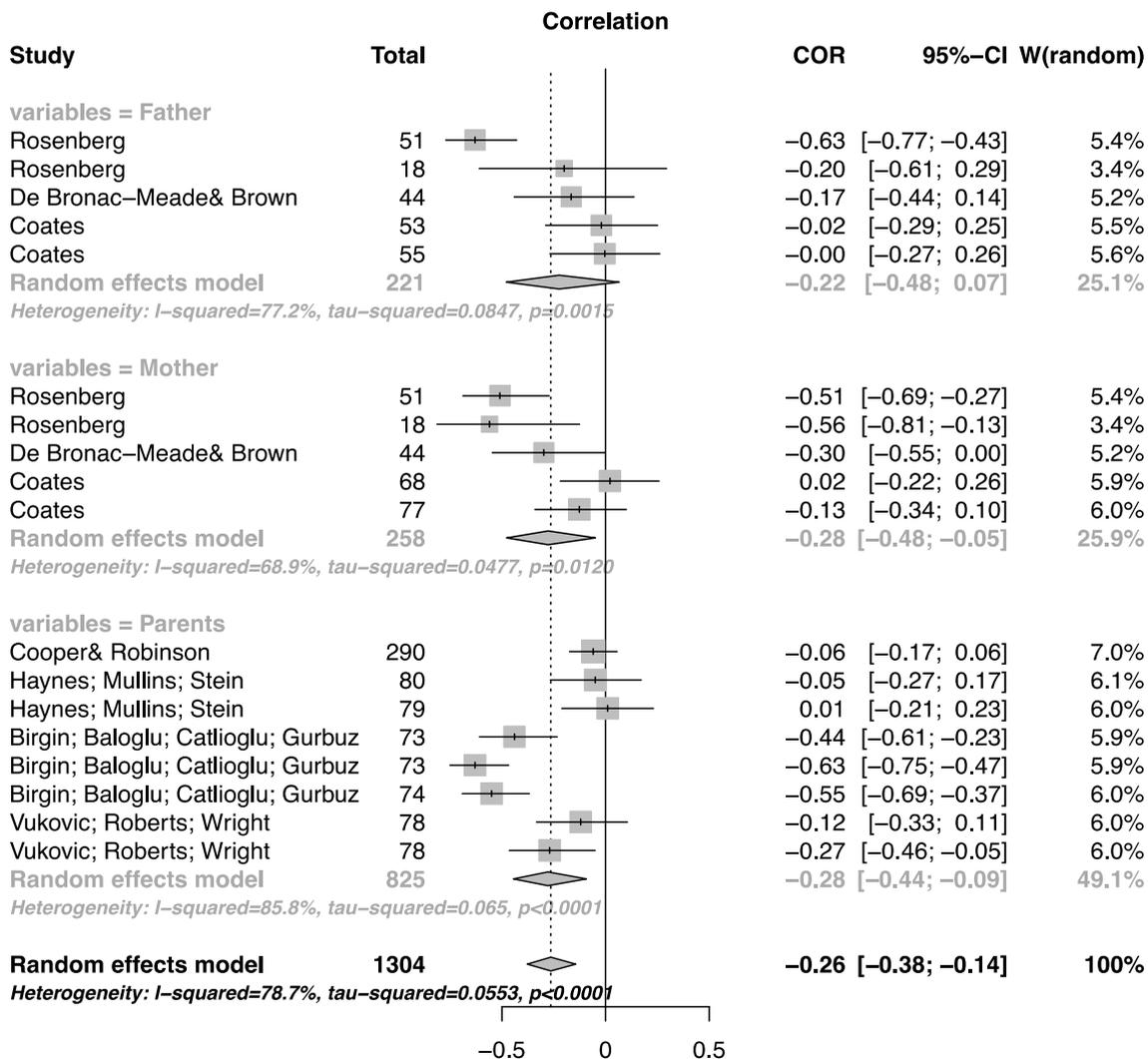
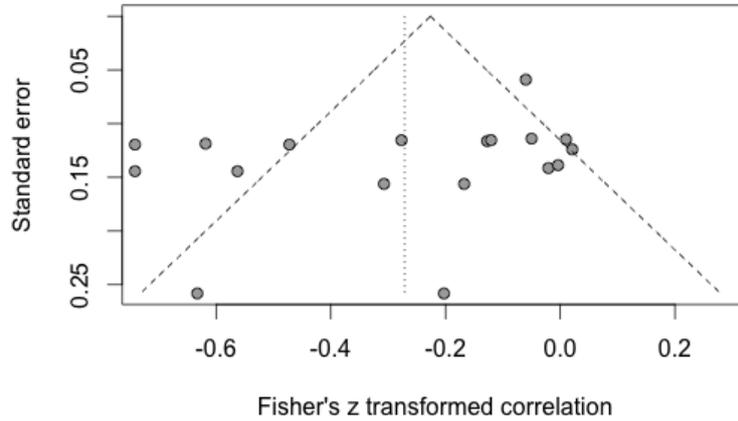


Figure 1. Forest plot of Correlation Coefficient between Mathematics Anxiety and Parent Attitude Toward Mathematics by Variables

**4.2. Publication Bias**

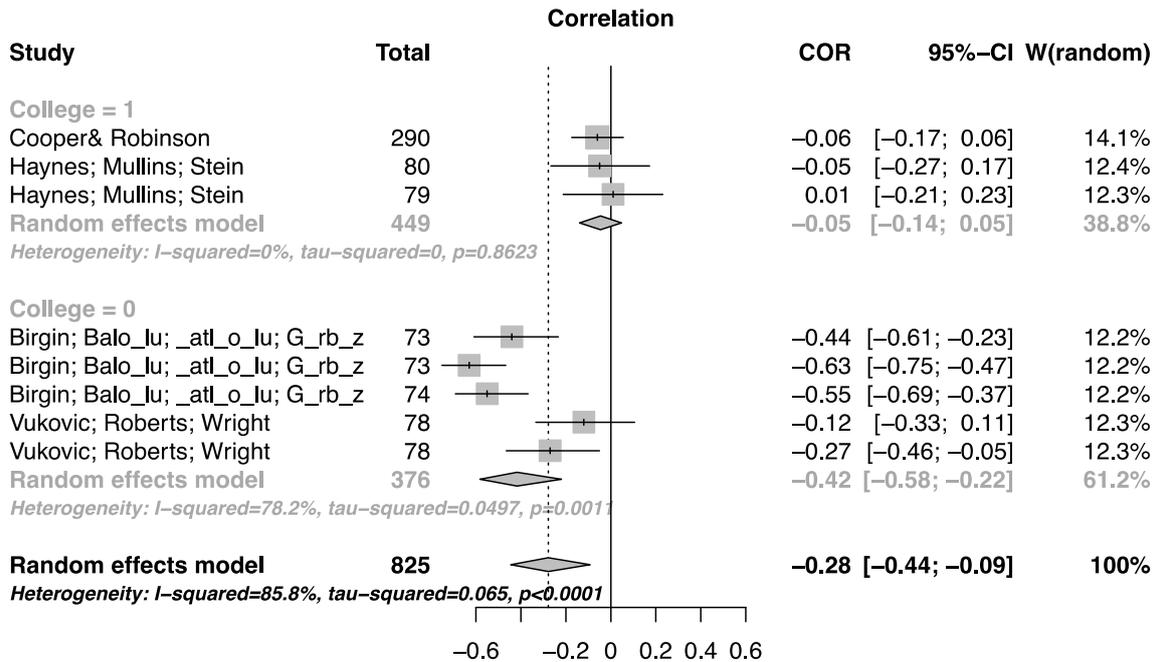
To see whether the entire effect is an artifact of bias, we visually examined a funnel plot (see Figure 2) and calculated Egger’s regression test. The results for the Egger’s test were non-significant ( $t = -1.5714$ ,  $p = 0.1357$ ) and the funnel plot supported this finding. Thus, publication bias does not appear to be a substantial threat to the results obtained in this meta-analysis.



**Figure 2.** Funnel plot of Standard Error by Fisher’s z transformed correlation

**4.3. College Students and Non-College Students in Parent's Attitude**

To assess differences by age, we created two subgroups: (a) college students and (b) non-college student (e.g., elementary and middle school students). We then estimated the overall effect size for each age group. The difference in the relationship between parents’ attitude and mathematics anxiety was statistically significant ( $p = 0.0011$ ). The relationship between parents’ attitudes towards mathematics for college students was much smaller ( $r = -0.0462$ ) than the same relationship for younger students ( $r = -0.4174$ ) (see Figure 3).



**Figure 3.** Forest plot of Correlation Coefficient between Mathematics Anxiety and Parent Attitude Toward Mathematics by school

## 5. Discussion and Conclusions

In this meta-analysis, we found that the average correlation for the relationship between students' mathematics anxiety and parents' attitude toward mathematics was  $-0.26$ . Though this is small, it is statistically significant. The inverse relationship indicates that as parents' attitudes towards mathematics increase, or are more positive, their students' anxiety decreases. This relationship appears to be consistent across both mothers and fathers as there was not a significant difference between father's attitudes, mother's attitudes, and the combined parents' attitude toward mathematics. This suggests that only one parent needs to have a positive attitude toward mathematics to reduce students' mathematics anxiety.

Ideally, we hoped to examine differences in the relationship between parental attitudes and students' anxiety by grade-level. Unfortunately, the literature is limited, and such an analysis could not be conducted. That being said, we were able to examine the difference between college students and elementary and middle school students. A large and statistically significant difference was found between college students and non-college students, with parental attitudes having a much stronger effect on younger students. Put differently, elementary and middle school students are much more affected by parents' attitude toward mathematics than are college students. Therefore, it seems that intervention efforts targeting parent attitudes to treat mathematics anxiety should focus on younger students, while different approaches may be necessary for college students.

Positive parental attitudes toward mathematics appear to have a positive influence on students' mathematics anxiety and this provides a clue for how to involve parents in mathematics anxiety interventions. Previous studies have found that direct parental involvement may be the most effective approach to student mathematics anxiety (Casad, Hale & Wachs, 2015; Maloney, Ramirez, Gunderson, Levine & Beilock, 2015). However, there are some barriers not thoroughly examined in this study that may need to be addressed. For example, parents of low socioeconomic status (SES) may not have the time or the energy to visit schools as volunteers or to help students do their homework. If parents do not have time to give instruction or help with homework that was designed to be assisted by parents, even though parent involvement can have a positive effect on student achievement, students of a low social economic status are at a disadvantage to students of a high or middle SES. However, parents' attitude does not require that they have time to help with homework or to actively participate at school events. It is enough just having a positive attitude for mathematics and showing it to children. Grades 9-10 is particularly a time when observers saw the highest level of mathematics anxiety.

Workshop or instruction for parents who have children

at these grade levels should give tips about how parents can show a positive attitude toward mathematics. If times, when parents help their children with homework, serve as opportunities for them to reveal their attitudes toward mathematics, homework does not need to assume parents' help. Parents can find the chance to show their positive attitude toward mathematics in their everyday life.

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## REFERENCES

- [1] Aiken, L. R., & Dreger, R. M. (1961). The effect of attitudes on performance in mathematics. *Journal of Educational Psychology, 52*(1), 19-24.
- [2] Aiken, L. R. (1972). Language factors in learning mathematics. *Review of Educational Research, 42*(3), 359-385.
- [3] 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*(3), 143-150.
- [4] Ashcraft, M. H. (2002). Math anxiety: Personal, educational, and cognitive consequences. *Current Directions in Psychological Science, 11*(5), 181-185.
- [5] Ashcraft, M. H., & Moor, A. M. (2009). Mathematics anxiety and the affective drop in performance. *Journal of Psychoeducational Assessment, 27*, 197-205. doi: 10.1177/0734282908330580
- [6] Beasley, M. A., & Fischer, M. J. (2012). Why they leave: The impact of stereotype threat on the attrition of women and minorities from science, math and engineering majors. *Social Psychology of Education, 15*(4), 427-448.
- [7] Birgin, O., Baloğlu, M., Çatlıoğlu, H., & Gürbüz, R. (2010). An investigation of mathematics anxiety among sixth through eighth grade students in turkey. *Learning and Individual Differences, 20*(6), 654-658.
- [8] Borenstein, M., Hedges, L. V., Higgins, J. P. T., & Rothstein, H. (2009). *Introduction to meta-analysis*. Chichester, U.K: John Wiley & Sons.
- [9] Casad, B. J., Hale, P., & Wachs, F. L. (2015). Parent-child math anxiety and math-gender stereotypes predict adolescents' math education outcomes. *Frontiers in Psychology, 6*, 1-21.
- [10] Christenson, S. L., Rounds, T., & Gorney, D. (1992). Family factors and student achievement: An avenue to increase students' success. *School Psychology Quarterly, 7*(3), 178-206.
- [11] Chiu, M. M. (2010). Effects of inequality, family and school on mathematics achievement: Country and student differences. *Social Forces, 88*(4), 1645-1676.
- [12] Coates, J. D. (1997). *Mathematics anxiety and its relationship to students' perceived teacher and parent attitudes toward mathematics* (Doctoral dissertation) Retrieved from ProQuest Dissertations & Theses Global. (UMI No. 304402738).

- [13] Cooper, S. E., & Robinson, D. A. (1991). The relationship of mathematics self-efficacy beliefs to mathematics anxiety and performance. *Measurement and Evaluation in Counseling and Development*, 24(1), 4-11.
- [14] Craik, F. I., & Byrd, M. (1982). Aging and cognitive deficits: The role of attention resources. In F.I.M. Craik & S. Trehub (Eds.). *Aging and cognitive processes* (pp. 191-211). New York, NY: Plenum Press.
- [15] De Bronac-Meade, M. L., & Brown, R. (1982). *Reduction of mathematics anxiety: A cognitive behavior modification approach*. Paper presented at the Annual Meeting of the American Educational Research Association, New York.
- [16] Devine, A., Fawcett, K., Szűcs, D., & Dowker, A. (2012). Gender differences in mathematics anxiety and the relation to mathematics performance while controlling for test anxiety. *Behavioral and brain functions*, 8(1), 2-9.
- [17] Dreger, R. M., & Aiken Jr, L. R. (1957). The identification of number anxiety in a college population. *Journal of Educational Psychology*, 48(6), 344-351.
- [18] Duncan, G. J., Brooks-Gunn, J., & Klebanov, P. K. (1994). Economic deprivation and early childhood development. *Child Development*, 65(2), 296-318.
- [19] Else-Quest, N. M., Hyde, J. S., & Linn, M. C. (2010). Cross-national patterns of gender differences in mathematics: a meta-analysis. *Psychological bulletin*, 136(1), 103-127.
- [20] Fennema, E., & Sherman, J. (1976). Sex-related differences in mathematics learning: Myths, realities and related factors. Paper presented at the annual meeting of American Association for the Advancement of Science, Boston.
- [21] Goetz, T., Bieg, M., Lüdtke, O., Pekrun, R., & Hall, N. C. (2013). Do girls really experience more anxiety in mathematics? *Psychological science*, 24(10), 2079-2087.
- [22] Goodman, J. (2012). The labor of division: Returns to compulsory math coursework. HKS Faculty
- [23] Research Working Paper Series RWP12-032, John F. Kennedy School of Government, Harvard University.
- [24] Guo, G., & Harris, K. M. (2000). The mechanisms mediating the effects of poverty on children's intellectual development. *Demography*, 37(4), 431-447.
- [25] Gunderson, E. A., Ramirez, G., Levine, S. C., & Beilock, S. L. (2012). The role of parents and teachers in the development of gender-related math attitudes. *Sex roles*, 66(3-4), 153-166.
- [26] Haynes, A. F., Mullins, A. G., & Stein, B. S. (2004). Differential models for math anxiety in male and female college students. *Sociological Spectrum*, 24(3), 295-318.
- [27] He, H. (2007). Adolescents' perception of Parental and Peer Mathematics Anxiety and Attitude Toward Mathematics: A Comparative Study of European-American and Mainland-Chinese Students (Doctoral dissertation). Retrieved from ProQuest Dissertations and Theses Global. (UMI No. 304805885)
- [28] Hembree, R. (1990). The nature, effects, and relief of mathematics anxiety. *Journal for Research in Mathematics Education*, 21(1), 33-46.
- [29] Hopko, D. R., Mahadevan, R., Bare, R. L., & Hunt, M. K. (2003). The abbreviated math anxiety scale (AMAS): Construction, validity, and reliability. *Assessment*, 10(2), 178-182.
- [30] Jackson, C. D., & Leffingwell, R. J. (1999). The role of instructors in creating math anxiety in students from kindergarten through college. *The Mathematics Teacher*, 92(7), 583-586.
- [31] Ma, X. (1999). A meta-analysis of the relationship between anxiety toward mathematics and achievement in mathematics. *Journal for Research in Mathematics Education*, 30(5), 520-540.
- [32] Maloney, E. A., and Beilock, S. L. (2012). Math anxiety: who has it, why it develops, and how to guard against it. *Trends Cogn. Sci.* 16, 404-406. doi: 10.1016/j.tics.2012.06.008
- [33] Maloney, E. A., Ramirez, G., Gunderson, E. A., Levine, S. C., & Beilock, S. L. (2015). Intergenerational effects of parents' math anxiety on children's math achievement and anxiety. *Psychological Science*, 26(9), 1480-1488.
- [34] McLeod, D. B. (1992). Research on affect in mathematics education: A reconceptualization. In D.A. Grouws (Ed.), *Handbook of Research on Mathematics Teaching and Learning* (pp. 575-596). New York, NY: Macmillan.
- [35] Muller, C. (1998). Gender differences in parental involvement and adolescents' mathematics achievement. *Sociology of Education*, 71(4), 336-356.
- [36] Osborne, J. W. (2001). Testing stereotype threat: Does anxiety explain race and sex differences in achievement? *Contemporary Educational Psychology*, 26(3), 291-310.
- [37] Peterson, R. A., & Brown, S. P. (2005). On the use of beta coefficients in meta-analysis. *Journal of Applied Psychology*, 90(1), 175-181.
- [38] Plake, B. S., & Parker, C. S. (1982). The development and validation of a revised version of the mathematics anxiety rating scale. *Educational and Psychological Measurement*, 42(2), 551-557.
- [39] R Development Core Team. (2017). R: A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing. Retrieved from <http://www.R-project.org/>
- [40] 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(2), 187-202.
- [41] Richardson, F. C., & Suinn, R. M. (1972). The mathematics anxiety rating scale: Psychometric data. *Journal of Counseling Psychology*, 19(6), 551-554.
- [42] Rohn, J. (1989). Systems of linear interval equations. *Linear Algebra and its Applications*, 126, 39-78.
- [43] Rosenberg, J. H. (1980). The ability of selected cognitive, affective, and educational variables to predict the presence of anxiety related to mathematics (Doctoral dissertation). Retrieved from ProQuest Dissertations & Theses Global. (UMI No. 303035729).
- [44] Rothwell, J. (2014). Still searching: Job vacancies and

STEM skills. Metropolitan Policy Program. Washington, DC: Brookings Institution.

- [45] Rubinsten, O., & Tannock, R. (2010). Mathematics anxiety in children with developmental dyscalculia. *Behavioral and Brain functions*, 6(1), 46.
- [46] Shaver, A. V., & Walls, R. T. (1998). Effect of Title I parent involvement on student reading and mathematics achievement. *Journal of Research & Development in Education*, 31(2), 90-97
- [47] Sister Mary Fides Gough, OP. (1954). Why failures in mathematics? mathemaphobia: Causes and treatments. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas*, 28(5), 290-294.
- [48] Smith, F. M., & Hausafus, C. O. (1998). Relationship of family support and ethnic minority students' achievement in science and mathematics. *Science Education*, 82(1), 111-125.
- [49] Suinn, R. M., & Edwards, R. (1982). The measurement of mathematics anxiety: The mathematics anxiety rating scale for Adolescents-MARS-A. *Journal of Clinical Psychology*, 38,576-577.
- [50] 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(4), 979-986.
- [51] Tobias, S. (1976). Achievement treatment interactions. *Review of Educational Research*, 46(1), 61-74.
- [52] Viechtbauer, W. (2010). Conducting meta-analyses in R with the metafor package. *Journal of Statistical Software*, 36(3), 1-48. URL: <http://www.jstatsoft.org/v36/i03/>
- [53] 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(4), 446-467.
- [54] Wigfield, A., & Meece, J. L. (1988). Math anxiety in elementary and secondary school students. *Journal of Educational Psychology*, 80(2), 210-216.
- [55] Wu, S., Amin, H., Barth, M., Malcarne, V., & Menon, V. (2012). Math anxiety in second and third graders and its relation to mathematics achievement. *Frontiers in psychology*, 3, 1-11.
- [56] Yan, W., & Lin, Q. (2005). Parent involvement and mathematics achievement: Contrast across racial and ethnic groups. *The Journal of Educational Research*, 99(2), 116-127.