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Math Anxiety, Coping Behavior, and Gender

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ABSTRACT

An abstract of the thesis of Sandra Joy Grossmann for the Master of Science in Psychology, presented June 13, 1994.

Title: Math Anxiety, Coping Behavior, and Gender.

Non-math majors enrolled in lower-division math courses at an urban university were surveyed on their math attitudes, coping behaviors, and math anxiety (MATHANX). The Revised Ways of Coping Checklist (RWCC), Revised Math Anxiety Rating Scale, and other questions were presented to 30 men and 32 women.

Hierarchical regressions showed that after controlling for attitudinal covariates, emotion-focused coping behaviors (EMOTFOC) were strongly associated with MATHANX ($F(5,54)=18.66$, $p < .0001$), but problem-focused coping behaviors (PROBFOC) were not. The RWCC subscale most highly correlated with MATHANX was Wishful Thinking ($r = .70$, $p < .0001$). Ss were then dichotomized on PROBFOC and EMOTFOC , providing four behavioral groups. An ANCOVA controlling for attitudinal covariates showed behavioral group membership significant with respect to MATHANX ($F(3,58)=6.07$, $p < .001$), and an ANOVA revealed that students who reported high EMOTFOC coupled with low PROBFOC experienced the greatest MATHANX ($F(3,58) = 12.66$, $p < .0001$).

Males and females reported virtually identical MATHANX (M=36.30 for males, 36.44 for females), and the only significant gender difference was for avoidance coping, which was used more by males ($\underline{F}(1,60) = 5.43$, $\underline{p} < .03$]. Results from this study suggest that fewer gender differences may exist in MATHANX and coping than have been found in the past. Additionally, this study identifies the need for future research to determine whether EMOTFOC is the behavioral component, or one of the determinants, of math anxiety.

MATH ANXIETY,
COPING BEHAVIOR,
AND GENDER

by

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TABLE OF CONTENTS

LIST OF TABLES

MATH ANXIETY, COPING BEHAVIOR, AND GENDER

Math anxiety and its usual consequence, math avoidance, are not simply private concerns for an individual student. Individually, math-anxious students steer clear of math and science courses (Chipman, Krantz, & Silver, 1992). Collectively, college students who are high in math anxiety are deliberate and assiduous at choosing majors that require the fewest number of math and science courses, consequently reducing their career options (Betz, 1978; Hendel & Davis, 1978; Hembree, 1990). This deliberate math avoidance may have a profound effect not only on students but also on the society in which they live.

Mathematician John Allen Paulos holds that the consequences of being uncomfortable with math are widespread. Stock scams, diet and medical claims, astrology, and lotteries are real-world examples which rely upon the public's ignorance of math and statistics (Paulos, 1988). Secretary of Labor Robert Reich stresses that the United State's economic success depends upon its global competitiveness in math and science-dependent technologies (Reich, 1992). Yet only 15-17 percent of U.S. college students graduate in science and engineering compared to 40 percent in Germany and Japan (Thurow, 1993, p. 276), an indicator of limited economic potential for the United States. Clearly, math anxiety and avoidance have serious consequences for the nation.

Although at a casual glance it would seem likely that math anxiety would be confined to low achievers in math, closer inspection shows this to be incorrect. A recent study of Barnard College students, for example, revealed that math anxiety mediated their career choices (Chipman, Krantz, & Silver, 1992). Barnard College has extremely competitive entrance requirements, and its student body is composed of high achievers. Ninety-five percent of Barnard College students were in the top quarter of their high-school class (Peterson's Guides, 1993), and 96% of the students scored over 500 on the math portion of the SAT. If math anxiety is not dependent on low achievement, what determines its occurrence?

While the question is straightforward, the answer is not. Although math anxiety has been studied for more than two decades, the lack of longitudinal studies prevents a thorough understanding of how it develops in individuals. Instead, researchers have taken a pragmatic approach toward the construct, defining math anxiety operationally according to its symptoms.

The main symptoms of math anxiety are a fear or dread of math courses, math symbols and language, math abstraction, math tests, math evaluation, and math homework (see Brush, 1978; Ferguson, 1985; Richardson & Suinn, 1972; Rounds & Hendel, 1980). Rounds and Hendel (1980) suggest that math anxiety can occur whenever "future career and educational goals in part depend on success in mathematics courses for which an individual feels inadequately prepared and insufficiently experienced" (p. 146).

Unfortunately, recent data suggest that insufficient preparation and experience are the norm for American students; the Educational Testing Service reports that 13-year-olds in the United States rank thirteenth out of 15 countries in math and science performance (Beardsley, 1992). Further evidence of poor preparation for math comes from the Carnegie Commission on Science, Technology and Government, which reports that 47% of America's 17-year-olds do not even know how to convert nine parts out of 100 to a percentage (Beardsley, 1992). It is not unreasonable to assume that ill-prepared students would experience higher levels of math anxiety than well-prepared students. Thus, the math deficiencies reported by such agencies as the National Commission on Excellence in Education (Gardner, et al., 1983) may hint at a wide-spread prevalence of math anxiety.

Little is known about the behaviors and coping strategies individuals employ to deal with their math anxiety. Some researchers have bypassed the investigation of math-anxious coping and have created intervention programs designed to improve math performance by reducing math anxiety (e.g., Hendel & Davis, 1978). Some of the least effective programs concentrated exclusively on physiological responses (see Hembree, 1990). In contrast, the most successful programs used broad-based interventions including cognitive-behavioral modification and restructuring (Hembree, 1988). It is possible that one of the "side effects" of the successful programs was to provide participants with alternative, problem-focused coping strategies. So far, though, no study has directly investigated the connections between math anxiety and coping.

This research proposal intends to study the relationships between math anxiety in current-term math students, the coping behaviors those students use when faced with math challenges, and gender differences in both math anxiety and coping behaviors. Included in this proposal are reviews of the literatures on math anxiety, test anxiety, and coping. Test anxiety is included because it is an essential component of the math anxiety construct.

TEST ANXIETY

Defining test anxiety

The Spielberger definition of test anxiety. Some researchers in test anxiety have adapted Spielberger's (1972) concept of general anxiety. According to Spielberger, anxiety is composed of state anxiety and trait anxiety. State anxiety is situation-specific, whereas trait anxiety refers to an individual's enduring dispositional characteristic to perceive situations as threatening.

Research has verified that high levels of state anxiety cause performance deficiencies (Malouff et al., 1992). Additional findings indicate that a high level of state anxiety restricts a student's ability to concentrate (Wine, 1971) and results in exaggerated startle responses

(Britt & Blumenthal, 1992), indicating that state anxiety involves both the cerebral cortex and the peripheral nervous system.

Trait-anxiety research shows that students with high levels of trait anxiety are more distractible than low trait-anxious students (Eysenck & Byrne, 1992). Additionally, trait anxiety is also associated with defensiveness and worry in test-takers (Eysenck & Berkum, 1992).

The trait-state model is advantageous in its orientation toward identifying an individual's base rate of anxiety (trait) and observing how that base rate changes in response to challenges from the environment (state). A major disadvantage of the model, though, is that subjects with high trait anxiety also tend to have high state anxiety, so the two measures may be confounded (Eysenck, 1982, as elaborated in MacLeod & Donnellan, 1993). Another disadvantage of the model is its inability to distinguish qualitative characteristics of anxiety: Only the level of arousal counts, not the relationship of the individual's cognitive, emotional, and behavioral responses to the environmental challenge.

<u>The Liebert and Morris model of test anxiety</u>. Test anxiety can be viewed entirely differently from the state-trait perspective. Liebert and Morris (1967) propose instead that test anxiety consists of two elements, worry and emotionality. Worry is the conscious, cognitive component, while emotionality encompasses somatic and behavioral responses.

Worry can either contribute to or hinder performance. Some students seem to use worry as a strategy for motivating themselves

(Showers & Ruben, 1990). Consider, for example, the profile of the defensive-pessimist student. Defensive pessimists can be characterized as worriers who engage in considerable preparation, report high levels of anxiety, and under-report their expected grade (Showers & Ruben, 1990). As defined by Showers and Ruben, defensive pessimists "set low expectations for an upcoming event even though they... have done well...in the past" (Showers & Ruben, 1990, p. 387). The authors add that "defensive pessimists do not seem to suffer performance deficits as a result of their negative approach" (p. 387). For defensive pessimists, then, worry may represent a strategic, motivating tool.

For other students, worry is detrimental and interferes with learning. Krohne and Hock (1993) investigated the effect of worry and emotionality on incidental learning. High levels of worry during the recognition phase of an anagram task resulted in a high false-alarm rate (Krohne & Hock, 1993), indicating a low discrimination criterion. If one considers the implications of this research, it seems possible that students with high levels of worry-based test anxiety may be more likely to identify incorrect solutions to multiple-choice questions.

Returning to the Liebert & Morris' (1967) test anxiety model, the other component is emotionality. The significance of emotionality in test anxiety is somewhat harder to interpret. In their study, Liebert and Morris (1967) found that emotionality was unlike worry in that it had no significant relation to grade expectancy. Emotionality does not seem to have much effect on performance, either, unless it reaches a high enough level to be distracting (Kellaway & Smith, 1978). Researchers have, however, found significant associations between worry and emotionality. Krohne and Hock (1993) report that worry and emotionality were significantly correlated (r = 55, p < .01) during an anagram-solving experiment. Similarly, Morris et al. (1978) report that worry and emotionality were highly correlated for psychology students taking a math class, r = .71, and were also significantly correlated for math majors, r = .31, with significance defined at the p < .05 level.

An implication of the Morris et al. (1978) finding is that the content of a test may affect the distribution of the worry and emotionality subscales. It seems likely that a longitudinal study would reveal changes in the composition of an individual's test anxiety. In terms of both subject material and test experience, an individual might show considerable variance in worry and emotionality.

An advantage of the Liebert and Morris (1967) model of test anxiety is its separation of cognitive and behavioral responses to the threat of a test. Its major disadvantage is that it provides no explication of the relation between those responses.

Test anxiety and performance

Numerous studies have documented lower performance levels for highly test-anxious students compared to students without high levels of test anxiety (Cooper & Robinson, 1989; Hunsley, 1987; Bruch, 1981; Sarason & Mandler, 1952, as cited in Hembree, 1990). Although the relationship between test anxiety and degraded performance had been known for more than four decades, a puzzle of causality surrounded the debate.

Two opposing explanations emerged: 1) the deficit model; and 2) the information-processing or interference model (Hembree, 1988, 1990). The deficit model holds that test anxiety is a natural consequence of limited ability or inferior skills (Bailey & Hailey, 1983; Calvo et al, 1992; Gross, 1990). In contrast, the interference model regards anxiety as competing with problem-solving for the scarce resource of working memory (Cooper & Robinson, 1989; Deffenbacher & Hazaleus, 1985; Eysenck & Byrne, 1991; MacLeod & Donnellan, 1993; Wine, 1971). Wine (1971) proposed that test-anxious students are preoccupied with worry and self-criticism. Such preoccupations consume time and concentration that could otherwise be spent on problem-solving. Eysenck and Byrne (1992), studying the relationship between anxiety and concentration, discovered that highly anxious subjects are more susceptible to distraction and consequently less able to concentrate on a single task.

Regardless of whether one applies the Spielberger model of test anxiety or the Liebert and Morris model, it is clear that test anxiety degrades performance. One would expect, then, to be able to improve students' performance by decreasing their test anxiety. Yet many test-anxiety treatment programs have only decreased test anxiety and have had no effect on students' test performance (Tryon, 1980).

Apparently, treatment programs that focus exclusively on relieving the autonomic, emotionality aspect of test anxiety are ineffective at improving performance (Tryon, 1980). In contrast, intervention programs which include both cognitive and behavioral treatments are consistently associated with performance improvements as well as anxiety reduction (Tryon, 1980; Hembree, 1988).

Hembree (1988), in a meta-analytic review of the causes and treatments of test anxiety, suggests a possible relationship between the worry and emotionality components of test anxiety that might explain why broad-based treatment programs are most effective:

> If there is cause-effect between the two components [worry and emotionality], test anxiety would appear to be essentially unidimensional. Cause and effect may be examined in terms of treatment results on test-anxiety reduction. The purely cognitive treatment, group counseling, did not seem effective in test-anxiety reduction. The purely behavioral treatments were considerably more effective. Moreover, these treatments reduced not only emotionality; they generalized to reduce the worry component. These findings suggest that emotionality triggers worry. Thus, test anxiety seems to be a behavioral construct (Hembree, 1988, p. 74).

Another pertinent finding is that the effective treatment of test anxiety is long-lasting (Hembree, 1988). Benefits from at least one short-term intervention have lasted for more than a year (Hembree, 1988). It is interesting to speculate that successful treatment programs provide students with more effective coping behaviors that are self-reinforcing due to their positive outcomes.

The next section explores the relationship of test anxiety to math anxiety. Also, the section contains discussions about math anxiety, math performance, and gender differences in math anxiety.

MATH ANXIETY

Overview

Mathemaphobia was a term used in the 1950's to describe "a syndrome of emotional reactions to arithmetic and mathematics" (Dreger & Aiken, 1957, as cited by Morris et al., 1978). By 1972, the term mathemaphobia was already out of vogue, with researchers instead using the label math anxiety to refer to "anxiety as stimulated by mathematics cues" (Suinn et al., 1972) or "feelings of anxiety, dread, nervousness and associated bodily symptoms related to doing mathematics" (Fennema & Sherman, 1976, as cited by Rounds & Hendel, 1980). Another description of math anxiety is "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). Rounds and Hendel argue, though, that mathematics anxiety is linguistically ambiguous (Rounds & Hendel, 1980). They report that "mathematics anxiety is less a response to mathematics than a response to evaluation of mathematics skills" (Rounds & Hendel, 1980).

Significantly, the definitions of math anxiety do not usually include descriptions of cognitive or behavioral responses. Although the label mathemaphobia alludes to avoidant behavior, the label math anxiety refers only to emotional and physiological responses. However, at least one researcher has examined math-anxious students' use of internal dialogue during a test as well as the roles of appraisal and attribution (Hunsley, 1987). Hopefully, future definitions of math anxiety will include cognitive and behavioral components. It seems, though, that most math-anxiety research has not waited for a complete definition of the label and has instead explored the ties between math anxiety, test anxiety, math performance, and gender.

Math anxiety and test anxiety

A persistent question is if math anxiety is a separate construct or whether it could be subsumed under the larger construct of test anxiety (Dew et al, 1983; Hembree, 1990). It seemed likely, for example, that at least part of math anxiety stemmed from anxiety about negative evaluation. If math anxiety were simply a subject-specific form of test anxiety, an adequate assessment of a student's math anxiety could be made by using a test-anxiety instrument.

The 1970's were a period of scale development for both test and math anxiety instruments. The constructs were operationalized and the scales refined, resulting in instruments such as the Mathematics Anxiety Ratings Scale (Suinn, 1972) and the Test Anxiety Inventory (Spielberger, 1977). Researchers in the 1980's and 1990's administered both types of scales to explore the relationships between math anxiety and test anxiety.

One investigation showed that several math anxiety scales shared 37.2% - 62.4% variance with each other but only 11.6% - 36% common variance with a test anxiety scale (Dew et al, 1983). In another meta-analytic study, the mean correlation between math anxiety scores and test anxiety scores was .52 (Hembree, 1990). When Hembree corrected for attenuation, the correlation increased to .61, but the corresponding coefficient of determination was only .37. That left 63% of variance unexplained if math anxiety were truly a subscale of test anxiety. Both Dew et al. (1983) and Hembree (1990) concluded that math anxiety was not subsumed by test anxiety.

Math anxiety and math performance

Consistent with the findings of test anxiety correlating with compromised performance is the specific relationship between math anxiety and math performance. Higher levels of math anxiety correlate with lower levels of math performance (Betz, 1978; Hembree, 1990; Morris et al., 1978; Wigfield & Meece, 1988). The direction of causality, though, is not obvious.

Intent on exploring the issue of causality, Hembree (1990) employed meta-analytic methods to pool numerous small-sample studies and investigate overall effects. His research integrated 151 studies. Overall, the combined studies represent a pool of more than 10,000 subjects. Hembree selected meta-analytic methods that would "describe relationships and effects with scale-invariant metrics" (p. 35).

Hembree concluded that compromised performance results from high math anxiety (Hembree, 1990). He supported this conclusion by pointing out that math-anxiety intervention programs which reduced math anxiety consistently resulted in higher math achievement. He stated that treatment programs "can restore the performance of formerly high-anxious students to the performance level associated with low mathematics anxiety" (Hembree, 1990, p. 44). Hembree fortified his position by adding that treatment programs which focused exclusively on enhancing students' math competence had no effect on reducing students' math anxiety (Hembree, 1990).

Although Hembree's arguments are internally consistent, there are other important variables which were not included in Hembree's meta-analysis but may have affected the intervention programs' outcomes. Among such variables are student self-esteem, self-efficacy, and study skills. The extent to which these variables mediated the intervention programs' outcomes is unknown. It is possible, though, that Hembree's conclusions may have differed if more information were available on the intervention programs' effects beyond that of reducing math anxiety. Future research may clarify the most beneficial components of intervention programs as well as the components' specific effects on performance outcomes.

Math anxiety and gender

Early studies of gender and math anxiety yielded conflicting and confusing results, sometimes within the same study. For example, Brush (1978), in a validation study of a math anxiety scale, reported that females in one sample received significantly higher math anxiety scores than did males, yet in another sample no significant gender differences were apparent. As Brush pointed out, the two samples differed in important ways that may have confounded the results. For example, the math background for females in the first sample was significantly less developed than for females in the second sample. At most, one can conclude that females with a relatively undeveloped math background exhibit more math anxiety than females with a more sophisticated math background. One cannot, however, conclude anything about gender differences in math anxiety based on the Brush study.

Another early study found no gender differences in math anxiety at the collegiate level (Morris, et al., 1978). However, the sample groups they chose to study and the method they employed to reach their conclusion may have been insufficient to reach meaningful conclusions about gender differences: Their study was not designed to investigate, nor were they primarily interested in, gender differences. Instead, their focus was on comparing math anxiety in two disparate groups, math majors versus psychology majors.

An added problem with the study is that the researchers did not balance for gender in the math-major group (16 females and 38 males). Importantly, they only investigated gender differences within each group. At no point were females from both groups compared to males from both groups. Because the authors did not provide gender-specific means and standard deviations for either group, it is not possible to perform ad hoc analyses of gender differences for the combined sample. It is therefore impossible to more fully interpret the lack of gender differences they report.

Other early studies concurred in finding higher math anxiety for women but differed considerably on the degree of gender difference. For example, in one study, the difference between males and females was only one-fifth of a standard deviation of the total sample (Dew et al., 1983), yet a study by Llabre and Suarez (1985) found substantially greater differences. Llabre and Suarez reported significance at the $p<.001$ level, with a reported $t = 17.63$.

Examining the samples of the Dew et al. (1983) study compared with the Llabre and Suarez (1985) study may help in understanding how one could show females at one-fifth of a standard deviation above males while the other showed females scoring approximately 2.6 standard deviations above males. Dew's study used a sample of first- and second-year undergraduates enrolled in introductory classes. One may presume that the term "introductory classes" includes both math and non-math courses. In contrast, the Llabre and Suarez study used a sample of students enrolled in Introductory Algebra. It is possible, arguably likely, that students actually enrolled and attending a math class may experience considerably more math anxiety than a student enrolled in only introductory humanities classes such as Introduction to Literature. The Dew study did not limit the sample to students attending a math class and thus may have lacked contextual relevance for questions about math anxiety.

In a recent, comprehensive, meta-analytic study of math anxiety, females in sixth grade through post secondary education consistently showed significantly higher levels of anxiety than did their cohort males (Hembree, 1990). The pooled sample size (based on more than 125 studies) was 10,428, with 6,250 females and 4,178 males. When math anxiety level is plotted against school grade level for this pooled sample, math anxiety increases between sixth and ninth grades for both males and females. The slopes for males and females in this interval are approximately the same, with females experiencing higher anxiety for all grades. Around ninth or tenth grade, levels of math anxiety for both genders peak, then follow different slopes. Although anxiety falls between tenth grade and post secondary education for males, anxiety simply levels off for females.

Extreme care is required when interpreting such data. Hembree's (1990) data combine more than 125 studies and is certainly not a longitudinal study. Without the longitudinal data, several questions which arise from the study cannot be answered yet. For example, no information is provided about the pooled samples' school dropout rates for males versus females. Perhaps math-anxious males drop out of school around the tenth grade in higher proportions than math-anxious females. Alternatively, Hembree's analysis includes a comparison of math-avoidance behaviors by gender. The data show that males who are more math-anxious are more avoidant of taking additional math courses in junior and senior high schools than are female students (Hembree, 1990). Thus the sharper decline of math anxiety evident in males compared to females after ninth grade could be due to avoidant behavior rather than an actual lessening of anxiety felt by any individual.

Differences in math anxiety between males and females at the collegiate level have been hypothesized as being due to differences in math experience rather than gender per se (Alexander & Martray, 1989; Richardson & Woolfolk, 1980, as cited by Llabre & Suarez, 1985). Studies have indicated that females take fewer math courses than males (Alexander & Martray, 1989; Hembree, 1990). According to the "math experience" hypothesis, females experience greater math anxiety than males because they take fewer math courses and are therefore less prepared to handle the demands of math than males.

If that hypothesis is true, males and females who are similarly prepared for a math class could be expected to experience the same level of math anxiety. If, however, males and females with the same level of math experience still have significantly different levels of math anxiety, the hypothesis that taking fewer math courses causes females to experience greater math anxiety would be refuted. Llabre and Suarez (1985) investigated this issue. In their study, the mean number of high school math classes was 1.95 for females and 1.97 for males, a near-perfect match of experience. Yet, as reported previously, females experienced significantly greater levels of math anxiety. This would seem to refute the hypothesis that math anxiety is strictly due to insufficient math experience. Instead of math experience, Rounds and Hendel (1980) assert that gender differences in math-class enrollment are best explained by "other more established and parsimonious constructs than by mathematics anxiety" (p. 147). An alternative explanation is that males and females with the same level of math experience can still differ greatly in other cogent factors such as coping behavior, and that these coping differences are more critical to math anxiety than are similarities in experience level.

Related to the math-experience hypothesis is the idea that gender differences in math anxiety are extant in students with low levels of math experience but that gender differences "disappear" in students with a high level of math experience. It seems reasonable to assume that highly math-anxious students may attempt to reduce their anxiety by avoiding math classes and therefore would not be represented in a sample of students with extensive math experience.

Cooper and Robinson (1989) designed a study to examine gender differences of math anxiety in a sample of engineering and technical undergraduates. The typical curricula for such students include three semesters of calculus and calculus-based physics, at least one semester of differential equations, and one semester of linear algebra. Thus, the sample represented students who willingly pursued extensive math experiences. As expected, Cooper and Robinson found that males and females showed no significant gender differences in levels of math anxiety; their finding is congruent with the previously cited Morris et al. (1978) study, wherein math majors exhibited no significant gender differences for math anxiety.

Why would there be gender differences for highly math-anxious students yet no gender differences for low levels of math anxiety? The Cooper and Robinson (1989) and Morris et al. (1978) studies seem to confirm that only the students with comparatively low levels of math anxiety pursue careers that demand complex levels of math abstraction, and that females who choose to operate in such a sphere are not more math-anxious than males. The studies do not illuminate how males and females who are not math anxious differ from those who are. Neither do the studies explain why gender differences appear in students with high math anxiety.

It is possible that gender differences in math anxiety occur because of differences in the way that males and females respond to math. If their behaviors and coping resources differ, perhaps that can help explain gender differences in math anxiety. In order to investigate this idea, an understanding of coping is required. The next section discusses the construct of coping and investigates the relationships between coping, gender, and anxiety.

COPING

Lazarus and Folkman (1984) have theorized a transactional model of stress, appraisal, and coping which describes several stages of interaction between individuals and their environments. During primary appraisal, a new event in the environment is appraised as threatening, neutral, or beneficial. If the event is perceived as threatening, the individual then assesses whether sufficient resources (internal and external) exist to deal with the threat. This is described as secondary appraisal. The process of coping is defined as the efforts an individual engages in when confronted with stressors perceived as more demanding than can be supported by available resources (Folkman et al., 1986).

The function of coping is to regulate stressful emotions and manage the stressor (Folkman, 1984). Emotion-focused coping includes efforts to reduce negative emotions, while problem-focused coping pertains to actions focused on changing or eliminating the stressor. Examples of emotion-focused coping include wishful thinking, emphasizing the positive, and seeking social support, whereas examples of problem-focused coping include planning, decision-making, and direct action (Folkman, 1984). It is important to realize that coping is an active process, with an individual's coping behaviors affecting, and being affected by, the environment.

If one imagines a feedback loop that inputs the individual's responses back into the environment, it is easier to view the continual cycle of threat, primary appraisal, secondary appraisal, and coping response. Imagine, for example, a sixth-grade math test, with a student noting the presence of a math "story" problem (environmental stressor). Perceiving that sort of problem as threatening (primary appraisal), the student scans the problem to see if it looks familiar or if there are resources to deal with it (secondary appraisal). If not (secondary appraisal of insufficient resources), the student may then grow angry at the instructor and feel stupid (emotion-focused coping).

Because the environmental stressor hasn't diminished, though, the student must again confront the stressor and eventually choose a coping approach that makes the stressor tolerable. The student's coping choices may be to storm out of the classroom (avoidant emotion-focused coping) or to systematically tackle the story problem (planful problem-focused coping).

The student may engage in a complex flurry of coping behaviors in response to one environmental stressor. Research shows, in fact, that most people use a combination of problem-focused and emotion-focused coping behavior (Folkman & Lazarus, 1980) to deal with a stressful situation. From a theoretical perspective, problem-focused coping may even depend upon successful emotion-focused coping to prevent heightened emotions from interfering with problem-solving (Folkman, 1984).

Identifying an individual's coping responses requires an instrument that provides a full range of possible behaviors, emotions, and cognitions. It is not surprising that the most commonly used measurement instruments for analyzing coping are taxonomies of typical coping behavior.

Measuring coping behavior

Perhaps the most widely used coping instrument is the Ways of Coping Checklist (WCC), created by Folkman and Lazarus (1980) and subsequently revised and adapted by the original researchers as well as others. The original WCC asked subjects to recall a recent, disturbing incident. Subjects then read a description of 68 typical coping behaviors, such as "Made a plan of action and tried to follow it", and indicated the frequency with which they engaged in that behavior when they were coping with their cited event. Frequency choices on the original WCC ranged from "Rarely" to "Very Often".

The original WCC featured two broad categories of coping strategies: problem-focused coping and emotion-focused coping. Folkman and Lazarus categorized each item on the WCC as either problem-focused or emotion-focused, according to theoretical bases. The category of problem-focused coping on the original WCC included such diverse behaviors as planning, suppressing competing thoughts, waiting for an appropriate opportunity, and confrontations. Emotion-focused coping, as operationalized on the original WCC, was equally broad in its scope, including behaviors as diverse as daydreaming, praying, drinking alcohol, and emotional venting.

Due to the length of the original WCC, and the limitations of interpretation of the two broad categories, other researchers either created their own scales or modified the WCC. Vitaliano et al (1985) created the Revised Ways of Coping Checklist (RWCC), a scale which retains the character of the WCC but improves its usability (see the Methods section for further information on the scale's reliability and validity). The RWCC comprises five subscales: Problem-focused, Blamed Self, Wishful Thinking, Seeks Social Support, and Avoidance (Vitaliano et al., 1985).

The RWCC appears in full in the Appendix, but sample items from the checklist are included here for convenience. For example, the

Problem-focused subscale includes items such as "Just took things one step at a time" and "Stood my ground and fought for what I wanted". The Blamed Self subscale includes statements such as, "Criticized or lectured myself" and "Realized I brought the problem on myself". The Wishful Thinking subscale contains items such as "Had fantasies or wishes about how things might turn out" and "Wished the situation would go away or somehow be finished". Examples of the Seeks Social Support subscale are "Accepted sympathy and understanding from someone" and "Talked to someone who could do something about the problem". Examples of the Avoidance subscale include "Slept more than usual" and "Got mad at the people or things that caused the problem".

Coping behavior and gender

In nearly every study which investigates the relationship between gender and coping style, significant gender differences are revealed (Brems & Johnson, 1989; Weiser, Endler, & Parker, 1991; Ptacek, Smith, & Zanas, 1992; Rim, 1986, 1987, 1990; Verlinden & Corpuz, 1981). Studies show that females are more likely than males to engage in emotion-focused coping and support-seeking (Ptacek, Smith, & Zanas, 1992). Congruent with their support-seeking strategy, females are more willing to consider seeking professional assistance (Verlinden & Corpuz, 1981). The coping strategy of self-blame is more often employed by females than males (Brems & Johnson, 1989).

Males are more likely to use problem-focused or task-oriented coping than females (Weiser, Endler, & Parker, 1991; Ptacek, Smith, &

Zanas, 1992). Although two studies found that more females than males use avoidance-oriented coping (Endler & Parker, 1990; Weiser, Endler, & Parker, 1991), two other studies found this to be a predominantly male strategy (Brems & Johnson, 1989; Rim, 1990). It should be noted that different instruments were used to measure avoidance-oriented coping in these studies, so it is possible that the instruments differ in what they term avoidant behavior. It is also possible that males and females both use avoidant coping but for different environmental stressors, and the experimental stressors used in different studies evoked different responses for each gender.

Coping behavior and test anxiety

Two studies are of special interest for understanding the connection between coping and test anxiety. A study by Blankstein, Flett, and Watson (1992) investigated the ways in which students' perceptions of their problem-solving ability related to their coping tendencies and levels of trait-oriented and state-oriented test anxiety. Results from their study generally indicated a positive correlation between emotion-focused coping and high trait-oriented test anxiety. That is, a high reliance on emotion-focused coping corresponded with a high level of trait-oriented test anxiety.

Some methodological problems may have limited the scope of their findings, however. They administered four instruments containing a total of 21 subscales (the variables), with one of those instruments an unvalidated, untested, substantially revised version of another scale. The untested instrument contained 3 of the 21 variables in the study;

their post-hoc alphas for these subscale factors were .06 (sic), .71, and .80. All the instruments were administered together, using a sample size of 125 students. It may be best to consider their results as an indicator of possible relationships rather than as proof of the relationships.

Another study of interest, designed by Folkman and Lazarus (1985), illuminates how coping behaviors change during the course of preparing for a test, waiting for test results, and accommodating the test results. Folkman and Lazarus sampled the students' coping mechanisms over a period of 14 days. Students filled out stress questionnaires at three points: 2 days before a test, 5 days after the test but before grades were announced, and 5 days after grades were known. More than 90% of the students reported they used both emotion-focused and problem-focused coping during each stage of the experiment (Folkman & Lazarus, 1985). The authors report, "On the average, subjects used between six and seven different types of coping. People do indeed cope with a single stressful encounter in complex ways" (Folkman & Lazarus, 1985, p. 158). Preceding the exam, students depended conjointly on social support and problem-solving (Folkman & Lazarus, 1985); it appears, in other words, that students sought instrumental support to help them solve problems. Following the exam, problem-focused coping decreased markedly and seeking social support also decreased significantly. Once grades were posted, students' coping behaviors depended on the grade they received, with low grades eliciting more coping behavior than high grades. The coping style most commonly associated with low grades was wishful thinking, followed by seeking social support, followed by self-blame.

The Folkman and Lazarus (1985) study points out the importance of regarding the way students cope with test anxiety as an active process. Lazarus (1993) writes, "Coping changes over time and in accordance with the situational contexts in which it occurs" (p. 235).

Coping behavior, test anxiety, and self-efficacy

The amount of effort and engagement an individual will employ to reduce environmental challenges depends in part upon that person's sense of efficacy or expectancy of a favorable outcome (Bandura, 1988; Carver & Scheier, 1988). For individuals with extremely low self-efficacy, it is unlikely they will expend much effort toward mastery of the challenge; it is far more likely that they will disengage (Carver & Scheier, 1988). It is interesting to consider degrees of engagement in terms of coping behavior. For example, learned helplessness might be expressed as a high reliance on avoidant coping and no reliance on problem-solving coping. In contrast, students with high self-efficacy are more likely to engage in active (problem-solving) behavior because they have learned that their efforts have a direct effect upon their outcome. Bandura (1988) believes that anxiety arousal and avoidant behavior are coeffects of an individual's perception of coping inefficacy. In other words, he theorizes that individuals become anxious and engage in avoidant coping behavior because they assess the environmental threat as exceeding their capacity to manage safely.

Although self-efficacy theory provides insight for understanding problem-focused versus avoidant coping, it does not explain why individuals with similar levels of self-efficacy might employ different coping strategies for similar stressors. For example, the theory cannot explain why one individual may express avoidant coping behavior by seeking social support while another individual expresses it by engaging in wishful thinking.

Self-efficacy theory maintains that anxiety is the result of the individual's evaluation that coping resources are insufficient (Bandura, 1988). If the outcome of anxiety is dependent upon only that evaluation, it would be reasonable to predict that males and females who are presented with similar stressors and who report similar perceptions of self-efficacy would experience similar levels of anxiety. This, however, is not always true, according to Torestad, Magnusson, & Olah (1990). Future research may clarify the relationships between self-efficacy theory, coping strategies, and gender differences in anxiety.

Coping behavior, math anxiety, and gender

The relationship between math anxiety and coping behavior is unexplored territory. Coping has been studied with respect to test anxiety, and test anxiety has been studied with respect to math anxiety, but the specific relationships between math anxiety and coping behaviors need to be defined. Similarly, the interactions between stress, gender, and coping behavior have been studied, as have the interactions between gender, math anxiety, and performance, but the interactions between gender, math anxiety, and coping behavior are unknown.

Do highly math-anxious men and women differ in their choices of coping behavior? Do men and women who are mildly math-anxious resort to the same or different coping strategies? At the low end of the math-anxiety spectrum, do men and women cope with math challenges in a similar fashion?

Previous research suggests that a pattern of interaction may occur between degree of math anxiety, gender, and choice of coping strategy. For students who do not regard math as especially threatening and do not experience much math anxiety, problem-focused coping strategies may emerge as the predominant choice by both men and women. For students who regard math with trepidation and experience moderate levels of math anxiety, a combination of problem-focused and other forms of coping may emerge, with the other forms of coping varying according to gender. While males may combine strategies of avoidant and problem-focused coping, females may instead combine support-seeking and problem-focused coping strategies. Finally, for students who dread math and regard it as a significant threat, it is unlikely that either gender will rely much on problem-focused coping; instead, females may rely entirely on wishful thinking or social-support seeking while males may rely entirely on avoidance.

HYPOTHESES

This study specifically examined the relationships between math anxiety, coping behaviors, and gender. The following hypotheses were investigated.

Hypothesis 1: After controlling for the covariates of math self-concept, perceived difficulty of math as a subject, and social comparison, students who engage in more problem-focused coping experience relatively lower math anxiety.

Hypothesis 2: After controlling for the same covariates, students who engage in more emotion-focused coping (wishful thinking, avoidance, self-blame, and social-support seeking) experience higher math anxiety.

Hypothesis 3: Problem-focused and emotion-focused coping interact with respect to math anxiety.

Hypothesis 4: Gender and coping behavior interact with respect to math anxiety.

METHOD

Subjects

Thirty male and 32 female PSU students enrolled in lower-division PSU mathematics classes (algebra, trigonometry, or introductory statistics) were recruited in cooperation with instructors in the Portland State University Department of Mathematical Sciences. Recruiting announcements were made about a research project to investigate the way students felt about mathematics class.

The algebra, trigonometry, and introductory statistics courses were chosen because (a) the only prerequisite for these courses is high-school algebra, and (b) the courses attract a wide range of students whose main reason for enrolling in the course is probably to satisfy degree requirements for other departments.

Materials

Mathematics Anxiety Rating Scale, revised (Plake & Parker, 1982). The revised Math Anxiety Rating Scale (Plake & Parker, 1982) was used to measure math anxiety. It contains 24 items, each describing a situation which may arouse math anxiety. Subjects are asked to rate how anxious they would be in the described situation on a 5-point Likert scale, where "1" is "not at all" and "5" is "very much". The possible range of scores for the RMARS is therefore 24 (no anxiety reported on any item) to 120 (very much anxiety reported on all items). The RMARS was modified for this study by anchoring items on a scale from 0 to 4 instead of 1 to 5. Thus, the possible range of scores is 0 to 96.

The original Math Anxiety Rating Scale (MARS) was developed by Suinn in 1972 and contained 98 items. Comprehensive data are available on the original scale's reliability and validity (see Suinn, 1972; Suinn et al., 1972; Brush, 1978). The RMARS by Plake & Parker (1982) shows a coefficient alpha internal-consistency reliability of .98 and a correlation of .97 with the original MARS.

The mean RMARS score as reported by Plake & Parker (1982) is 59.84 with a standard deviation of 20.55 based on a sample of 170 students. An adjusted, equivalent mean for the modified scale used in the present study is 35.84 (59.84 - 24).

Plake & Parker's factor analysis produced a two-factor (varimax) solution accounting for 60% of the total variance. In order to be included in the revised version, an item had to have a factor loading of .50 or greater and had to load on only one of the two rotated factors. Factor I is Learning Mathematics Anxiety and contains 16 items. Factor II is Mathematics Evaluation Anxiety and contains eight items. For the purpose of the proposed study, only the aggregate score of the two subscales were used. The RMARS is included in the Appendix.

Ways of Coping Checklist, revised (Vitaliano, et al., 1985). The Revised Ways of Coping Checklist (Vitaliano, et al., 1985) was used in the present study to measure coping behaviors. The original Ways of Coping Checklist (WCCL) was developed by Folkman & Lazarus in 1980. It consisted of 68 items based on their theoretical model of reaction to stress. In its original formulation, the WCCL contained two subscales: problem-focused coping and emotion-focused coping. Although useful conceptually, the WCCL suffered from methodological limitations such as high intercorrelations between the subscales.

Vitaliano et al. (1985) developed a revised Ways of Coping Checklist (RWCC) with improved psychometric properties. The RWCC resulted from a principal components analysis with varimax rotation. Five factors emerged: a Problem-Focused subscale ($\alpha =$ 13.29, 40% of variance), containing 15 items; a Blamed Self subscale (α= 5.03, 15.2% of variance), containing three items; a Wishful Thinking subscale (α= 2.72, 8.2% of variance), containing eight items; a Seeks Social Support subscale (α= 2.06, 8.3% of variance), containing six items; and an Avoidance subscale (α not provided, 6.2% of variance), containing 10 items. The RWCC is included in the Appendix. An item from the Blamed Self subscale was erroneously omitted from the questionnaire presented to students, replaced by another emotion-focused item from the original WCCL (Question #9 on the RWCC in the Appendix).

The traditional stimulus given to subjects for the WCCL and RWCC is a recent stressful event. Subjects reflect on this event and indicate what coping strategies they used. For this study, though, a set stimulus was used. Subjects were instructed, "Imagine that you are at home, working on your math homework. Some of the problems seem really difficult. You've been working on one problem for about 20 minutes with no success, and you suspect that this same sort of problem is going to be on the test that's coming up." The stimulus was designed to elicit a contextually relevant response from the subject on the RWCC items that directly followed.

Brief questionnaire. Past research indicated that a subject's prior math self-concept, current-term math grade expectations, and math social comparisons may contribute to math anxiety. Therefore, this information was gathered via a short questionnaire in order to control for effects on aggregate math anxiety during hierarchical regression analysis.

Questions 1 through 4 of the questionnaire (see the Appendix) were adapted from items developed by Stipek & Gralinski (1991) for their research on gender differences of math emotions. These questions measured the subjects' perceptions of how difficult math is as a subject, how good they are in math, how they compare to other classmates in math, and the grade they expect to receive.

Question 5 provided quantitative data regarding the subjects' utilization of instrumental support personnel (math tutors and instructors outside of math class hours). Although instrumental support would normally include family, friends, and acquaintances, it was operationally defined in a narrower sense for the purpose of this study.

In addition, the following demographics were requested but not used in the primary analyses: year in school (freshman, sophomore, junior, senior, postbaccalaureate, or graduate), highest level of math course taken, last math course taken (high-school algebra, high-school geometry, high-school trigonometry, college-level pre-algebra, college-level algebra, college-level trigonometry, other), college major, reason for taking this course (required for my major, recommended for my major, elective), and the average number of hours per week spent on math homework.

<u>Variables</u>

AVOID is an integer value that comes from the Avoidance subscale of the RWCC. AVOID includes 10 items. Each item in each of the subscales can range from 0 for "not used" to 3 for "used a great deal," providing AVOID with a total range of 0 to 30. AVOIDSCALED was created to allow comparisons between the different RWCC subscales. AVOIDSCALED is AVOID/10.

BLAME is an integer value from the Blamed Self subscale of the RWCC. BLAME includes 2 items, each ranging from 0 to 3, for a total range of 0 to 6. BLAMESCALED is BLAME/2.

COMPARE is a self-report of how the subjects feel they are doing compared to their classmates. COMPARE ranges from 1 to 5 for "much worse" to "much better", respectively. COMPARE was originally developed by Stipek and Gralinski (1991).

DIFF is the subject's report of how difficult math is as a subject, with values ranging from 1 to 5 for "very hard" to "very easy". DIFF was developed by Stipek and Gralinski (1991).

EMOTFOC (emotion-focused coping) is an integer value that comes from the RWCC and represents the sums of responses on four emotion-focused subscales (Blamed Self, Wishful Thinking, Seeks Social Support, and Avoidance) and the single item #9 on the scale (see the Appendix). The four subscales contain a total of 26 items, with possible responses for each item ranging from 0 to 3. Scaled in the same way is item #9. EMOTFOC can therefore assume values ranging from 0 to 81. EMOTSCALED is EMOTFOC/26.

GOOD is the subject's self-report of his or her math ability, with values ranging from 1 to 5 for "bad" to "very good," respectively. GOOD was originally developed by Stipek and Gralinski (1991).

GENDER is the subject's gender; it was coded by the researcher.

GRADEEXP is the grade the subject expects to receive for the course. The range of GRADEEXP is on a 12-point scale, where F = 1, D- = 2, D = 3, and so on, to B+ = 10, A- = 11, and A = 12. GRADEEXP was originally developed by Stipek and Gralinski (1991).

INSTR is the student's report of the number of visits to an instructor during the instructor's office hours.

MATHANX is an integer value representing aggregate math anxiety. It comes from the RMARS and represents the sum of 24 items, with the response for each item ranging from 0 for "not at all" to 4 for "very much." Consequently, the possible range of MATHANX is from 0 to 96.

PREVMATH is the number of high school and college math classes previously completed by the student.

PROBFOC (problem-focused coping) is an integer value from the RWCC representing the sum of responses on the Problem-focused subscale. There are 15 items included in the subscale, with each response ranging from 0 ("not used") to 3 ("used a great deal"). PROBFOC can therefore assume values from 0 to 45. PROBSCALED was created to allow comparison between the different RWCC subscales. PROBSCALED is the scaled version of PROBFOC; specifically, PROBSCALED is PROBFOC/15.

SOCIAL is an integer value from the RWCC. There are six items in the SOCIAL subscale, with each response ranging from 0 to 3, for a total range of 0 to 18. SOCIALSCALED is SOCIAL/6.

TUTOR is the student's report of the number of visits to a math tutor.

WISH is an integer value from the RWCC. There are eight items in the WISH subscale, each ranging from 0 to 3, for a total range of 0 to 24. WISHSCALED is WISH/8.

YEAR is the subject's self report of class year.

Procedure

Recruitment. Subjects were recruited by the researcher in undergraduate beginning statistics and algebra classes and psychology classes via prior arrangement with instructors. (In the psychology classes, only students who were currently enrolled in a beginning statistics or algebra class were recruited.) The research project was endorsed by the Chair of the Department of Mathematical Sciences, Dr. Bruce Jensen.

The researcher entered the instructors' classrooms at an arranged time and told classes that a research project was underway to discover more about the way students feel about taking a mathematics course. The researcher explained that participation was voluntary, that it would take 30 minutes or less to answer the questions on the survey, that responses would be treated confidentially, and that the results of the project would help educators understand more about the way students approach studying math. The researcher provided an extra incentive to participate by offering five random drawings among participants for $10 gift certificates to the Portland State University Bookstore or other merchant.

After making the announcement, the researcher answered students' questions and then distributed sign-up sheets in the classroom. Instructors who were so inclined also offered extra credit and told their classes that the research project was important, worthwhile, and had the support of the department.

Administration of the instruments. Subjects were given a coded packet which contained instructions, the two survey instruments, and the brief questionnaire. The code on each sheet of the packet indicated the subject's gender as well as a unique integer which indexed the student's name on the master list. Students marked their responses directly on the sheets.

RESULTS

Overview

There were 62 subjects in this study, of whom 30 were male and 32 female. Approximately 39% of the subjects were first-year students. Another 13% were sophomores, 34% were juniors, 11% were seniors, and 3% were graduate students. University records indicate that the average ages of first-year, sophomore, junior, and senior students are 20.7, 23.5, 26.5, and 28.7 years, respectively (Carney, 1994).

Approximately 77% were taking their math course to satisfy degree requirements for their major (none were math majors). An additional 10% were taking the course because it was recommended for their major, while approximately 13% reported they took the class as an elective. Math anxiety did not vary significantly according to the students' reason for taking the course, but those who took the course as an elective generally reported a lower level of math anxiety; a larger sample size may have provided more power to discern significance.

Only twenty-three students reported using university-sponsored instrumental support. Seven students (4 male, 3 female) used the university-paid math tutors. Twenty students (7 male, 13 female) visited their instructors during office hours (four students used both forms of instrumental support), but 14 of the 20 only visited the instructor once. The students who utilized either or both of the instrumental resources were more math anxious (N=23, M = 44.00, SD = 2.81) than those who did not (N = 39, M= 31.87, SD = 17.56), with $F(1,60) = 7.52$, $p < .01$. Students who reported above-average math anxiety and utilized instrumental support did not differ significantly in their grade expectations from other similarly anxious students who did not utilize instrumental support.

Scale Analyses

Reliability analyses were run on the subscales comprising the Revised Ways of Coping Checklist (RWCC). All subscales had alphas above .70 except for BLAME. Alphas were .71 for AVOID, -.37 for BLAME, .76 for PROBFOC, .76 for SOCIAL, .85 for WISH, and .85 for the combined EMOTFOC subscale. Removing the 2 BLAME questions from the EMOTFOC scale did not change the alpha for EMOTFOC. Consequently, the BLAME subscale was not used in data analysis but its questions were included in the analyses of EMOTFOC.

On an adjusted scale of 0 to 3, where 0 indicated "not used" and 3 indicated "used a great deal", the students in this survey indicated an adjusted average response of 1.21 for the subscales on the RWCC (AVOID, PROBFOC, SOCIAL, and WISHFUL). In ascending order of usage, the students averaged an adjusted response of 0.75 for the AVOID subscale, 1.31 for the WISH subscale, 1.33 for the SOCIAL subscale, and 1.45 for PROBFOC. In comparison with PROBFOC, the adjusted response for the combined EMOTFOC scale was 1.10. For this group of students, then, problem-focused coping behaviors were reported more frequently than emotion-focused coping behaviors.

Descriptive Analyses

Math anxiety was highly correlated with emotion-focused coping ($r = .70$, $p < .0001$), and was highly negatively correlated with perceived difficulty in math ($r = -.57$, $p < .0001$), perceived math ability ($r = -.52$, $p < .0001$), and social comparison ($r = -.41$, $p < .001$). Math anxiety and problem-focused coping were not significantly correlated. Although there was a significant correlation between problem-focused and emotion-focused coping, the magnitude of that correlation was modest ($r = .30$, $p < .05$).

Means and standard deviations for all variables are listed in Table 1.

Table 1: Descriptive Statistics

	Male (N = 30)		Female (N=32)		Total sample	
	M	SD	M	SD	M	SD
AVOID	8.87	4.08	6.25	4.71	7.52	4.58
AVOIDSCALED	0.89	0.41	0.63	0.47	0.75	0.46
BLAME	2.33	1.24	2.22	1.13	2.27	1.18
BLAMESCALED	1.17	0.62	1.11	0.56	1.14	0.59
COMPARE	3.35	0.78	3.19	1.20	3.32	0.93
DIFF	2.87	1.07	2.63	0.94	2.74	1.01
EMOTFOC	30.99	11.78	28.38	11.30	29.61	11.51
EMOTSCALED	1.15	0.44	1.05	0.42	1.10	0.43
GOOD	3.32	1.07	3.11	0.82	3.21	0.95
GRADEEXP	8.05	2.93	8.78	2.24	8.57	2.38
INSTR (# of visits to office)	.30	.65	.81	1.38	.56	1.11
MATHANX	36.30	17.71	36.44	17.96	36.37	17.69
PREVMATH (# of courses)	3.13	1.96	3.53	1.76	3.39	1.82
PROBFOC	21.20	6.40	22.28	6.76	21.76	6.56
PROBSCALED	1.41	0.43	1.49	0.45	1.45	0.44
SOCIAL	7.13	4.03	8.81	3.81	8.00	3.98
SOCIALSCALED	1.19	0.67	1.47	0.63	1.33	0.66
TUTOR (# of visits to office)	.20	.61	0.34	1.23	0.27	0.98
WISH	11.30	5.61	9.78	5.67	10.52	5.64
WISHSCALED	1.41	0.70	1.22	0.71	1.31	0.71
YEAR (in school)	1.97	1.13	2.56	1.19	2.27	1.19

Inferential Analyses

Hypothesis 1

After controlling for the covariates of perceived difficulty of math as a subject (DIFF), perceived math ability (GOOD), grade expectation (GRADEEXP), and social comparison (COMPARE), a hierarchical regression showed that no additional significant contribution to the variation of math anxiety was provided by problem-focused coping. Further evidence of the lack of relationship between problem-focused coping and math anxiety is a low Pearson's correlation coefficient (r = 21).

The covariates contributed significantly to math anxiety, with an adjusted R^2 of .33, $F(4,55) = 8.16$, $p < .0001$. A correlational analysis showed that math anxiety was significantly related at the $p = .01$ level (two-tailed) to DIFF ($r = .58$), GOOD ($r = -.52$), GRADEEXP ($r = -.37$), and COMPARE ($r = -.43$). In order to understand the interrelationships between DIFF and the other covariates, correlational analyses were conducted. DIFF was significantly related to GOOD ($r = .74$), GRADEEXP ($r = .60$), and COMPARE ($r = .46$) at the $p = .01$ level (two-tailed).

Hypothesis 2

After controlling for the same covariates as discussed in Hypothesis 1, a hierarchical regression showed there was a significant contribution to the variation of math anxiety provided by emotion-focused coping, with the incremental change in variation indicated by

F (5,54) = 38.43, *p* < .0001. The adjusted R^2 for the model was .60, with an overall *F*(5,54) = 18.66, *p* < .0001.

The predominant influence on emotion-focused coping for this sample population was the Wishful Thinking (WISH) subscale (*r* = .90), followed by the Avoidance (AVOID) subscale (*r* = .76). WISH and AVOID had a Pearson's correlation coefficient of *r* = .60, *t* = 5.76, *p* <.0001.

An ANOVA showed that the 36 students who indicated they expected to get less than a B in their math class employed more wishful thinking than the 25 students who said they expected to get a B or better (*F*[1,59] = 5.29, *p* < .03). (One student declined to provide a grade expectation.) However, of the 18 students who expected to receive a B+ or better, 7 reported above-average use of wishful thinking, 8 reported some use of wishful thinking, and only 3 reported no use of wishful thinking.

Hypothesis 3

Hypothesis 3 was investigated in three ways, using two regression analyses and a set of ANOVA's. The first regression analysis was run for the outcome of math anxiety given the inputs of problem-focused coping, emotion-focused coping, and the interaction between problem-focused and emotion-focused coping. The second regression analysis added DIFF, the student's perception of math difficulty. (DIFF was the significant covariate in Hypotheses 1 and 2.) The interaction term was significant when the covariate was omitted, but was insignificant with the inclusion of the covariate. Next, the different combinations of emotion- and problem-focused coping were analyzed. The following paragraphs separately present the results of both regressions and the ANOVA's.

Regression without the covariate. A hierarchical regression showed a significant interaction between problem-focused and emotion-focused coping with respect to math anxiety, with $F(3,58) = 5.82$, $p < .02$ for the incremental R^2 provided by the interaction, and an overall adjusted R^2 of .51, $F(3,58) = 22.18$, $p < .0001$. Both main effects were significant, also, as shown in Table 2.

Table 2: Significance of Main Effects and Interaction of Coping on Math Anxiety

Block	Variable	β(standardized)	t	p	R^2
1	Emotion-focused coping	1.40	4.58	.00	
1	Problem-focused coping	0.56	2.25	.03	.47
2	Interaction	-1.04	-2.41	.02	.05

The standardized β coefficient for the interaction term was negative, indicating that the combination of problem-focused and emotion-focused coping was associated with lower levels of math anxiety.

Regression with the covariate. The interaction regression was rerun for a post hoc analysis, this time including DIFF, the significant covariate from Hypotheses 1 and 2. The overall regression model was significant [$F(4,57) = 24.71$, $p < .0001$], with an adjusted R^2 of .61, but both the interaction term (PROBXEMO) and PROBFOC failed significance. Multicollinearity between DIFF, PROBFOC, EMOTFOC, and PROBXEMO was investigated by inspecting the intercorrelations and by running auxiliary regressions. The correlations between the independent variables were low, as can be seen in Table 3, but DIFF regressed significantly on PROBFOC [F (1,60) = 4.45, $p < .05$], EMOTFOC [F (1,60) = 7.76, $p < .01$], and PROBXEMO [F (1,60) = 6.71, $p < .05$]. Multicollinearity may account for the difference between regressions run with and without the covariate.

Table 3: Correlations between Variables in Hypothesis 3

	DIFF	DIFFXEMO	EMOTFOC	MATHANX	PROBFOC	PROBXEMO
DIFF	1.00	.45	-.34	-.57	-.26	-.32
DIFFXEMO	.45	1.00	.62	.17	.11	.47
EMOTFOC	-.34	.62	1.00	.70	.30	.84
MATHANX	-.57	.17	.70	1.00	.21	.54
PROBFOC	-.26	.11	.30	.21	1.00	.74
PROBXEMO	-.32	.47	.84	.54	.74	1.00

ANCOVA and ANOVA analyses. Subjects were dichotomized on two variables, problem-focused (PROBFOC) and emotion-focused (EMOTFOC) coping. Subjects who scored above the mean were classified as "high" on that variable, while subjects who scored below the mean were classified as "low." Four groups resulted: Low PROBFOC/Low EMOTFOC (20 students); Low PROBFOC/High EMOTFOC (13 students); High PROBFOC/Low EMOTFOC (11 students); and High PROBFOC/High EMOTFOC (18 students). An ANCOVA showed that both the group membership and the covariate of perceived difficulty were significant with respect to math anxiety. Group membership was significant at the $p < .001$ level [$F(3,58) = 6.07$], and DIFF was significant at the $p < .0001$ level [$F(1,61) = 36.63$]. Table 4 shows the groups' gender distributions, the groups' means, and the standard deviations of math anxiety.

Table 4: Math Anxiety by Coping Type

Group	Group Description	N (Female, Male)	M	SD
1	Low PROBFOC, Low EMOTFOC	20 (9, 11)	22.55	13.24
2	Low PROBFOC, High EMOTFOC	13 (7, 6)	50.92	18.56
3	High PROBFOC, Low EMOTFOC	11 (8, 3)	33.00	9.22
4	High PROBFOC, High EMOTFOC	18 (8, 10)	43.28	13.78

A one-way ANOVA was run to ascertain group differences in math anxiety. Significant treatment effects were found for the overall model [$F(3,58) = 12.66$, $p < .0001$], with the Student Newman-Keuls procedure revealing differences at the $\alpha = .05$ level for Groups 1 and 4 ($t = 2.84$), Groups 1 and 2 ($t = 3.40$), and Groups 2 and 3 ($t = 3.74$).

The four groups differed also with respect to their perception of math difficulty. A one-way ANOVA showed significant group differences [$F(3,58) = 7.90$, $p < .0005$]. The Student Newman-Keuls procedure showed that Group 1 perceived significantly lower difficulty in math than each of the other groups at the $\alpha = .05$ level ($t = 4.07$ for each comparison with Group 1).

Another difference between the groups involved their expectations of their final grades ($F[3,57] = 4.44$, $p < .05$]. Students in Group 1 expected a B+ on average, while students in Groups 2, 3, and 4 expected a B-. The Student Newman-Keuls procedure showed Group 1 significantly different from the other groups at the $\alpha = .05$ level ($t = 2.84$, 3.40, and 3.74 for Group 1 contrasted with Groups 3, 2, and 4, respectively).

Overall, students who employed high levels of emotion-focused coping and low levels of problem-focused coping experienced the highest level of math anxiety. Students experiencing the lowest levels of math anxiety scored low for both emotion-focused and problem-focused coping and rated math as less difficult a subject than other students.

Hypothesis 4

Gender did not interact significantly with any of the coping scales or subscales with respect to math anxiety. Similarly, gender did not interact with the coping types shown in Table 4. Hypothesis 4 was not supported.

Gender was not significantly related to the variables of math anxiety, problem-focused coping, or emotion-focused coping. Gender was significant only with respect to the Avoidance subscale for emotion-focused coping, with males more avoidant than females [F (1,60) = 5.43, $p < .03$].

No significant gender differences were found in the math course in which subjects were enrolled or their reasons for taking the math course. Neither were there gender differences in the number of math courses taken previously, the subjects' assessments of how difficult math was as a subject, their appraisals of how good they were in math, their descriptions of how well they compared to their classmates, or the grades they expected in their math courses.

DISCUSSION

This study examined the relationships between math anxiety, coping behavior, and gender in a group of Portland State University students who were taking a math course for non-math majors. In this study, emotion-focused coping was strongly associated with math anxiety. Students in the study who indicated an above-average level of emotion-focused coping also reported an above-average level of math anxiety. Problem-focused coping, however, showed no discernible association with math anxiety in this study. Neither was there much evidence of gender differences in math anxiety or coping in this group of students. The men and women surveyed in this study reported similar coping strategies when presented with an imagined math stressor, and indicated virtually identical levels of math anxiety. The only significant gender difference in this study was with avoidance coping, which was used more by males than females.

Students who relied heavily on the emotion-focused coping behaviors that were included in the Wishful Thinking subscale reported the highest levels of math anxiety. At least three interpretations are possible: (a) Wishful thinking may elevate math anxiety; (b) students who are highly math anxious may tend to rely on wishful thinking when trying to cope with a stressful math event; or (c) a latent variable (for example, low self-esteem) exists that elevates a reliance on wishful thinking and heightens a sense of math anxiety.

Congruent with Folkman and Lazarus' (1985) results, wishful thinking was highly characteristic of students who expected to receive a grade lower than B. However, students who expected math grades of B+ or better also reported wishful thinking. In fact, more than one-third of students with high grade expectations reported above-average use of wishful thinking coping. Such results seem to indicate that wishful thinking is not incompatible with high achievement, assuming that students are accurately predicting their grades. Perhaps wishful thinking is a constructive form of emotion-focused coping when it provides a brief respite from problem-solving but is harmful when it replaces problem-solving. If so, wishful thinking could in fact serve as either a byproduct of anxiety or a causal agent, depending on the interaction of engagement and disengagement toward a goal.

Some of the students in this study apparently depended almost exclusively on emotion-focused coping when faced with a math challenge, and those students reported high levels of math anxiety. It is possible that they regarded emotion-focused coping as the only tool available to them. Hopefully, future research will explore the best strategies for helping students who abandon problem-focused coping when presented with a math stressor. It is quite possible that the treatments which help such students are considerably different from treatments that help other students with different baseline strategies of math coping behavior.

Problem-focused coping behavior was not correlated with lower math anxiety. In fact, students who were quite similar in their use of problem-focused coping varied widely with respect to math anxiety and emotion-focused coping . Two patterns of response are of particular interest. One pattern is that of the students grouped according to Low PROBFOC/ High EMOTFOC responses on the RWCC; the other is that of the students grouped by Low PROBFOC/ Low EMOTFOC responses. The Low PROBFOC/ High EMOTFOC group scored highest in math anxiety of any other group, expected a final grade of B-, and indicated that they found math difficult. In contrast, the Low PROBFOC/ Low EMOTFOC group scored lowest in math anxiety, expected a B+, and reported that math was not difficult for them.

Another group of students reported High PROBFOC/ High EMOTFOC responses; this group indicated greater than average math anxiety. Their responses may be consistent with that of defensive pessimists (Showers & Ruben, 1990). Defensive pessimists would be expected to report high levels of math anxiety yet engage in considerable problem-focused coping while preparing for their studies and tests.

Not surprisingly, students who perceived math as difficult reported higher levels of math anxiety. For this sample population, perceived math difficulty affected the students' experiences of math anxiety more predictably than the combination of their reported use of emotion- and problem-focused coping. It is possible that the interaction term (emotion-focused coping multiplied by problem-focused coping) represents a subtle but important effect that requires a larger sample size to remain significant in a stable way when other variables are added. Future research with a larger sample size may further illuminate the nature of the interaction between emotion- and problem-focused coping and may clarify the effect of coping on math or test anxiety.

Turning to Hypothesis 4, one of the purposes of this study was to examine gender differences in math anxiety and coping behavior. In congruence with some previous research and in contrast with others, this study found some gender differences in coping behavior but no significant gender differences in math anxiety. In fact, math anxiety scores for the men and women in this study were virtually identical.

This finding is congruent with Cooper and Robinson (1989) as well as Morris et al. (1978), and Brush (1978), but conflicts with Hembree's

(1990) meta-analytic study and with Dew's (1983) study. It is possible that the students for this sample differed in important ways from previously studied students, and it is also possible that this study's method differed importantly from other studies' methods. The following discussion examines both possibilities, first by comparing the various populations and then by comparing the methodologies used in studying the populations.

The most comprehensive studies were Hembree's (1988, 1990), combining data from studies conducted between 1950 and 1986. All of the studies he used were published at least seven years ago, and some of the studies were more than 40 years old (Hembree, 1988). Specifically, 30 studies were published before 1960, 150 during 1960-1969, 271 during 1970-1979, and 111 during 1980-1986 (Hembree, 1988). Another important characteristic of the Hembree analyses is the inclusion of data from public school children and teenagers (Hembree, 1990). For the article on math anxiety, eight of the analyzed studies included data from children in grades three through six; 43 studies included data from junior high students in grades seven through nine; 57 studies included high school students in grades ten through twelve; and 122 studies included college students (some studies included students from multiple grades).

In contrast with the Hembree articles which were global in scope, the current study was narrowly focused on a specific, relatively homogeneous group of college students. The entire sample population was currently enrolled in a lower-division math course, most of the students were taking the course to satisfy requirements for their major, and none of the students reporting math as their chosen major. Although the Hembree analyses undoubtedly included similar students, the Hembree sample population was heterogeneous in terms of the level of the students sampled, their reasons for taking a math class, the freedom or incentive that the students had to participate or not participate in the study, and of course the era that the study took place.

The last twenty years have seen significant curricula and gender-bias changes in U.S. public schools. These changes may have reduced gender differences in math attitudes for young college students. Regrettably, this study did not ask students for their age. It is possible that the current study was skewed toward relatively young students who received a math education that was less gender-biased than in previous eras. Future studies should include age and gender as variables. That would allow researchers to study age differences in math anxiety within as well as across genders. It would be interesting, for example, to study whether older females report more math anxiety than either younger females or males of any age.

Methodology and purpose differed widely among the studies included by Hembree. For example, some were studies of pre-treatment versus post-treatment anxiety, some attempted to correlate math attitudes with math performance, others examined the relationship between anxiety and self-esteem, and others investigated the distinctions between cognitive and behavioral test anxiety

(Hembree, 1988). These differences of purpose and methodology suggest that testing or survey administration occurred at widely varying times in equally varying environments. For the current study, the survey instruments were administered one week before finals. It is conceivable that the most highly math-anxious students had already dropped their math course and consequently were underrepresented in this survey. In contrast, Hembree's data was more comprehensive, including students such as sixth-graders who presumably could not drop their math course.

In the current study, men and women did not differ significantly in their self-assessments of how good they were in math or how well they compared with other students. Neither did they differ significantly in the number of math courses they had taken, which is similar to Llabre and Suarez' (1985) findings but different from a study conducted by Alexander and Martray (1989). It is possible that gender differences in math preparation are affected by regional or cultural factors, and that the conflicting results for the three studies can be partly explained by such differences. Another possibility is that the demands placed on math students differ from school to school, and that gender differences in math anxiety tend to appear or disappear according to the demands.

One variable on which there were significant gender differences was the Avoidance subscale of the Revised Ways of Coping Checklist. As expected, males used avoidance coping more than females. This result is in line with previous research by Brems and Johnson (1989) as well as Rim (1990), but in conflict with results found by Endler & Parker

(1990) and by Weiser, Endler, and Parker (1991). Whether differences in results are due to differences in scales, differences in stressors, or differences in the subjects is unclear. All three explanations are possible. Additional research into the interrelationships between the various coping scales may illuminate the conflicting results between studies which purport to explore the same construct.

Although previous studies have found gender differences for social-support seeking (Ptacek, Smith, & Zanas, 1992), this study found only limited differences. There were no differences in social-support coping behaviors as measured by the coping checklist, but nearly twice as many females as males (13 females, 7 males) visited their instructors for instrumental support. Future studies on coping behaviors may profit from including specific questions on instrumental coping, as coping checklists may not be able to separate social-support seeking from instrumental-support seeking.

Returning to the discrepancy between this study's and other studies' results on gender differences in social-support seeking, it may be that a reasonable explanation is the stimulus for the coping checklist. In this study, the stimulus was controlled by the researcher. For most studies that use coping checklists, the researcher asks the subject to think of a distressing incident that occurred recently. It is possible that males and females recall different types of distressing incidents and consequently describe different coping strategies. In the current study, however, each subject received the same stimulus for the coping checklist. It is notable that such a controlled stimulus resulted in similar coping patterns between men and women. Additional research should clarify whether there are gender differences in the recall of distressing incidents; if so, additional research can clarify the relationship between differences in gender recall and gender coping.

This study took place toward the end of a term, approximately one week before final exams. A reasonable question to ask is who dropped out before the study was conducted, and how would those students have impacted the results? It seems likely that students who expected to receive a D or lower would have dropped the course; their math anxiety would probably have been considerably higher, and their math self-concepts and grade expectations considerably lower, than most students who elected to stay in the course. The range for grade expectation should be considered restricted for this study's sample.

It is also possible that males and females withdrew from their math classes in unequal proportions, and that the students who withdrew from a math class might have scored higher in math anxiety than those who finished the class. If, for example, more females than males withdrew, it is possible that females as a group would have scored significantly higher in math anxiety.

Another limitation of this study is its snapshot view of the students. It would have been more useful to administer surveys at the beginning as well as end of the term in order to understand (a) whether students were consistent over time in their use of coping strategies; (b) if the students who dropped out before finals differed in coping behavior from those who finished the course; and (c) the temporal relationships between coping behavior and math anxiety.

This study investigated the relationships between math anxiety, coping strategies, and gender. The expected results were that (a) higher math anxiety scores would be reported by students who engaged in higher levels of emotion-focused coping; (b) lower math anxiety scores would be reported by students who engaged in higher levels of problem-focused coping; and (c) males and females would differ in both their reported levels of math anxiety and their approaches to coping with math anxiety.

The students in this study who indicated a high level of math-anxiety relied on emotion-focused coping behaviors to deal with a math stressor. The highest levels of math anxiety were experienced by those students who indicated they relied almost exclusively on emotion-focused coping. Whether emotion-focused coping induces math anxiety or simply accompanies the anxiety is not clear. Further research should investigate whether reducing a student's dependence on emotion-focused coping behaviors can reduce that student's math anxiety, or whether emotion-focused coping is simply the behavior component of math anxiety rather than its cause.

Results from this study show that the males and females in this sample population were remarkably similar in their reports of math anxiety and differed only slightly on their strategies of coping. The results suggest that there may be fewer gender differences in math anxiety, math preparedness, and math self-concept than have been found in the past, although this study's results must be tempered with the previously mentioned cautions. Future studies may reveal whether younger female students experience lower levels of math anxiety than older females, and whether the younger students are more likely to (a) choose majors which require the use of math; (b) enroll in more math courses; and (c) actually gain employment in math-oriented careers. After all, it is a necessary but insufficient objective to reduce distress in math as indicated by math anxiety. The real objective is to help tomorrow's students achieve their goals in a world increasingly dependent on mathematical skills and knowledge.

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APPENDIX

Questions from Vitaliano's Revised Ways of Coping Checklist

Scale: Not used = 0

Used somewhat = 1

Used quite a bit = 2

Used a great deal = 3

Questions:

1. Just concentrated on what I had to do next--the next step
2. Bargained or compromised to get something positive from the situation.
3. Talked to someone to find out more about the situation.
4. Criticized or lectured myself.
5. Tried not to burn my bridges, but leave things open somewhat.
6. Hoped a miracle would happen.
7. Went on as if nothing had happened.
8. I tried to keep my feelings to myself.
9. Looked for the silver lining, so to speak; tried to look on the bright side of things.
10. Slept more than usual.
11. Accepted sympathy and understanding from someone.
12. Tried to forget the whole thing.

13. I got professional help & did what they recommended.

14. Changed or grew as a person in a good way.

15. I made a plan of action and followed it.

16. I accepted the next best thing to what I wanted.

17. Realized I brought the problem on myself.

18. I came out of the experience better than when I went in.

19. I came out of the experience better than when I went in.

20. Talked to someone who could do something about the problem.

21. Tried to make myself feel better by eating, drinking, smoking, using drugs or medication, etc.

22. I tried not to act too hastily or follow my first hunch.

23. Changed something so things would turn out all right.

24. Avoided being with people in general.

25. Asked someone I respected for advice and followed it.

26. Kept others from knowing how bad things were.

27. Talked to someone about how I was feeling.

28. Stood my ground and fought for what I wanted.

29. I knew what had to be done, so I doubled my efforts to make things work.

30. Refused to believe that it had happened.

31. Came up with a couple of different solutions to the problem.

32. Wished that I could change what had happened.

33. Wished I could change the way I felt.

34. I changed something about myself so I could deal with the situation better.

34. I daydreamed or imagined a better time or place than the one I was in.

35. Wished that the situation would go away or somehow be finished.

36. Had fantasies or wishes about how things might turn out.

37. Just took things one step at a time.

38. Accepted my strong feelings, but didn't let them interfere with other things too much.

39. Wished that I was a stronger person -- more optimistic and forceful.

40. Thought about fantastic or unreal things (like perfect revenge or finding a million dollars) that made me feel better.

41. Felt bad that I couldn't avoid the problem.

42. Got mad at the people or things that caused the problem.

Questions from Plake and Parker's Revised Mathematics Anxiety Rating Scale

Scale: Not at all = 0

A little = 1

A fair amount = 2

Much = 3

Very much = 4

1. Buying a math textbook.
2. Watching a teacher work an algebraic equation on the blackboard.
3. Signing up for a course in Statistics.
4. Listening to another student explain a math formula.
5. Walking into a math class.
6. Taking an examination (quiz) in a math course.
7. Taking an examination (final) in a math course.
8. Picking up a math textbook to begin working on a homework assignment.
9. Being given a homework assignment of many difficult problems which is due the next class meeting.
10. Reading and interpreting graphs or charts.
11. Looking through the pages on a math text.

12. Being given a "pop" quiz in a math class.

13. Walking on campus and thinking about a math course.

14. Getting ready to study for a math test

15. Reading the word "Statistics".

16. Working on an abstract mathematical problem, such as: "if x = outstanding bills, and y = total income, calculate how much you have left for recreational expenditures".

17. Listening to a lecture in a math class.

18. Having to use the tables in the back of a math book.

19. Being told how to interpret probability statements.

20. Solving a square root problem.

21. Waiting to get a math test returned in which you expected to do well.

22. Reading a formula in chemistry.

23. Thinking about an upcoming math test one day before.

24. Starting a new chapter in a math book.

Questions from Stipek and Gralinski

1. Compared to your classmates, how are you doing in math?

   (1=much worse...5=much better)

2. How difficult do you feel math is as a subject?

   (1=very hard...5=very easy)

3. How good are you in math?

   (1=bad...5=very good)

4. What grade do you expect to receive in this math course?

   (F=1, D-=2, D=3, D+=4, C-=5, C=6, C+=7, B-=8, B=9, B+=10, A-=11, A=12)

Questions from Stipek and Gralinski

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   (F=1, D-=2, D=3, D+=4, C-=5, C=6, C+=7, B-=8, B=9, B+=10, A-=11, A=12)