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ABSTRACT

While much progress has been made in treating math anxiety, little is yet known about its causes, correlates or effects. The present study examined factors related to the prevalence and intensity of math anxiety in college students and the extent to which math anxiety is predictive of math course grades. The 655 subjects were obtained from two math courses and one psychology course at Ohio State University. Results indicated that math anxiety occurs frequently among college students, and that it is more likely to occur among women than among men and among students with inadequate high school math backgrounds. Higher levels of math anxiety were related to lower mathematics achievement test scores, higher levels of test anxiety and higher levels of trait anxiety. Students reporting confidence in their ability to learn math and who perceived their parents and teachers as having positive attitudes toward math tended to report lower levels of math anxiety. Math anxiety was not a significant predictor of grades in math courses. However, it was the second strongest predictor (after ACT Math subtest scores) in one subject group and for females in the other subject group. (Author)

Math Anxiety: What is it?

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In an increasingly technological society, knowledge of mathematics is critical to the pursuit of many existing and emerging occupational fields (Carnegie Commission on Higher Education, 1973; Sells, 1973). In addition to its necessity in scientific and technical fields, knowledge of mathematics is increasingly important in business, the social sciences, and the humanities (Stent, 1977). In spite of the importance of mathematics, however, many intellectually capable students avoid taking math courses in high school and in college and, consequently, restrict the range of careers from which they may choose to those which do not require quantitative skills. Many other students fail to perform as well in math as they are capable and, again, do not attain the mathematics knowledge which would expand the range of career options available to them.

The problems of math avoidance and poor math performance are particularly apparent among women (Brooks, Faderman, Gregory, & Rice, 1976; Carnegie Commission on Higher Education, 1973; Maccoby & Jacklin, 1974). Women take significantly fewer math courses than do men both in high school and in college, and far fewer women than men elect to major in mathematics (Ernest, 1976; Hewitt & Goldman, 1975). Women continue to be seriously under-represented in scientific and technical occupations (U.S. Department of Labor, 1975; Wilburn, 1974), and a study by Sells (1973) demonstrates the critical role of mathematics preparation in the choices of women to enter such fields. Sells found that in a random sample of freshmen entering the University of California at Berkeley in the fall of 1972, 92% of the women, versus 57% of the men, lacked the high school math prerequisites for any college-level

calculus or intermediate statistics course. Calculus and/or statistics are required in 15 of 20 possible major fields at Berkeley, but the school offers no pre-calculus math course nor any other opportunity to compensate for inadequate prior preparation. Thus, an overwhelming majority of women students were left, many by default, to major in the traditionally female, and hence lower paying, fields of education, the social sciences, the humanities, librarianship, and social welfare.

One concept being used increasingly to explain both math avoidance and poor math performance is that of "math anxiety" (Stent, 1977; Tobias, 1976). Math anxiety, defined as "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (Richardson & Suinn, 1972), is postulated to affect both the extent to which a student pursues any more than the minimally required amount of mathematics training and the extent to which he/she is able to learn or perform math skills and concepts. Further, as a result of traditional societal views of mathematics as a more appropriate field of study for males than for females and of men as "better" in math than women, the problem of math anxiety has been assumed to be more common and more severe among women than men.

Because of increased acknowledgement of math anxiety as potentially important in explaining both math avoidance and poor math performance, programs for its treatment have been instituted at several colleges and universities throughout the country. Math anxiety treatment programs have been offered at Wellesley, Mills College, The University of Minnesota, The University of California at Santa Barbara, and Wesleyan

University, among others. These programs have typically involved a combination of mathematically-based and psychologically-based interventions.

While much progress has been made in developing programs to treat math anxiety, there has been less progress toward understanding its psychological bases. Research contributing to the understanding of math anxiety would be useful in the design of programs for both its treatment and its prevention and, further, is necessary for the establishment of math anxiety as an important explanatory construct linked to other major psychological variables.

For example, little is yet known about the actual prevalence and intensity of math anxiety in various sub-populations of individuals; research of this type could aid in the identification of groups or types of people particularly in need of treatment. Information concerning background and experiential factors related to the occurrence of math anxiety could aid in explaining its genesis and, additionally, provide suggestions for its prevention.

Research on cognitive and personality trait correlates of math anxiety is necessary to determine the extent to which math anxiety tends to occur as part of a constellation of other traits or is, rather, independent of other major psychological traits. For example, different implications for the treatment of math anxiety would stem from findings of a high, rather than a low, degree of association between math anxiety and manifest or "trait" anxiety. Knowledge of the relationship of other attitudes toward mathematics to math anxiety could be useful in the development of treatment modules focused on

attitudes as well as anxieties. And, finally, further information is needed concerning the effects of math anxiety on math avoidance, on performance in math courses, and on educational and vocational plans.

Thus, the present study was designed to investigate factors related to the prevalence and intensity of math anxiety in college students and to begin to assess the effects of math anxiety on participation and achievement in mathematics curricula. More specifically, its purposes were as follows: 1) to estimate the prevalence and intensity of math anxiety in college students in general and as a function of sex and race; 2) to investigate the relationships between math anxiety and background variables, prior preparation and achievement in mathematics, general "trait" anxiety, and test anxiety; 3) to investigate the relationships between math anxiety and several other components of attitudes towards mathematics, including perceptions of the attitudes of "significant others"; and 4) to determine the extent to which math anxiety is predictive of performance in college-level math courses.

Method

Subjects

Three groups of subjects, a total of 655 people, were utilized in the present study. The first subject sample consisted of 125 students, 50 male and 75 female, enrolled in the most basic mathematics course offered at Ohio State University. This course, herein denoted "Math 1", is a review of high school algebra and is designed for students whose math placement scores indicate least readiness for college-

level math. Math 1 must be followed by a more advanced math course in order for the student to satisfy Ohio State's Basic Educational Requirements. Students in this group either had less than 3 years of high school math or did poorly on math placement tests in spite of having 3 or 4 years of high school math.

The second subject sample consisted of 348 students, 188 male and 160 female, from a more advanced math course. This course, denoted as "Math 2", is the pre-calculus course for students planning majors in engineering, the physical sciences, mathematics, and pre-medicine. Math 2 is followed by the most rigorous calculus sequence offered at Ohio State. Thus, students in Math 2 tended to have had more high school math, had scored considerably higher than Math 1 students on placement tests, and were planning majors and careers requiring extensive preparation in math.

The third subject group consisted of 182 students, 81 male and 101 female, from an introductory psychology course. Because introductory psychology is required as part of basic educational requirements for most major fields, these students represented a variety of major fields and differed from each other in terms of prior math background and achievement. Students in the "Psychology 1" group, as well as those in the Math 1 and Math 2 groups, were primarily freshmen and sophomores.

Instruments

Math anxiety was measured using a revised version of the Mathematics Anxiety scale, one of nine scales constituting the Fennema-Sherman Mathematics Attitudes Scales (Fennema & Sherman, 1976). The Mathematics Anxiety scale is intended to assess "feelings of anxiety, dread,

nervousness, and associated bodily symptoms related to doing mathematics" (Fennema & Sherman, 1976, p. 4). Because the Fennema-Sherman Mathematics Anxiety Scale was designed for administration to high school students, several items were rewritten to be more appropriate for college students and, of the 12 items used on the Fennema-Sherman scale, 10 were selected to measure math anxiety in college students. Item responses were obtained on a 5-point Likert scale; responses ranged from 1 (Strongly Disagree) to 5 (Strongly Agree). Half the items were positively worded, while the other half were negatively worded. Scoring of negatively worded items was reversed so that higher scores would indicate more positive attitudes toward math, that is, less math anxiety. The items used in the Math Anxiety scale and their scoring weights are contained in Appendix A.

Four other components of attitudes toward mathematics were measured using revised versions of the Fennema-Sherman scales. The Confidence in Learning Mathematics scale is designed to measure "confidence in one's ability to learn and to perform well on mathematical tasks" (Fennema & Sherman, 1976, p. 4); higher scores on this scale are indicative of greater confidence in learning math.[1] The Math as a Male Domain scale measures "the degree to which students see mathematics as a male, neutral, or female domain in the following ways: a) the relative ability of the sexes to perform in mathematics; b) the masculinity/femininity of those who achieve well in mathematics; and c) the appropriateness of this line of study for the two sexes" (Fennema & Sherman, 1976, p. 3). Items on the Math as a Male Domain scale were scored so that higher scores indicate more positive attitudes toward math or, in

this case, less tendency to view males as innately better in math or math as a more appropriate field of study for males than for females.

The third component of attitudes toward mathematics involved students' perceptions of its usefulness; the Fennema-Sherman Mathematics Usefulness scale measures "students' beliefs about the usefulness of mathematics currently and in relationship to their future education, vocation, or other activities" (Fennema & Sherman, 1976, p. 5).

And the final mathematics attitude scale utilized was the Effectance Motivation in Mathematics scale. This scale involves attitudes related to problem-solving in mathematics; it measures "effectance as applied to mathematics. The dimension ranges from lack of involvement in mathematics to active enjoyment and seeking of challenge" (Fennema & Sherman, 1976, p. 5). Each of the four attitudes toward mathematics scales consisted of 10 items, and responses were obtained on a 5-point scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree).

Perceptions of the attitudes to mothers, fathers, and teachers toward mathematics were assessed using the Mother, Father, and Teacher scales of the Fennema-Sherman Mathematics Attitudes Scales.[1] Each of these scales consisted of 10 items, and responses were obtained on a 5-point scale.

Trait anxiety was measured using the A-Trait scale of the State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, & Lushene, 1970). The STAI A-Trait Scale, intended to assess "relatively stable individual differences in anxiety proneness" (Spielberger et al., 1970, p. 3), consists of 20 statements that ask people to describe how they generally feel. Subjects are asked to respond to each item using a 4-point scale;

response categories are: (1) Almost never; (2) Sometimes; (3) Often; and (4) Almost always. For items on which ratings of "4" indicate high levels of anxiety (e.g., "I worry too much over something that really doesn't matter"), scoring weights are those of the item response chosen. For items on which ratings of "4" indicate low levels of anxiety (e.g., "I am calm, cool, and collected"), the scoring weights are reversed. Total scores range from a minimum of 20 to a maximum of 80, and the higher the score, the higher the level of trait anxiety.

Test anxiety was assessed using the Test Anxiety Inventory (TAI), an instrument developed recently by C.D. Spielberger of the University of South Florida. The TAI consists of 20 statements pertaining to feelings and reactions while taking tests; responses are obtained on a 4-point Likert scale with response categories identical to those used on the STAI. Scores may range from 20 to 80, and higher scores indicate higher levels of test anxiety. Correlations between the TAI and Sarason's (1958) Test Anxiety Scale range between .85 and .95, and the TAI provides subscales for Worry and Emotionality components of test anxiety (C.D. Spielberger, personal communication, January 15, 1977). Items and instructions for the TAI are contained in Appendix B.

Scores on the American College Test (ACT) were available through the Admissions Office for about two-thirds of the subjects in each group. For purposes of the present study, the ACT Mathematics and ACT English subtest scores were obtained. Demographic and background information was obtained using a questionnaire administered to each subject tested. Finally, subjects in the two Math course groups were asked to sign a form releasing their final math course grade; grades

for those students signing the form were provided by their instructors.

Procedure

Through the cooperation of the faculty of the Department of Mathematics at Ohio State University, permission was obtained to enter sections of the Math 1 and Math 2 courses and administer the math anxiety and attitudes toward mathematics scales and the questionnaire pertaining to demographic and background information. Data was collected during the first few weeks of the Winter quarter, 1977, and at the end of the quarter the course instructors supplied the final course grades of those students who had signed the release form.

Students in the introductory psychology course were obtained through the Psychology Department subject pool. These students were administered the math anxiety and attitudes toward mathematics scales, the STAI, the Test Anxiety Inventory, and the background questionnaire. So that students would not be tested twice, introductory psychology students enrolled in one of the selected sections of Math 1 or Math 2 were eliminated from the study. Because Psychology 1 students were either not enrolled in a math course or were enrolled in different math courses, math course grades could not be obtained for this sample.

Data Analysis

Descriptive statistics for each of the anxiety and attitude scales administered were obtained for the three subject groups and for males and females and caucasian and black students within each group. Group differences in math anxiety were examined using one-way analyses of variance.

Pearson product-moment correlation coefficients were calculated to describe the degree of relationship between math anxiety and background variables, ACT scores, trait and test anxiety, other components of attitudes toward mathematics, and perceptions of the attitudes of others toward mathematics.

Finally, multiple regression analyses were utilized to assess the extent to which ACT English, ACT Math, Math Anxiety, and Effectance Motivation were predictive of final grades in Math 1 and Math 2.

Results

Results are presented in terms of the following five categories: 1) prevalence of math anxiety; 2) demographic and background correlates of math anxiety; 3) relationships with measures of ability and anxiety; 4) attitudinal correlates of math anxiety; and 5) math anxiety and performance.

Prevalence of Math Anxiety

Table 1 presents the means and standard deviations of scores on the Math Anxiety scale for each of the three subject groups and for males, females, and white and black students within each group. As shown in the table, students in Psychology 1 and Math 2 reported lower levels of math anxiety (means of 31.1 and 31.6, respectively, where higher scores indicate lower levels of math anxiety) than did the Math 1 group (M = 26.9). Analysis of variance of the three means indicated a significant effect for group ($p < .01$), and post-hoc contrasts indicated that the Psychology 1 and Math 2 means were both significantly greater

than was the Math 1 mean.

Insert Table 1 about here.

Females reported significantly higher levels of math anxiety than did males in two of the three subject groups. In the Psychology 1 group, the mean for females (29.1) differed significantly from that for males (33.5) at $p < .001$, while in the Math 1 group, the difference between the female (25.6) and male (28.9) means was significant at $p < .01$. No significant sex differences in math anxiety in the Math 2 group were found.

As shown in Table 1, levels of math anxiety did not differ significantly for white and black students within each subject group. Blacks reported somewhat higher levels of math anxiety than did whites in the Psychology 1 group, but reported slightly lower levels in the Math 1 and Math 2 groups.

In order to interpret scores on the math anxiety scale in terms of the general prevalence of math anxiety in college students, it is helpful to look at item response percentages. Table 2 indicates response percentages for items in the math anxiety scale in the three subject groups. For the positively-worded items (numbers 1 through 5), responses of disagree or strongly disagree indicate higher levels of math anxiety. For the negatively-worded items (numbers 6 through 10), responses of agree or strongly agree indicate higher levels of math anxiety.

Insert Table 2 about here.

It may be noted, first, that while the responses of Math 1 students (the middle percentage within each column of three) indicate consistently more math anxiety than do the responses of Psychology 1 (top percentage in each column) or Math 2 (bottom percentage) students, significant percentages of students within all three groups responded in ways suggesting the existence of math anxiety.

Disagreement with the positively-worded items was most apparent for item 5; 46%, 68%, and 59% of Psychology 1, Math 1, and Math 2 students respectively disagreed with the statement "I almost never get uptight during math tests." The other positive item related to math tests (#2), elicited disagreement percentages nearly as high as those for item 5. On other positively-stated items, 44% of Math 1 students indicated being bothered by the idea of taking more math courses (item 1) and 61% worried about their ability to solve math problems.

Responses to the negatively-worded items also suggested that a high proportion of college students may be "math anxious". Approximately half the Math 1 students and one-fourth the Psychology 1 and Math 2 students agreed with the statements "Mathematics makes me feel uncomfortable and nervous" (Item 9) and "Mathematics makes me feel uneasy and confused" (Item 10). Thirty-one percent of Math 1 students and 20% of Psychology 1 and Math 2 students agreed that "My mind goes blank and I am unable to think clearly when working

mathematics" (Item 8). Again, the expression of anxiety was most widespread in conjunction with math tests; 46%, 63%, and 53% of students in the Psychology 1, Math 1, and Math 2 groups, respectively, agreed with the statement "I get really uptight during math tests" (Item 6).

Demographic and Background Correlates of Math Anxiety

Table 3 presents Pearson product-moment correlations between math anxiety and five background variables: age, number of years high school math, mother's and father's educational levels, and mother's work involvement.

Insert Table 3 about here.

The ages of students studied ranged from 17 to 34 and within that range, older students in the Math 1 and Math 2 groups tended to report higher levels of math anxiety (as evidenced by negative correlations) than did younger students. Correlations of $r = -.29$ ($p < .01$) for Math 1 females and $r = -.17$ ($p < .05$) for Math 2 females are larger than those for males in the two groups and would appear to account for the overall significance of the relationship between math anxiety and age.

The strongest relationship between math anxiety and background variables was that found for number of years of high school math. Correlations between math anxiety and years of high school math were positive, of moderate magnitude ($r = .19$ to $r = .43$), and were statistically significant for males and females in all three subject groups. Thus, the more prior math preparation a college student has had, the less likely he/she is to report high levels of math anxiety.

No important relationships between math anxiety and mother's or father's educational levels were found, but in the Psychology 1 and Math 2 subject groups, significant positive relationships were found between math anxiety and degree of mother's work involvement. In the Psychology 1 group, lower levels of math anxiety were associated with greater work involvement of the mother for both males and females. In the Math 2 group, the correlation between math anxiety and mother's work involvement was statistically significant for females (r = .32, p <.001) but not for males (r = .00).

Relationships with Measures of Ability and Anxiety

Correlations between math anxiety and English and Math Achievement test scores are shown in Table 4. As shown in the table, level of math anxiety was not related to ACT English scores but was moderately related to ACT Math scores. Correlations between math anxiety and ACT Math scores ranged from r = .17 (Psychology 1 males) to r = .42 (Psychology 1 females), indicating that higher levels of math anxiety are related to lower math achievement test scores. The relationship between math anxiety and achievement appears strongest in the Math 2 group, where correlations were of moderate magnitude and statistically significant for both males (r = .39, p <.001) and females (r = .34, p <.001). In the Psychology 1 group, the relationship was significant for females (r = .42, p <.001) but not for males (r = .17, p <.10). Correlations in the Math 1 group ranged from r = .21 to r = .26 and were marginally significant.

Insert Table 4 about here.

Table 5 presents the Pearson product-moment correlations among scores on the Mathematics Anxiety Scale, the A-Trait Scale of the State-Trait Anxiety Inventory, and the total score, emotionality score, and worry score of the Test Anxiety Inventory. As shown in the table, higher levels of math anxiety (as indicated by lower scores on the math anxiety scale) were related to higher levels of trait anxiety ($r = -.28$), overall test anxiety ($r = -.42$), and emotionality ($r = -.38$) and worry ($r = -.43$) components of test anxiety. All of these correlations were statistically significant ($p < .001$) and indicate a moderate degree of association between math anxiety and other types of anxiety. Correlations computed separately for male and female students did not differ significantly from each other or from the total group correlations.

Insert Table 5 about here.

Attitudinal Correlates of Math Anxiety

Data concerning relationships between math anxiety and four other components of attitudes toward math are shown in Table 6. The table indicates, first, that scores on the Math Anxiety scale were most strongly related to scores on the Confidence in Learning Mathematics scale. Correlations ranged from $r = .73$ to $r = .84$ in the three subject groups and indicate that greater confidence in learning math is strongly related to students' reports of lower levels of math anxiety.

Insert Table 6 about here.

Math anxiety was also significantly and consistently related to the Usefulness of Mathematics and Effectance Motivation scales. Lower levels of math anxiety were associated with more positive views of the usefulness of math (r = .37 to r = .57) and with higher levels of effectance motivation (r = .40 to r = .71). Level of math anxiety was not related to scores on the Math as a Male Domain scale; a statistically significant correlation between the two scales in the Math 2 group (r = .12, p <.01) was not of sufficient magnitude to suggest the existence of a practically important relationship. Correlations computed separately for males and females were of similar magnitude.

Table 7 presents data concerning the relationship of math anxiety to students' perceptions of the attitudes of their mothers, fathers, and teachers toward math. As shown in the table, more positive attitudes toward math among significant others are generally related to lower levels of reported math anxiety in college students. Statistically significant positive relationships between math anxiety and mother's attitudes toward math were found in the Psychology 1 and Math 2 subject groups and for females in the Math 1 group. Relationships between math anxiety and father's attitude were positive and statistically significant for all Math 2 subjects, females in Psychology 1, and males in Math 1. Strong positive relationships between math anxiety and perceptions of teachers' attitudes toward math were found for both sexes in all subject groups. The correlations between math anxiety and teachers' attitudes were somewhat higher (ranging from r = .30 to r = .54) than were those between math anxiety and mother's attitudes (r = -.01 to r = .30) or between math anxiety and father's attitudes (r = .04 to

r = .32). The relationships between math anxiety and perceptions of the attitudes of others were strongest in the Math 2 group, where all correlations were statistically significant and of moderate magnitude (r = .20 to r = .52).

Insert Table 7 about here.

Math Anxiety and Performance

Results of the multiple regression analysis for the prediction of grades in the math course being taken at the time the study was conducted are presented in Table 8. Independent variables used in the analysis were ACT English score, ACT Math score, score on the Math Anxiety scale, and score on the Effectance Motivation scale. Analyses were done separately for males and females in the Math 2 group, but due to the smaller size of the Math 1 sample (n = 61), the sexes were combined for the Math 1 analysis.

Insert Table 8 about here.

In the Math 1 group, only ACT Math score was a statistically significant predictor of math course grade. After ACT Math score, the next strongest predictor of course grade was the Math Anxiety score; while its beta weight was only marginally statistically significant (p <.10), lower levels of math anxiety were somewhat predictive of higher math course grades.

Among Math 2 students, the predictive power of the independent variables differed substantially for males and females. For males,

no predictors received significant beta weights and the value of the multiple correlation coefficient was non-significant ($R = .18$). For females, however, ACT Math score received a significant beta weight ($p < .05$) and Math Anxiety, again the next strongest predictor, received a marginally significant beta weight ($p < .10$). For females, lower levels of math anxiety were related to higher course grades (as evidenced by a positive beta weight and a correlation of $r = .27$ between course grade and math anxiety).

Discussion

The results of the present study indicated that math anxiety occurs relatively frequently among college students in general, but that average levels of math anxiety do differ within subgroups of individuals.

Examination of response percentages for each of the 10 items on the Math Anxiety scale suggested that math anxiety is a problem for a large proportion of college students and that it may be problematic even for those students who plan majors and/or careers requiring extensive math background. Approximately half the Math 1 students and one-fourth the Psychology 1 and Math 2 students indicated that math made them feel "uncomfortable, nervous, uneasy, and confused." Agreement with the statement "My mind goes blank and I am unable to think clearly when working mathematics" was expressed by 31% of Math 1 students and 20% of Psychology 1 and Math 2 students. Expressions of anxiety were most common when the items concerned math tests; about half the students in all three groups reported getting "really uptight" during math tests.

As indicated by the item response percentages and higher levels of math anxiety of students in the Math 1 group, college students enrolled in courses designed for people with inadequate high school math background or relatively low placement and achievement test scores are the most anxious in comparison to the other groups studied; probably half of these students can be considered to have math anxiety. Additionally, however, about 1 out of 4 students in the other two subject groups indicated the presence of math anxiety. This prevalence is particularly surprising in a group of students enrolled in a relatively advanced math class; the Math 2 students tend to have had more math in high school and have achieved higher scores on math achievement tests than have most students entering Ohio State University. Further, these students will need to take considerable additional mathematics in order to achieve their educational and vocational goals.

Sex differences on the Math Anxiety scale varied according to subject sample. In the Psychology 1 and Math 1 groups, women reported significantly higher levels of math anxiety than did men. In the Math 2 group, however, women and men reported equivalent levels of math anxiety. Findings of greater math anxiety among women than men correspond to those of Fennema & Sherman (1977), who found that high school boys generally reported significantly more positive attitudes toward mathematics, including greater confidence in their ability to learn math, than did high school girls.

The absence of sex differences in the Math 2 group may be due to the nature of the sample. Women in this group have had considerable high school math background, have scored relatively well on math

achievement tests, and, in general, view math positively enough to consider majors and careers in mathematical and scientific areas. While these characteristics do not lead to an absence of math anxiety (as indicated by item response percentages), they do appear to result in a group of women who are not more math anxious than their male classmates.

Results did not indicate significant race differences in math anxiety. Greater math anxiety was reported by blacks than by whites in the Psychology 1 group, but levels of math anxiety were higher for whites than blacks in the Math 1 and Math 2 groups; none of these differences were, however, large enough to be statistically significant. In addition, these results should be interpreted cautiously because of the small numbers of black students sampled; there were only 23, 12, and 17 blacks in the Psychology 1, Math 1, and Math 2 groups, respectively.

Results concerning the relationship between math anxiety and demographic and background data indicated a strong relationship of math anxiety with number of years high school math. This relationship, consistent across sexes and subject groups, suggests that high school math preparation strongly influences how a college student will feel about math. Statistically significant correlations ranging from $\underline{r} = .19$ to $\underline{r} = .43$ between math anxiety and number of years of high school math are similar in magnitude to that found by Hendel (Note 1) in a sample of adult women enrolled in a math anxiety treatment program; Hendel found a correlation of $\underline{r} = -.31$ between scores on the Math Anxiety Rating Scale (MARS) and number of semesters high school math.

In two subject groups (Math 1 and Math 2), older women reported higher levels of math anxiety than did younger women. The younger students in these samples were the "typical" college undergraduates who enter college immediately following high school graduation. For the older, "non-traditional" women students, more time has passed since they took high school mathematics; thus, it would not be surprising if they felt more anxious about math than do the younger women.

While no relationships were found between math anxiety and parents' educational level, significant relationships between math anxiety and the extent to which the mother worked outside the home were found in both the Psychology 1 and Math 2 groups; greater work involvement of the mother was related to lower levels of reported math anxiety. In the Math 2 groups, the correlation between math anxiety and mother's work involvement was significantly greater for females (r = .32) than for males (r = .00). While there are likely several explanations for this finding, it is possible that working mothers themselves have and/or convey to their children more positive attitudes toward math than do non-working mothers.

Math anxiety was found to be moderately related to mathematics achievement test scores (ACT Math subtest). Correlations ranged from r = .17 to r = .42, and were in general statistically significant. Thus, higher achievement in math is related to lower reported levels of math anxiety. These results are in agreement with previous research investigating the relationship between math anxiety and math achievement; for example, Sherman & Fennema (1977) found that high school students in the upper half of the achievement distribution reported

more positive attitudes toward math than did students in the lower half.

Math anxiety was also moderately related to both trait anxiety and test anxiety. The correlation with test anxiety (r = -.42) was somewhat larger than that with trait anxiety (r = -.28), but this difference was not large enough to be statistically significant. In Hendel's study (Note 1), a correlation of .65 between math anxiety and test anxiety was found. Hendel's conclusion that anxiety about evaluation is one component of math anxiety is supported by the present data and, in addition, the present data suggest that people who tend to be anxious in a variety of situations (trait anxiety) are also more likely to report math anxiety.

Results concerning the relationships between math anxiety and other components of attitudes toward math indicated, first, that degree of math anxiety is highly related to confidence in one's ability to learn and perform math. Correlations ranged from r = .73 to r = .84 in the three subject groups and were similar in magnitude to the correlation of .89 between the Math Anxiety and Confidence in Learning Mathematics scales found by Fennema & Sherman (1976) in their sample of high school students.

Math anxiety was also found to be moderately related to the Usefulness of Mathematics and Effectance Motivation scales; lower levels of math anxiety were associated with more positive views of the usefulness of mathematics and with higher levels of effectance motivation in math. Level of math anxiety was not highly related to tendency to stereotype math as a male domain, and correlations computed separately for males and females were of similar magnitude. While views of math

as a male domain would appear to bear a logical relationship to math anxiety in women, assessment of this attitude using a relatively transparent instrument did not reveal a statistical relationship. However, sex-role socialization is probably one of the major factors related to the fact that girls take fewer math courses in high school than do boys (Ernest, 1976), and the present study does suggest that high school math background is an important factor in the occurrence of math anxiety in college students.

Moderately strong positive relationships were found between a student's level of math anxiety and his/her perception of the attitudes of his/her mother, father, and teachers toward mathematics. Correlations between math anxiety and teachers' attitudes were consistently statistically significant and of substantial magnitude, ranging from $\underline{r} = .39$ to $\underline{r} = .54$. While the retrospective nature of the Mother, Father, and Teachers scales makes it difficult to draw any causal conclusions, it does seem reasonable that the attitudes of parents and, especially, teachers toward math would be influential in shaping children's attitudes toward and feelings about mathematics.

Score on the ACT Mathematics subtest was the only significant predictor of math course grades; higher ACT Math scores were predictive of better performance in math courses. However, in the Math 1 group and for females in the Math 2 group, level of math anxiety was the next strongest predictor, with lower levels of math anxiety predictive of higher course grades. While these results and those of Hendel (Note 1) do not lend themselves to an interpretation of math anxiety as a powerful predictor of math performance, the difference between Math 2 males

and females in the predictive power of math anxiety could have interesting implications, especially if replicated. While the males in Math 2 were as "math anxious" as were the females, their math anxiety was not related to their course grade. Thus, math anxiety may interfere more with the performance of women than men, and, if so, its treatment may be particularly useful in improving the performance of women.

In conclusion, the relatively high prevalence of math anxiety across the three groups of college students utilized in the present study strongly suggests the need for math anxiety treatment programs in colleges and universities. Math anxious students are probably found at all levels of math background and achievement, but students whose prior math background and achievement are inadequate appear particularly prone to math anxiety. Returning students, especially women, are another group who would appear to benefit from treatment of math anxiety.

Moderately strong relationships between math anxiety and test and trait anxiety suggest the incorporation of basic anxiety management techniques into math anxiety treatment programs; methods for treating test anxiety may be particularly appropriate.

While encouraging high school students to take more math courses would probably reduce the prevalence of math anxiety in college students, there is now and will continue to be a need for programs which can alleviate math anxiety and increase participation and achievement in mathematics.

Reference Notes

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Footnotes

[1]Copies of the revised scales measuring attitudes toward mathematics and perceptions of the attitudes of mothers, fathers, and teachers toward mathematics may be obtained from Nancy E. Betz, Department of Psychology, Ohio State University, 1945 North High Street, Columbus, Ohio 43210.

Table 1

Group, Sex, and Race Differences in Math Anxiety in College Students

	Subject Group											
	Psychology 1				Math 1				Math 2			
	N	M	SD	F	N	M	SD	F	N	M	SD	F
Total Group	182	31.1	9.0		125	26.9	7.6		348	31.6	8.7	
Sex				13.0**				5.6*				1.6
Male	81	33.5	8.2		50	28.9	7.3		188	31.1	8.0	
Female	101	29.1	9.1		72	25.6	7.5		160	32.3	9.5	
Race				1.7				1.5				.20
White	153	31.4	8.6		105	26.6	7.7		324	31.5	8.7	
Black	23	28.7	11.4		12	29.4	6.9		17	32.5	9.1	

Note. Means were obtained from a 10-item Math Anxiety scale. Scores may range from 10 to 50; higher scores indicate more positive attitudes toward mathematics, i.e., lower levels of math anxiety.

*p <.01
**p <.001

Table 2

Response Percentages for Items in the Math Anxiety Scale

Item	Response Categories[1] SA or A %	U %	D or SD %
1. It wouldn't bother me at all to take more math courses.	39	26	35
	37	19	44
	49	22	29
2. I have usually been at ease during math tests.	41	19	40
	33	12	55
	40	14	46
3. I have usually been at ease in math courses.	56	17	27
	48	14	38
	63	14	23
4. I usually don't worry about my ability to solve math problems.	48	17	35
	24	15	61
	45	15	40
5. I almost never get uptight while taking math tests.	35	19	46
	25	7	68
	29	12	59
6. I get really uptight during math tests.	46	13	41
	63	8	29
	53	14	33
7. I get a sinking feeling when I think of trying hard math problems.	35	23	42
	58	20	22
	35	21	44
8. My mind goes blank and I am unable to think clearly when working mathematics.	20	19	61
	31	15	54
	20	14	66
9. Mathematics makes me feel uncomfortable and nervous.	27	19	54
	51	12	37
	22	15	63
10. Mathematics makes me feel uneasy and confused.	28	16	56
	45	18	37
	23	16	61

Note. Under each response category, the top, middle and bottom percentages were obtained in the Psychology 1 (N=182), Math 1 (N=122), and Math 2 (N=348) subject groups, respectively.

[1]Response categories are as follows: 1) SA or A is Strongly Agree or Agree; 2) U is Undecided; 3) D or SD is Disagree or Strongly Disagree.

Table 3

Relationships Between Math Anxiety and Demographic and Background Variables in Three Subject Groups

Variable	Psychology 1 N	Psychology 1 r	Math 1 N	Math 1 r	Math 2 N	Math 2 r
Age						
Total Group	182	.11	122	-.20**	348	-.13**
Males	81	.01	50	-.10	188	-.10
Females	101	.13	72	-.29**	160	-.17*
Number of Years High School Math						
Total Group	182	.42***	122	.35***	348	.27***
Males	81	.19*	50	.35**	188	.34***
Females	101	.43***	72	.30**	162	.24**
Mother's Educational Level						
Total Group	181	.05	120	.02	348	.00
Males	80	-.09	50	-.08	188	.04
Females	101	.15	70	.10	162	-.05
Father's Educational Level						
Total Group	181	.01	120	-.13	348	.09*
Males	80	-.08	50	-.08	188	.07
Females	101	.04	70	-.10	162	.10
Mother's Work Involvement[1]						
Total Group	181	.20**	120	-.02	348	.16***
Males	80	.30**	50	-.21	188	.00
Females	101	.17*	70	.10	162	.32***

[1]Mother's work involvement was assessed on a 5-point scale where 1 = Did not work outside the home, 2 = worked part time fewer than 10 years, 3 = worked part time 10 or more years, 4 = worked full-time for less than 10 years, and 5 = worked full-time for 10 or more years.

*p .05
**p <.01
***p <.001

Table 4

Relationships Between Math Anxiety and

English and Mathematics Achievement Test Scores

in Three Groups of College Students

	Psychology 1		Math 1		Math 2	
	N	r	N	r	N	r
ACT Verbal Score						
Total Group	120	.10	84	-.02	269	.04
Males	47	.10	32	-.18	153	.05
Females	73	.07	52	.00	116	-.01
ACT Math Score						
Total Group	120	.40***	84	.22*	269	.34***
Males	47	.17	32	.26	153	.38***
Females	73	.42***	52	.21	116	.34***

*p <.05

***p <.001

Table 5

Relationships Among Math Anxiety, Trait Anxiety,

and Test Anxiety in College Students

Scale	Trait Anxiety	Test Anxiety		
		Total	Emotionality	Worry
	r	r	r	r
Math Anxiety	-.28	-.42	-.38	-.43
Trait Anxiety (STAI-Trait)		.42	.38	.46
Test Anxiety (TAI)				
Total Score			.95	.93
Emotionality				.79
Worry				

Note. All correlations are based on n = 182 and are statistically significant at p <.001.

Table 6

Relationships Between Math Anxiety and Four Components of Attitudes Toward Math in Three Subject Groups

Attitude Scale	Subject Group: Psychology 1 N	r	Math 1 N	r	Math 2 N	r
Confidence in Learning Math	180	.82**	125	.73**	354	.84**
Math as a Male Domain[1]	180	.11	125	.13	354	.12*
Usefulness of Math	180	.57**	125	.37**	354	.39**
Effectance Motivation	180	.71**	125	.40**	354	.56**

Note. Higher math anxiety scores indicate lower levels of math anxiety.

[1]Higher scores indicate less tendency to view math as a male domain.

*p <.01
**p <.001

Table 7

Relationships Between Math Anxiety and Perceived Attitudes of Parents and Teachers Toward Mathematics

Variable	Subject Group: Psychology 1 N	r[1]	Math 1 N	r[2]	Math 2 N	r[3]
Mother's Attitude						
Total Group	182	.29***	121	.14	342	.27***
Males	81	.23*	49	-.01	182	.25***
Females	101	.29***	72	.21*	160	.30***
Father's Attitude						
Total Group	182	.22**	121	.16*	342	.24***
Males	81	.04	49	.32**	182	.29***
Females	101	.25**	72	.06	160	.20**
Teachers' Attitude						
Total Group	182	.48***	122	.44***	342	.48***
Males	81	.54***	50	.51***	182	.43***
Females	101	.48***	72	.39***	160	.52***

Note. Higher scores on math anxiety indicate more positive attitudes toward math, i.e., lower levels of anxiety about math.

*p <.05
**p <.01
***p <.001

Table 8

Correlations and Regression Equations for Predicting

Grades in Current Math Course

Variable	Intercorrelations 1	2	3	4	5
Math 1 (n = 61)					
1. Grade in Current Math Course		.04	.45	.34	.22
2. ACT - English			.11	-.35	-.39
3. ACT - Math				.17	.31
4. Math Anxiety					.56
5. Effectance Motivation					

Raw Y = $-5.14 + .28X_2 + 1.01X_3 + .46X_4 - .07X_5$

Standardized Y = $.08X_2 + .40X_3 + .33X_4 - .05X_5$

R = .53

Math 2 (Males, n = 131)

1. Grade in Current Math Course		.03	.14	-.02	.05
2. ACT - English			.30	.03	-.15
3. ACT - Math				.37	.14
4. Math Anxiety					.48
5. Effectance Motivation					

Raw Y = $19.0 - .01X_2 + .46X_3 - .19X_4 + .15X_5$

Standardized Y = $.18X_3 - .13X_4 + .08X_5$

R = .18

Math 2 (Females, n = 106)

1. Grade in Current Math Course		.11	.32	.27	.18
2. ACT - English			.40	.02	-.19
3. ACT - Math				.37	.13
4. Math Anxiety					.60
5. Effectance Motivation					

Raw Y = $7.2 + .06X_2 + .51X_3 + .17X_4 + .08X_5$

Standardized Y = $.02X_2 + .25X_3 + .15X_4 + .06X_5$

R = .36

Appendix A

Mathematics Anxiety Scale

	Weight	Item	Means Psychology Math 1[a]	Math 1[b]	Math 2[c]
1.	+	It wouldn't bother me at all to take more math courses.	3.0	2.9	3.3
2.	+	I have usually been at ease during math tests.	3.0	2.6	2.9
3.	+	I have usually been at ease in math classes.	3.3	3.1	3.5
4.	+	I usually don't worry about my ability to solve math problems.*	3.2	2.6	3.1
5.	+	I almost never get uptight while taking math tests.*	2.8	2.3	2.6
6.	-	I get really uptight during math tests.*	3.1	3.7	3.3
7.	-	I get a sinking feeling when I think of trying hard math problems.	3.0	3.6	2.9
8.	-	My mind goes blank and I am unable to think clearly when working mathematics.	2.5	2.7	2.4
9.	-	Mathematics makes me feel uncomfortable and nervous.	2.7	3.2	2.4
10.	-	Mathematics makes me feel uneasy and confused.	2.7	3.2	2.5

Note. Responses were coded on a five-point scale where 1 = Strongly Disagree, 2 = Disagree, 3 = Undecided, 4 = Agree, 5 = Strongly Agree.

[a] $\underline{n}$ = 182
[b] $\underline{n}$ = 125
[c] $\underline{n}$ = 348

*Indicate items revised from those on the original Fennema-Sherman Scales.

Appendix B

Items and Instructions for the Test Anxiety Inventory

Directions: Read each of the following statements carefully and then circle the appropriate space on your answer sheet to indicate how you generally feel regarding tests. There are no right or wrong answers. Do not spend too much time on any one statement, but give the answer which seems to describe how you generally feel with regard to tests and examinations.

			Almost Never	Sometimes	Often	Almost Always
	1.	I feel confident and relaxed while taking tests.	1	2	3	4
E	2.	While taking final examinations I have an uneasy, upset feeling.	1	2	3	4
W	3.	Thinking about the grade I may get in a course interferes with my work on tests.	1	2	3	4
W	4.	I freeze up on final exams.	1	2	3	4
W	5.	During exams I find myself thinking about whether I'll ever get through college.	1	2	3	4
W	6.	The harder I work at taking a test, the more confused I get.	1	2	3	4
W	7.	Thoughts of doing poorly interfere with my concentration on tests.	1	2	3	4
E	8.	I feel very jittery when taking an important test.	1	2	3	4
E	9.	Even when I'm well prepared for a test, I feel very anxious about it.	1	2	3	4
E	10.	I start feeling very uneasy just before getting a test paper back.	1	2	3	4
E	11.	During tests I feel very tense.	1	2	3	4
	12.	I wish examinations did not bother me so much.	1	2	3	4
	13.	During important tests I am so tense that my stomach gets upset.	1	2	3	4
W	14.	I seem to defeat myself while working on important tests.	1	2	3	4
E	15.	I feel very panicky when I take an important test.	1	2	3	4
E	16.	If I were to take an important examination, I would worry a great deal before taking it.	1	2	3	4
W	17.	During tests I find myself thinking about the consequences of failing.	1	2	3	4
E	18.	I feel my heart beating very fast during important tests.	1	2	3	4
	19.	As soon as an exam is over I try to stop worrying about it, but I just can't.	1	2	3	4
W	20.	During a course examination I get so nervous that I forget facts I really know.	1	2	3	4

E = Emotionality Item
W = Worry Item