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THE NATURE, EFFECTS, AND RELIEF OF MATHEMATICS ANXIETY

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Results of 151 studies were integrated by meta-analysis to scrutinize the construct mathematics anxiety. Mathematics anxiety is related to poor performance on mathematics achievement tests. It relates inversely to positive attitudes toward mathematics and is bound directly to avoidance of the subject. Variables that exhibit differential mathematics anxiety levels include ability, school grade level, and undergraduate fields of study, with preservice arithmetic teachers especially prone to mathematics anxiety. Females display higher levels than males. However, mathematics anxiety appears more strongly linked with poor performance and avoidance of mathematics in precollege males than females. A variety of treatments are effective in reducing mathematics anxiety. Improved mathematics performance consistently accompanies valid treatment.

Anxiety has fostered strong research concerns within the last quarter century (Endler & Edwards, 1982). The construct is broadly defined to be a state of emotion underpinned by qualities of fear and dread (Lewis, 1970). This emotion is unpleasant, is directed toward the future, and is out of all proportion to the threat. Its special characteristics are "the feelings of uncertainty and helplessness in the face of danger" (May, 1977, p. 205). Anxiety is an omnibus construct, and under its rubric there has appeared a host of subconstructs that relate to discrete situations. In academics, two of these seem prominent: *test* anxiety and *mathematics* anxiety.

To examine the latter anxiety, it will help to look at the former. From its beginning, the research of test anxiety has proceeded on well-defined theoretical paths. The effect of test anxiety on performance has remained the focal concern.

On the basis of their responses to a Test Anxiety Questionnaire (Sarason & Mandler, 1952), students at Yale University were categorized as high- or low-test-anxious. In test after test, the low-anxious students outperformed their high-anxious peers in both the scores and their variability. Mandler and Sarason (1952) interpreted this differential performance on the basis of learned psychological drives. Two kinds were said to be evoked by the test situation. First are *task-directed* drives; these stimulate behaviors to reduce the drive by completing the test. Second are learned *anxiety* drives that stimulate two behaviors: 1) task-relevant efforts to finish the test and thereby reduce the anxiety; and 2) self-directed, task-irrelevant behaviors such as heightened heartbeat, anticipations of punishment and loss of status or esteem, and strong desires to escape the test situation. Persons with strong anxiety drives are prompted by habit to reenact their task-irrelevant behaviors that impair performance. Low-test-anxious persons can more easily attend to task-directed efforts that enhance achievement.

Later researchers built on this behavioral foundation for the test anxiety construct. Liebert and Morris (1967) proposed that test anxiety consists of two components: *emotionality*, behavioral in nature, and conscious *worry* or concern, a cognitive element. Wine (1971) adopted a purely cognitive orientation. According to her attentional theory, test-anxious persons divide their attention between task-relevant efforts and preoccupations with worry, self-criticism, and somatic concerns. With less attention available for test-directed activities, their performance is depressed.

These theories all conceptualize an interference model of test anxiety, in which test anxiety disturbs the recall of prior learning, thereby degrading performance. An alternative *deficits* model has been proposed (Tobias, 1985) that attributes the lower scores of test-anxious students to poor study habits and/or deficient test-taking skills. Within this model, test anxiety does not cause poor performance; the reverse is true. An awareness of poor past performance causes test anxiety.

Conflicts within this discussion raise questions. Is test anxiety a cognitive construct, or is it behavioral? What is the causal direction in the relationship between test anxiety and performance? A synthesis of test anxiety research (Hembree, 1988a) found the construct more behavioral than cognitive in nature. It was seen to cause poor performance; hence, the evidence supported the interference rather than the deficits test-anxiety model.

No such theoretical base has been constructed for the research of mathematics anxiety (Reyes, 1984). Early in the 1970s, results of its study began to appear, using the methods, procedures, and treatments already applied to test anxiety. Most researchers have viewed the two constructs as highly related. Some describe mathematics anxiety as no more than subject-specific test anxiety (Brush, 1981). Others define its context more broadly, including a general dread of mathematics, and of tests in particular (Richardson & Woolfolk, 1980). Often, reviews of test anxiety research contain a section that explicitly regards mathematics anxiety (for example, Tryon, 1980). A tacit belief has seemed to prevail that test-anxiety theory can be used to support both constructs.

Despite its lack of independent identity, the research of mathematics anxiety has prospered, spurred by increasing perceptions that the construct threatens both achievement and participation in mathematics. These suggestions have national import; when otherwise capable students avoid the study of mathematics, their options regarding careers are reduced, eroding the country's resource base in science and technology. Especially, this avoidance has been thought to apply to females. Their anxiety toward mathematics seems consistently higher than that of males (Betz, 1978), and the construct is charged with being a cause of Ernest's (1976) finding that far fewer women than men take part in high school and college mathematics (Meece, Parsons, Kaczala, Goff, & Futterman, 1982; Tobias, 1980).

In light of these concerns, it seems wise to challenge the prior assumptions and develop a scholarly base for the construct, assuring that treatments toward its relief coincide with its nature. Existing research can be used for this effort. The present review was thus conceived with comprehensive intentions: to help build theory, examine effects, compare prescriptions for treatment, and describe the construct as fully as the mass of research will allow.

Problem Statement

The purpose of the study was to integrate the findings of the research on mathematics anxiety, regarding its nature, effects, and relief. Methods of meta-analysis were selected for this synthesis, to describe relationships and effects with scale-invariant metrics. Focus was supplied by a drive to reduce or resolve theoretical issues surrounding the construct.

Research Tasks

To perform these objectives, five tasks were defined. The first two regarded the nature of mathematics anxiety. Task 1 set out to identify variables that correlate with the construct (for example, mathematics performance, mathematics avoidance, and test anxiety). Task 2 was meant to identify variables that exhibit different levels of the construct (for example, gender and school grade level). Task 3 regarded the relation between mathematics anxiety and mathematics performance on the basis of effect size. Task 4 examined treatments to reduce mathematics anxiety, to (a) compare their relative degrees of mathematics anxiety reduction and (b) determine if the treatments affected performance.

Fulfillment of these tasks would allow for a probing of issues related to theory. Task 5 was defined to address the following theoretical questions, using the results of Tasks 1 through 4:

1. Is there a causal direction in the relationship between mathematics anxiety and mathematics performance?
2. Does test anxiety subsume mathematics anxiety?
3. Are behaviors related to mathematics anxiety more pronounced in females than males?

Collecting the Studies

The identification of studies to be used in the meta-analysis began with computer and manual searches of three data bases: *Dissertation Abstracts, Psychological Abstracts,* and the Educational Resources Information Center (ERIC). Other studies were found by tracking citations from study to study. All candidate reports were screened against the following criteria:

1. The study report provided product-moment correlation coefficients and their sample sizes or, in the case of experiments, sufficient data for effect-size calculations.
2. Mathematics anxiety measurements were made with validated instruments.
3. Experiments used at least two groups, including a control.
4. Each experimental group contained at least 10 subjects (for rigor in the meta-analytic tests of homogeneity).

This screening delivered a body of 151 studies: 49 journal articles, 23 ERIC documents, 75 doctoral dissertations, and 4 reports in other sources. A bibliography is present in Hembree (1988b). The distribution of studies performed at each grade level 1 through 12 and postsecondary (P) is shown in Table 1. (Some studies dealt with more than one grade, so the total exceeds 151.) The data were coded through guidelines provided by Hembree (1988a). This effort produced the following totals addressing the tasks of research: 428 correlations, 85 effects for variables that exhibited different levels of mathematics anxiety, 13 effects involving the relationship between mathematics anxiety and mathematics performance, and 115 effects of treating mathematics anxiety. Treatments ranged in length from 3 to 12 hours or greater, with median 8. Design ratings, which evaluate design quality on a scale of 1 = poor to 3 = excellent, ranged from 1.5 to 2.5, with median 2.0.

Table 1
Distribution of Grade Levels in 151 Studies of Mathematics Anxiety

Grades	1	2	3	4	5	6	7	8	9	10	11	12	P
Number of studies	0	0	1	0	1	5	12	14	17	21	18	18	122

Coding the Data

The studies differed across a broad range of properties and features such as school grade level, ability levels, and quality of the research designs. Thus, their findings seemed likely to vary because of these differing characteristics. Meta-analysis draws strength from its capacity to identify interactions and relationships among the properties of studies and their outcomes. To prepare for this eventuality, study properties were coded as independent variables, with outcomes (correlations or experimental comparisons) treated as dependent variables. Interactions could then be explored at the time of data analysis.

Independent Variables

Each study was coded regarding properties that could change from study to study, including:

- Grade level (K–12, postsecondary)
- Ability level (low or high where indicated, otherwise average)
- Socioeconomic status (low, middle, upper where indicated, otherwise composite)
- Ethnicity (predominant ethnic or cultural group)
- Instrument used for mathematics anxiety measurement
- Length of treatment (number of hours across number of weeks)
- Research design quality (1 = poor to 3 = excellent)

Dependent Variables

In correlational studies, the product-moment coefficients were directly the outcome variable. To guard against skew, all values of r were changed to Fisher's z (Ferguson, 1981, p. 194) for their analysis. In experimental studies, the criterion was effect size as defined by Glass, McGaw, and Smith (1981, p.102):

$$ES = \frac{\bar{X}_1 - \bar{X}_2}{s} \quad (1)$$

The numerator terms are posttest means, with s computed as the pooled standard deviation of the posttest data, the square root of within-cell variance, or the square root of error mean square.

Procedures

The total collections of data were partitioned into subsets that related to the tasks and subtasks of research. Then each subset was analyzed separately, in the hope that its mean could be used to integrate the subset. A use of the mean was appropriate if the subset was consistent, as determined by a test of homogeneity (Hedges & Olkin, 1985). Whenever a subset was homogeneous, its mean value, weighted with respect to sample sizes, was declared *the correlation* or *the effect* for its research task. A 99% confidence interval tested the null hypothesis that the mean was not significantly different from zero, and the synthesis of that subset was complete. Whenever a subset was heterogeneous, two conditions were implied: (a) the presence of outlier data, or (b) interactions among the independent and dependent variables. A search for the cause was then performed, to find and exclude the outlier data or find and describe interactions, using procedures detailed by Hembree and Dessart (1986). Where a cause could not be found, the mean of the heterogeneous group was offered as a descriptor from which no statistical inferences were drawn.

RESULTS

Correlational Findings

To gather insight into the nature of mathematics anxiety, Task 1 of the study set out to identify correlates of the construct and to learn the extent of each relationship. Tables 2–5 present the findings with regard to mathematics performance, student attitudes toward mathematics, avoidance behaviors, and measures of other anxieties. The data regarding each correlate are summarized by 1) providing the number of correlations for each relationship plus the total number n of students involved, values of outliers (if any), smallest and largest values of r (excluding outliers), and the grades involved; 2) providing the group mean as the correlation that, in the presence of homogeneity, describes the relationship; and 3) indicating whether or not the mean was significantly different from zero.

Performance Correlates

Table 2 gives mean correlations between mathematics anxiety and measures of student performance. Higher mathematics anxiety was slightly related to lower IQ levels, whereas its relationship with verbal ability was so low that it was not of practical importance. Correlations between mathematics anxiety and aptitude/

achievement measures were inverse across grade levels, so higher mathematics anxiety consistently related to lower mathematics performance. In Grades 5–12, the inverse relation was stronger for males than females, a difference that disappeared among college students. Grades in mathematics courses seemed depressed in relation to anxiety by about the same proportion as the students' test scores.

Table 2
Mean Correlations of Mathematics Anxiety and Performance

Correlate of mathematics anxiety	Description of correlational group				Mean[a] r
	n	Outliers	End values	Grade level	
IQ test	5(449)	—	−0.23/0.22	6, P	−0.17*
Verbal apt/ach	17(1941)	—	−0.27/0.05	9–12, P	−0.06*
Math apt/ach by grades 5–12:					
Males	6(2794)	—	−0.46/−0.28	5–12	−0.36*
Females	6(2864)	—	−0.39/−0.16	5–12	−0.30*
Both genders	7(5555)	—	−0.47/−0.18	7, 8, 11	(−0.34)
College	58(6137)	—	−0.64/−0.04	P	−0.31*
Math apt/ach by subtest					
Computation	5(957)	—	−0.43/−0.10	7, 9–12, P	−0.25*
Concepts	4(894)	—	−0.40/−0.13	7, 9–12, P	−0.27*
Problem solving	3(871)	—	−0.42/−0.15	7, 9–12, P	−0.27*
Abstract reasoning	3(325)	—	−0.43/−0.29	P	−0.40*
Spatial ability	5(374)	—	−0.34/0.21	P	−0.29*
Grade in math course					
High school	4(903)	—	−0.46/−0.27	9–12	−0.30*
College	17(1624)	—	−0.57/0.02	P	(−0.27)

Note. P = postsecondary. apt/ach = aptitude/achievement.
[a]Entries in parentheses are mean correlations for heterogeneous data.
*$p < .01$.

Attitude Correlates

Table 3 presents mean correlations between mathematics anxiety and attitudinal constructs. Positive attitudes toward mathematics consistently related to lower mathematics anxiety, with strong inverse relations observed for an enjoyment of mathematics and self-confidence in the subject. Relationships seemed weaker at postsecondary levels. Small correlations were found between mathematics anxiety and desire for success and a view of mathematics as male-oriented.

High-anxious students viewed parents and teachers as somewhat negative toward mathematics. These relations too were smaller at postsecondary levels.

Avoidance Behaviors

Table 4 relates mathematics anxiety with tendencies of students to avoid mathematics. High-anxious students took fewer high school mathematics courses and showed less intention in high school and college to take more mathematics. A significant gender difference appeared in junior and senior high school. Males with higher levels of mathematics anxiety appeared less likely than high-anxious females to take more mathematics.

Table 3
Mean Correlations of Mathematics Anxiety and Attitude-Related Variables

Correlate of mathematics anxiety	Description of correlational group: *n*	Outliers	End values	Grade levels	Mean *r*
Student attitudes					
Enjoyment of math					
Grades 5–12	6(3856)	−0.36	−0.76/−0.63	5–12	−0.75*
College	9(1383)	—	−0.63/−0.38	P	−0.47*
Self-confidence in math					
Grades 6–11	4(514)	—	−0.85/−0.76	6–11	−0.82*
College	19(2912)	—	−0.84/−0.37	P	−0.65*
Self-concept in math	6(3748)	−0.44	−0.74/−0.61	5–8, 11, P	−0.71*
Motivation in math	3(2623)	—	−0.64/−0.57	8,11	−0.64*
Math as male domain	19(3678)	—	−0.12/0.31	6–12, P	0.14*
Attitude toward:					
Success in math	8(1703)	−0.42	−0.22/0.08	9–12, P	−0.12*
Usefulness of math	24(8889)	—	−0.70/−0.16	5–12, P	−0.37*
Problem solving	12(2709)	—	−0.71/−0.38	7–12, P	−0.58*
Math teachers	4(2723)	—	−0.69/−0.25	7, 8, 11	−0.46*
Computers	7(1018)	—	−0.53/−0.23	7–12, P	−0.32*
Self-confidence with computers	5(478)	—	−0.58/−0.39	7–12, P	−0.43*
Student perceptions of others' attitudes toward math					
Father					
Grades 9–12	3(575)	—	−0.45/−0.36	9–12	−0.39*
College	11(1592)	—	−0.42/−0.06	P	−0.25*
Mother					
Grades 9–12	3(575)	—	−0.44/−0.33	9–12	−0.37*
College	12(1643)	—	−0.51/0.01	P	−0.23*
Math teacher					
Grades 9–12	3(575)	—	−0.55/−0.45	9–12	−0.49*
College					
Males	3(313)	—	−0.54/−0.43	P	−0.47*
Females	7(1178)	—	−0.68/−0.35	P	−0.41*

Note. P = postsecondary.
*$p < .01$.

Table 4
Mean Correlations of Mathematics Anxiety and Student Avoidance Behaviors

Correlate of mathematics anxiety	Description of correlational group: *n*	Outliers	End values	Grade levels	Mean *r*
Extent of high school math	28(6358)	—	−0.44/0	12, P	−0.31*
Intent to take more math					
Grades 7–12					
Males	3(1272)	—	−0.45/−0.28	7–12	−0.35*
Females	3(1333)	—	−0.35/−0.19	7–12	−0.25*
College	8(2225)	—	−0.63/−0.05	P	−0.32*

Note. P = postsecondary.
*$p < .01$.

Correlations Among Anxieties

Table 5 displays correlations between mathematics anxiety and other anxieties. Direct relationships were found regarding a general anxiety proneness and its components, chronic A-Trait and transitory A-State as defined by Spielberger

(1972). Mathematics anxiety related directly to debilitating test anxiety and inversely to the anxiety drive that facilitates performance during testing (Alpert & Haber, 1960).

Table 5
Mean Correlations of Mathematics Anxiety and Other Anxiety Measures

Correlate of mathematics anxiety	Description of correlational group: n	Outliers	End values	Grade levels	Mean r
General anxiety	7(1692)	0.80	0.33/0.50	6, 8–10, P	0.35*
Trait anxiety	11(1941)	—	0.24/0.54	P	0.38*
State anxiety	4(815)	—	0.31/0.52	P	0.42*
Fear of negative evaluation	4(257)	—	0.40/0.48	P	0.44*
Test anxiety	21(3187)	0.78	0.29/0.73	P	0.52*
Worry component	8(1329)	—	0.30/0.69	P	0.45*
Emotionality	8(1329)	—	0.29/0.72	P	0.46*
Facilitating TA	7(792)	—	−0.34/−0.15	P	−0.28*
Computer anxiety	8(840)	—	0.21/0.58	7–12, P	0.39*

Note. P = postsecondary. TA = test anxiety.
* $p < .01$.

Results for Differentials

The second task of the study set out to compare the degrees of anxiety *within* variables ("differentials") that exhibit different levels of the construct (for example, gender, female versus male). Each comparison was drawn in terms of an effect size; then related groups were analyzed through the procedures given before. Table 6 presents the results for ability level, sex, and ethnicity. Mathematics anxiety seemed somewhat higher in slow and average students, but no difference was found between these groupings. Females displayed higher levels than males, especially in college. Studies describing ethnic effects were limited to college students. No difference appeared between white and black students, but the Hispanic group (in two studies) seemed more anxious than the other ethnic groups.

Table 6
Mean Effects for Differentials Regarding Mathematics Anxiety

Differentials and comparisons	Description of effect-size (ES) group: n	Outliers	End values	Grade levels	Mean ES
Ability level					
High vs. average	6(1511)	—	−0.57/−0.04	6, 7, 9–12, P	−0.23*
Low vs. average	3(741)	—	−0.06/0.32	6, 7, P	0.07
Sex, female vs. male					
Precollege	22(6299)	—	−0.02/0.52	5–12	0.19*
College	47(9209)	—	−0.24/0.77	P	0.31*
Ethnicity					
Black vs. white	5(804)	—	−0.33/0.30	P	−0.01
Hispanic vs. white	2(1489)	—	0.82/0.83	P	0.82*

Note. P = postsecondary.
* $p < .01$.

Is mathematics anxiety related to school grade level? How do its levels compare between courses and respecting college majors? These questions were examined by descriptive methods.

School Grade. Figure 1 shows average mathematics anxiety levels of females and males in Grades 6–P, based on 10 428 measurements of the construct. (No data were available for the earlier grades.) The levels increased through junior high school, peaked near Grades 9–10, and leveled off in upper high school and college.

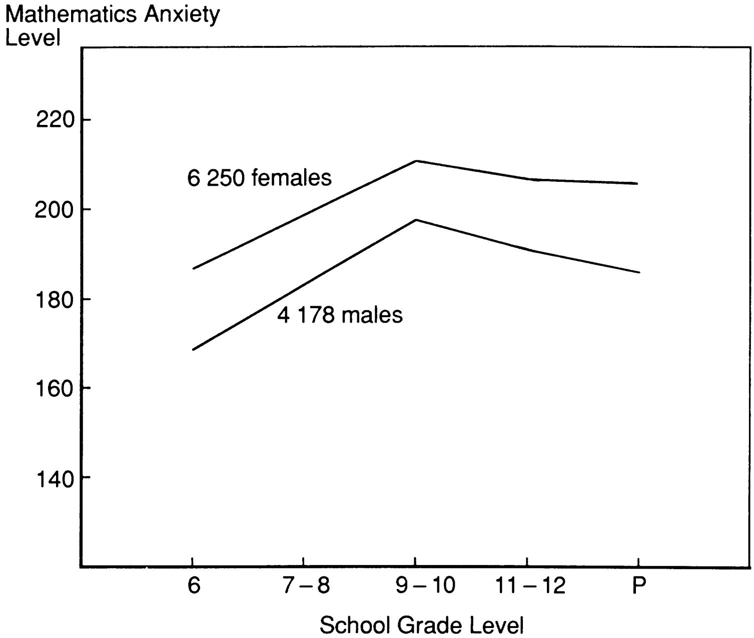

Figure 1. Average mathematics anxiety levels for Grades K–12 and undergraduate.

Courses and Majors. Table 7 shows levels of mathematics anxiety for various college courses and majors, along with the numbers of studies and students involved. High levels appeared in remedial mathematics and declined with more

Table 7
Mathematics Anxiety Level by College Courses and Majors

Course	*n*	Anxiety level[a]	Major	*n*	Anxiety level[a]
Developmental math	12(836)	236.3	Math/science	5(169)	166.5
Remedial algebra	11(1028)	206.1	Elementary education	25(1835)	219.2
College algebra	9(578)	201.8	Business	4(194)	187.8
Precalculus	5(436)	180.5	Social sciences	5(161)	190.3
Calculus/analytic geometry	10(730)	152.5	Health sciences	2(50)	187.5
Math for elementary teachers	6(420)	243.0	Physical sciences	2(54)	149.4
Elementary statistics	5(435)	185.6	Humanities	5(174)	198.5
Elementary accounting	3(88)	193.8			

[a]Based on the Mathematics Anxiety Rating Scale (MARS) of Richardson and Suinn (1972).

advanced study. Mathematics and science majors were predictably low in the construct. The highest levels occurred for students preparing to teach in elementary school.

Effects on Performance

Task 3 of the study set out to determine the relationship between mathematics anxiety and performance in terms of effect size. Thirteen studies of college mathematics were found, comparing the test scores of students with high and low levels of mathematics anxiety. Within these studies, all samples were formed before obtaining scores on any measure. The mean of the 13 effects was –0.61, so the low-anxious students consistently scored better. An effect size represents the number of pooled standard deviations between the scores of the two groups being compared. If a pooled standard deviation of 12 is assumed for scores on a 100-point scale, the effect size of –0.61 depicts a difference of about 7 points between the high-low categories.

Findings for Mathematics Anxiety Treatments

Task 4 of the study set out to display the effects of treating mathematics anxiety on the level of anxiety and on performance. These effects were measured by equation 1, comparing the posttreatment scores of treated versus untreated students. The data were then partitioned on two dimensions: posttest measure (mathematics anxiety level, or test performance); and type of treatment. *Classroom interventions* attempted to relieve mathematics anxiety within whole classes. Reductions in mathematics anxiety levels were sought through changes in the curriculum or through psychological interventions. Psychological treatments were behavioral or cognitive in nature. *Behavioral* modes proposed to relieve 'emotionality' toward mathematics (feelings of dread and nervous reactions). *Cognitive* treatments were set to relieve expressed concerns or worry about the subject. *Cognitive-behavioral* treatments attended to the worry factor but also provided elements to reduce emotionality. Each subset of data was synthesized through the procedures given for computing effect size. Tables 8 and 9 present the findings. Mean effects near ±0.8 may be considered fairly large, with sizes near ±0.2 considered small (Cohen, 1977, pp. 24-27).

Effects on Mathematics Anxiety

Table 8 compares the end-of-treatment mathematics anxiety levels of treated and untreated subjects.

Classroom Interventions. Curricular changes as a means of reducing mathematics anxiety included concentrated efforts to improve the students' achievement, heuristic versus algorithmic instruction, special classwork in microcomputers, provision of special equipment (for example, calculators), and special techniques for presenting material (tutorial, small-group, and self-paced). Such changes did not seem effective in reducing mathematics anxiety. Whole-class psychological treatments were also not effective.

Table 8
Mean Effects of Treatment on Mathematics Anxiety

Result by treatment style	Description of effect-size (ES) group				Mean ES
	n	Outliers	End values	Grade levels	
Classroom intervention					
Curricular change	17(1045)	—	−0.46/0.48	10, P	−0.04
Psychological	8(581)	—	−0.38/0.18	9–12, P	−0.10
Behavioral					
SD and others	18(673)	—	−2.41/−0.36	9–12, P	−1.04*
Relaxation training	3(80)	—	−0.62/−0.41	9–12, P	−0.48
Cognitive					
Group counseling	3(94)	—	−0.22/0.17	10–12, P	−0.03
Restructuring	14(746)	—	−1.12/0.05	9–12, P	−0.51*
Cognitive-behavioral	10(364)	—	−1.83/−0.46	7–12, P	−1.15*

Note. P = postsecondary. SD = systematic desensitization.
*$p < .01$.

Out-of-Class Psychological Treatments. The most common behavioral treatment mode was systematic desensitization. This technique, along with anxiety management training and conditioned inhibition, were highly successful in reducing mathematics anxiety levels. Typically, these techniques used relaxation training as a component. However, this training alone did not seem effective. The cognitive treatment of group discussion was also not effective. Cognitive modification to restructure faulty beliefs and build self-confidence in mathematics produced a moderate reduction in mathematics anxiety. Cognitive restructuring combined with systematic desensitization or relaxation training succeeded in mathematics anxiety reduction at a level comparable to systematic desensitization alone.

Effects on Mathematics Performance

Table 9 gives mean effects comparing the post-treatment test performance of treated and untreated subjects. Treatments that resulted in significant mathematics anxiety reduction were accompanied by significant increases in mathematics test scores. The largest increases referred to the treatments providing the largest mathematics anxiety reduction, that is, to behavioral methods (except relaxation) and cognitive-behavioral treatments. The cognitive modifications that had emphasized confidence building produced both moderate mathematics anxiety reductions and moderate increases in test performance. There were no performance improvements from the classroom interventions, relaxation training, or group counseling.

The behavioral treatments (except relaxation) and cognitive-behavioral methods produced a collective mean improvement of 0.57 in test performance. This value compared the average scores of students with low mathematics anxiety (the treated students) and students with high mathematics anxiety (the untreated control groups). Previous comparisons between high- and low-anxious students had displayed a mean effect of -0.61 (see the previous discussion on effects of mathematics anxiety on performance). Thus, mathematics anxiety reductions by way of these methods appeared to be related to better performance approaching the level of students with low mathematics anxiety.

Table 9
Mean Effects of Treatment on Mathematics Test Performance

Result by treatment style	Description of effect-size (ES) group				Mean ES
	n	Outliers	End values	Grade levels	
Classroom intervention					
Curriculum-related	6(441)	—	−0.36/0.19	10, P	0.02
Psychological	9(570)	—	−0.31/1.01	9–12, P	0.03
Behavioral					
SD and others	12(517)	—	0.19/0.94	9–12, P	0.60*
Relaxation training	2(52)	—	−0.17/0.31	P	0.07
Cognitive					
Group counseling	2(110)	—	−0.37/0.04	P	−0.07
Restructuring	7(318)	—	−0.13/1.21	P	0.32*
Cognitive-behavioral	4(142)	—	0.14/0.84	P	0.50*

Note. P = postsecondary. SD = systematic desensitization.
*$p <$ 01.

CONCLUSIONS AND DISCUSSION

Mathematics Anxiety and Performance Causality. Does mathematics anxiety tend to contribute to poor performance? Does a knowledge of poor past performance induce the anxiety? Or is the relationship circular?

Because of the following evidence, it seems that mathematics anxiety depresses performance:

1. Higher achievement consistently accompanies reduction in mathematics anxiety.

2. Treatment can restore the performance of formerly high-anxious students to the performance level associated with low mathematics anxiety.

There is no compelling evidence that poor performance causes mathematics anxiety. The construct's relations with IQ and ability seem small (see Tables 2 and 6), and special work to enhance students' competence failed to reduce their anxiety levels.

Mathematics Anxiety and Test Anxiety. Does test anxiety subsume mathematics anxiety? A comparison of the present findings for mathematics anxiety with the results of a similar analysis of test anxiety (Hembree, 1988a) shows a number of parallel properties:

1. Mathematics and test anxieties both relate to general anxiety.

2. The differences in anxiety level regarding student ability, gender, and ethnicity are similar for both constructs.

3. Both forms affect performance in similar fashion.

4. The constructs respond to the same treatment modes, with best relief from behavioral-related methods and little result from the cognitive treatment, group counseling.

5. Improved performance relates to the relief of both constructs.

These findings suggest that researchers of mathematics anxiety have been reasonably prudent in adopting test anxiety's theoretical base for mathematics anxiety. Like test anxiety, mathematics anxiety seems to be a learned condition more behavioral than cognitive in nature. However, the observed mean correlation between mathematics anxiety and test anxiety was 0.52 (Table 5), a moderate value. Corrected for attenuation using instrument reliabilities near 0.85 (Tryon, 1980), an r of 0.52 increases to 0.61. The corresponding coefficient of determination r^2 is 0.37; thus, only 37 percent of one construct's variance is predictable from the variance of the other. The remaining 63 percent must be attributed to other sources, factors attending one construct that are absent at the other. Hence, it seems unlikely that mathematics anxiety is purely restricted to testing. Rather, the construct appears to comprise a general fear of contact with mathematics, including classes, homework, and tests.

Gender-Related Behaviors. Across all grades, female students report higher mathematics anxiety levels than males. However, the higher levels do not seem to translate into more depressed performance or to greater mathematics avoidance on the part of female students. Indeed, male students in high school exhibit stronger negative behaviors in both these regards. This paradox may be explained along two lines: 1) Females may be more willing than males to admit their anxiety, in which case their higher levels are no more than a reflection of societal mores; 2) females may cope with anxiety better. Whatever the cause, at precollege levels mathematics anxiety effects seem more pronounced in male than female students.

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