The Effects of Math Anxiety and Stereotype Threat on Women's Math Performance

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THE EFFECTS OF MATH ANXIETY AND STEREOTYPE THREAT ON WOMEN'S MATH PERFORMANCE

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A Thesis

Submitted to

the Graduate Faculty of

Auburn University-Montgomery

in Partial Fulfillment of the

Requirements for the

Degree of

Master of Science

Montgomery, Alabama
August 6, 2004

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Meagan Houston, daughter of Robert and Rosemary (Harris) Houston was born March 17, 1979, in Cedar Rapids, Iowa. She graduated from South Aiken High School in 1997. She attended Coastal Carolina University in Myrtle Beach, South Carolina and graduated with a Bachelor of Arts degree in 2001. Upon graduating, she entered Graduate School, Auburn University - Montgomery, in August 2001; graduating in August 2004 obtaining a Master of Science in Psychology. Upon graduating from Auburn University-Montgomery, she entered Graduate School, University of Tennessee, in August 2004, pursuing a Ph.D. in Counseling Psychology.

THESIS ABSTRACT

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ON WOMEN'S MATH PERFORMANCE

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Master of Science, August 6, 2004
(B.A., Coastal Carolina University, 2001)

80 Typed Pages

Directed by Peter Zachar, Ph.D.

The purpose of this study was to investigate the effects of math anxiety and stereotype threat on women's math performance. Math Anxiety refers to feelings of apprehension about mathematics performance. Stereotype threat refers to performing poorly on a test due to the fear of confirming a negative stereotype about a group to which one belongs. During the first part of the study 131 participants from finite math, pre-calculus algebra, and introductory psychology classes were administered the PHOBUS math anxiety questionnaire and a demographics survey. Participants were then matched by their reported level of anxiety (low, medium, high) and placed in a stereotype threat or a stereotype threat-removed condition. During the second part of the study, a white male researcher administered a math test. He informed participants in the threat condition that they were taking a math test in which men do better than women and

informed the threat-removed condition that they were taking a math test in which women perform better or equal to men.

Overall men performed better than women on the math test; however there was no significant difference between men and women with respect to reported levels of math anxiety. For women only, there was a main effect for anxiety, no effect for stereotype threat condition, and no interaction effect. Women who reported low levels of math anxiety performed better on the math test than women who reported medium and high levels of math anxiety. Women with higher levels of math anxiety were also more likely to blame poor performance on internal factors such as lack of ability.

Additional analyses were conducted examining race and the extent to which participants view math as a male domain. Overall black participants performed worse on the math test than white participants, and black participants reported higher levels of math anxiety. Men who reported high levels of math anxiety were less likely to view math as a male dominated area, and women who reported high levels of math anxiety were more likely to view math as a male dominated area.

Possible reasons for the lack of significant findings with respect to the stereotype threat manipulation are discussed. These include stereotype threat being a weak effect, stereotype threat being dependent on a type of statistical control not used in this study, and participants in this study not having members of the population affected by stereotype threat.

ACKNOWLEDGEMENTS

The author would like to thank Dr. Peter Zachar for assistance with the development of this thesis and the faculty of the Math Department at Auburn University-Montgomery for their cooperation in the data collection process. Thanks are also due to family members (Robert and Rosemary Houston), loved ones and friends for their support during the course of this research.

Style Manual or Journal Used: Graduate School Auburn University Guide to Preparation and Submission of Theses and Dissertations, 2003.

Table Of Contents

List of Tables

Introduction to the Problem

Is it possible for a black person to do worse on an intelligence test when the examiner is a white person, or for a woman to do worse on a mathematics test if the examiner is a male? The answer to these questions is yes. It is possible, and psychologists refer to this phenomenon as stereotype threat. Stereotype threat is the disruption of cognitive processing that occurs when people are in danger of confirming a negative stereotype about a group to which they belong. This threat usually affects minorities (including women) who highly identify with the academic domain being tested (Keller, 2000). Even though stereotype threat is an unconscious process and its effects are temporary and subtle, the long-term consequences of these effects can be devastating if an individual chooses to disidentify with or avoid a particular academic domain. For example, stereotype threat is hypothesized to be one of the reasons why black students perform at least one standard deviation below the mean on standardized tests compared to white students, and public awareness of this difference between black and white students can itself perpetuate stereotype threat.

Having to continuously face stereotypical threat situations can influence minorities to disidentify with the domain of academics and invest in alternative domains where their identity and self-esteem are more secure. Unfortunately, the other domains in which psychological comfort is obtained may not be as beneficial as the academic domain.

Being in the same classroom does not mean that men and women or black people and white people share the same classroom experiences. As research in child development has shown, it is possible for the instructor to be biased so that white males

in the classroom are provided more adequate, detailed, and attentive instruction than others, which can lead the others to develop the negative feelings towards this particular area of academia. For example Sadker and Sadker (1988) report that, from kindergarten to graduate school, teachers give more praise, criticism and feedback to males, who are eight times more likely to call out answers and demand attention. They found that the amount of attention from a teacher is positively correlated with participation and negatively correlated with withdrawal in the classroom. According to Lawrence (2003) minorities, including Blacks, Latinos and Native Americans, are two years behind their White and Asian classmates by the end of fourth grade, three years behind by the end of eighth grade, and four years behind by the twelfth grade. Not performing as well can lead to the development of feelings of hostility and resentment about academia.

In the domain of mathematics, math anxiety impairs performance even more so than does stereotype threat. Those individuals who suffer from math anxiety do not take enough math classes and when they do take math classes they may not learn as much, leading to poor scores on standardized tests. Scores on standardized tests are related to the opportunity to attend college and graduate school. Those who suffer from math anxiety may even choose careers and/or majors that may not be as lucrative as jobs that require more mathematical skills.

Minorities carry the burden of having to constantly seek ways to obtain psychological and economic security in the face of adversities and barriers. They have long faced external barriers hindering them from entering the middle class. These barriers include any stigma they may acquire simply because of their race and/or gender, often attributed to racism and sexism. Although the Civil Rights Movement, until recently,

succeeded in having some of these barriers removed, internal barriers, such as stereotype threat and math anxiety, which may involve an internalization of negative social expectations may be even more insidious factors with respect to the opportunity for minorities to pursue the American dream.

The purpose of this study is to better understand the relationship between the internal barriers of stereotype threat and math anxiety. Increased awareness of all the factors that create barriers to self-improvement among minorities is an important step to reducing the impact of those factors.

Literature Review

Stereotype threat

According to Steele and Arnonson (1995) stereotype threat requires being aware of a negative stereotype about a group to which one belongs. For example, when the stereotype is very negative, it may be threatening enough to disrupt an individual's performance. In situations where the stereotype is potentially applicable, one is at risk of confirming the negative characterization of the group. For example, whenever Black students perform on an explicitly scholastic or intellectual task, they face the threat of being judged by and confirming a negative societal stereotype established by society, specifically, a stereotype about their lack of intellectual ability and competence. However, stereotype threat exists only when the individual identifies or relates to the abilities being tested.

Stereotyped individuals may learn to protect themselves from negative stereotypes by using what Steele (1999) refers to as "disidentification." In disidentification, the person adopts a negative attitude toward the stereotyped activity. Pain is lessened by ceasing to identify with the part of life in which the pain occurs. However, not caring about the activity could mean possessing little or no motivation, and when the activity includes academic performance, disidentification is a high price to pay for psychological comfort. It is a price that groups contending with powerful negative stereotypes about their academic abilities pay too often. If the threat pressures them to disidentify, then academic achievement is rejected as a basis for both self-esteem and personal identity.

Steele and Arnonson (1995) conducted several studies to test their stereotype threat hypothesis. In the first study Black and White students were given a 30-minute test composed of difficult items from the verbal section of the *Graduate Record Examination* (GRE). All participants were asked to provide their verbal and quantitative SAT scores. In the stereotype threat condition, the test was described by a White male experimenter as being diagnostic of intellectual ability, specifically, that it measured "various personal factors involved in performance on problems requiring reading and verbal reasoning abilities" (p.799). In the non-stereotype threat condition the same test was described as a laboratory problem-solving task, specifically, it measured "understanding psychological factors involved in solving verbal problems" (p.799). A third condition, referred to as the non-diagnostic-challenge condition, was used in order to determine if stressing the challenge of the test would further increase participants' motivation and performance. In this condition participants were informed that the test was developed to be very challenging. Participants in both the non-threat and challenge conditions were informed that *ability* was not being evaluated. The experimenter informed participants in all conditions that they needed to put forth their best effort while taking the test.

Steele and Arnonson found that participants in the non-diagnostic-challenge condition performed better than participants in the threat and non-threat conditions. They also found that White participants performed better overall than Black participants. This latter finding confirms past studies that black people and white people differ on standardized test of academic ability (APA Task Force, 1996). They also found that Black participants in the threat condition performed worse than Black participants in the non-threat condition. Black participants in the threat condition also performed worse than

White participants in the threat condition. However, in the non-threat condition Black participants performed as well as White participants. There were no differences reported between White participants in the stereotype threat and non-threat conditions. This suggests that Black-White differences on standardized test of academic ability may be related to stereotype threat.

In reference to the significant findings in this study, the stereotype threat hypothesis predicted an interaction, specifically that race and threat level have an interactive effect. Steele and Arnonson found no significant interaction when an ANCOVA using SAT scores as the covariate was conducted. The ANCOVA was used in order to statistically control for SAT differences among all participants. Significant differences between the groups were found only using orthogonal planned comparisons.

In a second study, female participants were either assigned to a threat condition or a non-threat condition (race and gender of experimenter was not specified). Male participants were not used due the low availability of Black males as well as the finding of no gender differences in the first study. Nor did Steele and Arnonson use a non-diagnostic-challenge group, and the time allowed to take the test was reduced from thirty to twenty-five minutes. Steele and Arnonson also examined several additional factors. They measured the amount of time spent on each test item. They calculated the percentage of correct items related to all items attempted (accuracy). They also measured the number of items completed.

Findings from this second study were consistent with those from the first study. White participants performed better than Black participants overall, but Black participants performed as well as White participants when no stereotype threat was

present. Black participants in the threat condition performed worse than Black participants in the non-threat condition. These findings replicate the somewhat weak effect from the first study. Furthermore, in this study the interaction effect was significant.

Steele and Arnonson also found that Black participants in the threat condition took longer to respond to items than White participants and Black participants in the non-threat group. Black participants in the non-threat condition responded to items as quickly as did the White participants. Black participants in the threat condition had lower accuracy and completed fewer items compared to Black participants in the non-threat condition and White participants in both conditions. There was no significant difference between Black and White participants with respect to accuracy and completion of items in the non-threat group.

In a series of studies, Spencer, Steele, and Quinn (1999) investigated stereotype threat with respect to women's math performance. Eccles (1987) claims that mathematics and related areas of study are consistently stereotyped as a masculine field, and women are underrepresented in fields that involve high levels of mathematics. According to Hyde et, al. (1990) negative attitudes about math have a detrimental impact on women's current and future math performance as well as their career choices. In effect, women should be vulnerable to stereotype threat when asked to do math.

In a first study, Spencer et al. chose a sample of equally, highly qualified men and women in the domain of mathematics. They were required to have scored above the 85^{th} percentile on the math portion of the SAT or ACT, and they were required to have completed at least one semester of calculus, obtaining a "B" or better. These

requirements were taken to demonstrate investment in mathematics. The participants were randomly administered either a difficult test comprised of items taken from the GRE mathematics subject exam or a test of easier items taken from the quantitative portion of the GRE general exam. The questions were administered on a computer in order to measure the amount of time participants spent on the test (the authors do not make reference to the type of math items selected, i.e. numerical or word problem). All participants were informed by a male experimenter that they would be taking a math test (**race of experimenter was not specified**).

The results revealed that men and women performed equally on the easier math test. Participants in the difficult test condition performed worse than participants in the easier test condition. Men in the difficult test condition performed worse than men and women in the easier test condition. Women in the difficult test condition performed worse than men and women in the easier test condition. Importantly, women in the difficult test condition performed worse than men in the difficult test condition. Overall, women's performance appeared to decrease with the increase of item difficulty.

Spencer et al. hypothesized that if women performed worse due to stereotype threat, then eliminating the threat should improve performance. If performance was worse due to actual ability differences between men and women, then women should have performed worse on a difficult math test in comparison to men regardless of the presence of stereotype threat.

In a second study Spencer, et al. (1999) tested the effects of stereotype threat directly by giving all participants a difficult math test (similar to the test in the first study), but varied how the test was presented. Participants in a threat condition were

informed by a male experimenter that the test had shown gender differences in the past. Participants in a non-thereat condition were informed by a male experimenter that the test had never shown gender differences in the past.

Spencer et al. found that women participants in the threat condition performed worse than men, while women in the non-threat condition performed just as well as the men. These results suggest that women's underperformance on these difficult math tests resulted from stereotype threat rather than sex-linked differences, i.e., stereotype threat is a causal factor.

Spencer et al. (1999) conducted a third study that replicated study 2, but with a less selective sample and a wider array of problems. Instead of comparing a threat to a non-threat condition, they compared a control condition, in which participants were given no information about gender differences on the math test,. to a non-threat condition, in which participants were informed that there were no gender differences on the test. Participants selected for this study scored between 400 and 650 on the math portion of the SAT and had completed less than one year of calculus. They were administered a paper and pencil test composed of easier items taken from the math portion of the Graduate Management Test (GMAT). The directions, given by a male experimenter, were the same as those given in studies 1 and 2.

In this third study they found that women in the control condition performed worse then men in the control condition, but women in the non-threat condition performed as well as men in both the control condition and the non-threat condition. These results suggest that the removal of stereotype threat improves women's math performance.

Oswald and Harvey (2000) examined the impact of stereotype threat and a hostile environment on women's math performance. Each participant was assigned to either a hostile or non-hostile condition, and a stereotype threat or non-threat condition. The hostile condition was created by using a sexist cartoon depicting a woman as being less intelligent at math. The sexist cartoon was placed in front of the desk where participants would be taking the test. In the non-hostile environment, no cartoon was presented. Participants in the stereotype threat condition were informed by a white male experimenter that they had thirty minutes to complete fifty math items and no reference to gender differences were made. Participants in the non-threat group were given the same instructions by a white male experimenter with the additional statement that males and females do equally well on this test. Participants were also given a state anxiety measure in order to measure any immediate state anxiety due to stereotype threat and a hostile environment.

The results revealed no difference between the hostile and non- hostile conditions, and no difference between the threat and non-threat conditions, yet there was an interaction between the variables. Within the hostile condition, those in the stereotype threat group performed worse than the non-threat group. Within the non-hostile condition, there were no differences between the threat and non-threat groups. Unexpectedly, participants in the threat-hostile group performed better than participants in the threat-non-hostile group.

In addition, Oswald and Harvey attempted to understand the psychological processes underlying decreased performance caused by stereotype threat. Participants were asked to complete a cognitive response-listing task in which they were asked to

report all thoughts that occurred during the math test. They also examined if participants' thoughts were correlated with levels of self-presentation, anxiety, and self-efficacy.

Results indicate that participants in the threat condition had more negative thoughts than participants in the non-threat condition, but there was no difference between the groups with respect to thoughts about self-presentation, anxiety and self-efficacy. Oswald and Harvey speculated that the relationship between stereotype, hostile environment, and decreased math performance is non-conscious, meaning that participants are not consciously aware of the impact that stereotype threat and hostile environment has on their cognitive processing.

Keller (2000) examined the effects of negative stereotype expectations, or blatant stereotype threat, on both women's math performance and their tendencies to increase self-handicapping. *Self-handicapping* is a defensive strategy involving a search for external explanations for possible weak performance. According to Keller the manifestation of self-handicapping tendencies should be related to the degree of uncertainty regarding performance on a task created by stereotype threat manipulation. Keller hypothesized that increasing the applicability of negative stereotypic expectations would result in a decrease in performance by female participants. Keller also hypothesized that heightened awareness of stereotype threat is related to self-handicapping tendencies.

Keller selected male and female ninth grade students. All students had math as a regular subject. A male experimenter administered a paper and pencil math test, which consisted of twenty math problems. The math problems consisted of fourteen problems taken from the *Third International Mathematics and Science Study* and six problems

were taken from the math portion of the *Graduate Management Test (*GMAT). All problems were presented in multiple choice format. Participants in the stereotype threat condition read a statement prior to taking the math test that stated "males perform better on this test than females". Participants in the control condition did not read this statement. Following the twenty-minute math test, participants completed two items that measured self-handicapping tendencies: "How much stress have you been under lately?" and "How unfair/tricky did you find the test?"

Using an ANCOVA, with participants' math grades from the previous year as a covariate, Keller found that, overall, female participants who were introduced to the stereotype threat condition displayed poorer performance. Females in the threat condition performed worse than males in the threat condition. Females in the threat condition also performed worse than males and females in the control condition. However, females in the control condition performed equally to males in the control condition. With respect to self-handicapping, Keller found that, overall, female participants in the stereotype threat condition had a greater tendency to self-handicap. Females in the threat condition had a higher tendency to self-handicap than males in the threat condition. Females in the threat condition also had a higher tendency to self-handicap than males and females in the control condition. There were no gender differences in self-handicapping in the control condition.

Keller concludes that these findings indicate that increasing the awareness of a negative stereotype can result in a decrease in performance. He also claims that blatant stereotype threat induces the need to protect the self from negative attributes, which may explain why females in the threat condition were more likely to develop tendencies to

self-handicap than males in the threat condition and males and females in the control condition.

In reference to the significant findings in this study, Keller found a main effect using an ANCOVA, but found no significant interaction when an ANCOVA using participants' math grades from the previous year as the covariate, was conducted. The significant differences were found using a planned comparison. The use of planned comparisons is important because Steele and Arnonson (1995) also used planned comparisons when examining the effects of stereotype threat. The use of a less rigorous statistical analyses suggest that stereotype threat is a weak effect.

Quinn and Spencer (2001) hypothesized that stereotype threat interferes with mathematical problem solving by impairing a woman's ability to formulate mathematical strategies. They believe that women have the conceptual skills necessary to solve difficult math problems, but the additional anxiety and diminished cognitive capacity associated with stereotype threat interferes with their ability to strategize, which requires attentional resources and focused concentration. To test this hypothesis, they examined whether removing the requirement for strategizing improved women's performance when stereotype threat was high.

Quinn and Spencer exposed both males and females to a stereotype threat condition. A female experimenter informed them that they would be taking a math test. Participants were then randomly assigned to take one of two tests. One test consisted of word problems and the other test consisted of the same word problems, converted into numerical or algebraic problems. The groups were of mixed gender and the experimenter was unaware of which type of test each participant received. The type of test (word

problem or numerical) also varied within groups. The experimenter ended the testing session after 15 minutes. The word problem test required strategizing, specifically, converting the words into numeric problems. Although the amount of stereotype threat was not manipulated in either testing condition, Quinn and Spencer assumed that the amount of stereotype threat in this situation, a difficult word problem test in which one's ability is being judged, should have been high enough to impair women's math performance.

Results indicate that women did not score as high as men on the tests that contained word problems, however when the word problems were converted to mathematical equations, women and men performed equally. Quinn and Spencer concluded that the women had the mathematical ability and knowledge needed to solve problems, but stereotype threat interfered with their ability to strategize, specifically to convert the word problems when the math content was presented in word problem form.

Quinn and Spencer note that women must still care about math and believe they have the skills to do well on a test for stereotype threat to affect performance. Unfortunately, some women disassociate themselves from math at an early age, and for these women removing stereotype threat will probably not affect their score. Thus the cultural stereotype about women's inferior math abilities works in many ways. It may account for women's greater anxiety about their math skills, it may discourage women from math classes, and fewer women may value math as an important personal ability.

Arnonson, Lustina, Good, Keough, Steele, and Brown (1999) claim that a stigmatized or negatively labeled identity may not be necessary for a person to suffer from the effects of stereotype threat, because in theory, stereotype threat derives its

power from a motive common to all individuals, the motive to sustain a self-image of goodness and competence. Stereotype threat is said to arise when these motives are threatened by an awareness of an ability-depleting stereotype, which can be confirmed by low performance. Arnonson et al. also add that because most people are motivated to feel and to appear competent, nearly anyone can experience the pressure of stereotype threat in some situations, and thus suffer the short-term consequences of impaired performance.

Arnonson et al. tested this hypothesis by attempting to invoke stereotype threat in white males. Male undergraduates who scored 610 or above on the math section of the SAT were told by a white female experimenter that she was conducting a study with differences in math ability. Participants in the stereotype threat condition were given a packet of articles to read about the phenomenal math achievement of Asians and were informed that the study was specifically concerned with understanding why Asians appear to outperform other students, specifically white students, on tests of math ability. Participants in the non-threat condition did not read the articles or hear any reference to Asian-White ability differences. All participants were administered a computer based math test composed of eighteen questions from the GRE mathematics subject test, and they were given twenty minutes to complete the test. Arnonson et al. found that participants in the stereotype threat condition solved fewer problems than participants in the non-threat condition.

Arnonson et al. claim that this indicates that contrary to the theories that state stereotype threat affects those who are stigmatized; stereotype-related underperformance

does not appear to require the existence of doubts "drummed" in by chronically stigmatizing conditions or by minority status.

In a second study, Arnonson et al. examined the effects of stereotype threat on those individuals who are highly identified with the domain of mathematics. Participants were white males enrolled in a calculus course that could only be taken if students acquired a quantitative SAT score of 550 or above. Based on responses to a math attitude questionnaire, participants were divided into three groups, high-math identified, moderate-math identified, and low-math identified. Only highly and moderately math identified participants were used, and all participants were randomly assigned to a threat or a non-threat condition. Participants in the stereotype threat condition were informed that the study was attempting to understand why Asians are superior to other groups in the domain of mathematics. Participants in the non-threat group were informed that the study was being conducted in order to understand the mental processes underlying math ability. All participants were administered a math test that was composed of math problems from the math subject GRE practice booklet.

The results indicated a significant interaction in reference to math identification by experimental condition. High math identified participants performed worse on the test in the stereotype threat condition than high math identified participants in the non-threat condition. Moderately identified participants performed worse in the non-threat condition than moderately math identified participants in the stereotype threat condition. Arnonson et al. claim that these results show that individuals who are highly identified with mathematics are more prone to the effects of a stereotype threat. Those individuals

who are not highly identified with mathematics are not prone to the effects of stereotype threat.

Arnonson et al. claim that these findings suggest that stigma is not necessary for stereotype threat to undermine performance. Situational pressures alone (the stereotype threat about Asians combined with a high desire to perform well) were sufficient to interfere with performance.

Smith and White (2002) claim that an implicitly activated stereotype threat may have the same impact as an explicitly activated stereotype threat. An explicit reminder may be more detrimental to performance because it makes the relevance of the stereotype hard to ignore, whereas an implicit threat may make it easier to ignore the stereotype.

They examined the effects of explicit stereotype threat, implicit stereotype threat, and nullified stereotype threat on women's math performance. Explicit stereotype threat is activated by directly reminding participants of the stereotype, by directly increasing the awareness of their group membership, or both. Implicit stereotype threat is defined as an enduring threat that already exists and does not require any reminder. Just being placed in the situation may trigger the threat, and thus affect performance under everyday "normal" conditions. Nullification of a stereotype occurs when participants are informed that no differences exist between participants' performance.

Participants were White female students from an undergraduate psychology course. The researchers initially determined the extent to which an individual identifies with mathematics by administering the Domain Identification Measure (DIM), which included an assessment of identification with the math domain. The study was introduced as the testing of a new math instrument called the "P.M.A.A."

Participants in the explicit stereotype threat condition and nullified stereotype threat condition were asked to read an article "to get a better idea" (p.183) about the study. The article explained that men were better at math than women and that this superiority may be a result of biological differences. Participants in the explicit stereotype threat condition were also informed by the experimenter that on the P.M.A.A. men also perform better than women. Participants in the nullified stereotype threat condition were informed by the experimenter that on the P.M.A.A. men and women perform equally well. Participants in the implicit stereotype threat condition were given no information about math performance differences.

The P.M.A.A. does not exist; instead each participant was randomly administered either a "typical" math exam or an "atypical" math exam. Both exams were timed and administered using a computer. The typical math exam consisted of ten moderately difficult items modeled after the GRE, general quantitative test. These test items were expected to invoke more stereotypical thoughts regarding gender and mathematics. The atypical math exam consisted of two phases: an initial two-minute period to study a table of measurements and the actual testing period. This test was made up of thirty-five computations which represented the measurement conversions participants studied earlier (e.g. 3 hrs = seconds). Being that this test was composed of conversion problems that are dissimilar to traditional math problems, it was expected that these items would not prime expectations for gender differences.

Using an ANCOVA with participants' math domain identification scores as the covariate, Smith and White found a stereotype X exam type interaction. Stereotype threat condition (explicit, implicit, nullified) did not impact performance on the atypical

exam. However, on the typical exam, participants, in the implicitly and explicitly activated stereotype threat conditions performed worse than participants in the nullified stereotype threat condition. Smith and White conclude both explicit and implicit threats are equally harmful to performance on the typical math exam.

In a second study, Smith and White (2002) examined the impact of explicit, implicit, and nullified stereotype threat on what past literature refers to as the traditionally non-stigmatized group (often treated as the "normative" group) of white males. Smith and White claim that even though white males are not traditionally viewed as 'victims' of stereotype threat, they may still be influenced by a less ubiquitous stereotype.

White male participants were selected from an undergraduate psychology course. The same procedures from the first study were implemented. Participants in the explicit stereotype threat condition were informed by the experimenter that on the P.M.A.A. men perform better than women. Participants in the nullified stereotype threat condition were informed by the experimenter that on the P.M.A.A. men and women perform equally well. However, in this study participants assigned to the explicit stereotype threat condition and the nullified stereotype threat condition read an article that described Asian Americans as being superior to White Americans in mathematical performance, and all participants' were administered the typical exam.

Smith and White found a significant main effect of stereotype threat condition on math performance. Participants in the implicit and explicit stereotype threat conditions performed worse than participants in the nullified stereotype threat condition. There were no differences in scores between the implicit and explicit stereotype threat conditions.

Smith and White claim that this finding suggests that for White males, an implicitly activated stereotype threat appears to be triggered by normal math test taking conditions, leading to a level of poor test performance, similar to that with the explicit stereotype threat. They also note that nullification of the stereotype threat appears to positively impact performance.

Schamder (2002) claims that social identity is an important variable in the development of stereotype threat. He describes social identity as the extent to which one identifies with his or her social group (e.g. race, sex). Just as domain identification is important in the prevalence of stereotype threat, so is the degree or extent to which an individual identifies with his or her social identity. Schmader stated that a basic factor of social identity is that people are motivated to maintain positive social identities and social identity is threatened when one's in-group compares unfavorably with the out-group.

Schmader attempted to examine group identification as a moderator of stereotype threat effects among white male and female undergraduate students with quantitative GRE scores ranging from 500 to 700. All participants completed a self-identity scale, which included items such as "being a woman/man is an important part of my self image." Participants were then given instructions by a tape-recorded male voice, who introduced himself as a researcher and informed participants he was developing a standardized math exam. He explained that he was interested in each individual's performance on the test and that he would be comparing participants' individual test scores to those of other students. He also stated that the scores on the test would be used as an indicator of their personal math ability.

Participants were randomly assigned to one of two conditions. Those in the Gender Not Relevant condition were given no further information on the test and gender was not mentioned. In the Gender Relevant condition, the male on the tape continued to explain that he was interested in how women score compared to men on the test, and he also added that because he would be comparing women's scores to men's math scores, he would be using each individual's score as an indicator of women's and men's math ability in general. The participants' were asked to provide their gender on the cover sheet of the math exam. The math exam consisted of twenty multiple-choice items taken from the quantitative section of the GRE.

Results indicate a significant three-way interaction among gender, gender relevance, and gender identification. In the Gender Relevant Condition, when gender was linked to test performance and gender identification was high, women performed worse than men. When gender was linked to test performance and gender identification was low, women performed equally to men. Women in the Gender Not Relevant condition performed equally to men, regardless of whether they were high or low in gender identification.

Schmader also found that the gender identity relevance manipulation only affected women who tended to be highly identified with their gender. Women in the Gender Relevance condition who were highly gender-identified answered fewer problems correctly on the math exam than women in the Gender Not Relevant condition. This same manipulation (gender relevance) had no significant effect on women with lower levels of gender identification or on men with either high or low levels of gender identification.

With respect to number of items attempted, Schmader found that women in the Gender Relevant condition who were highly gender-identified attempted fewer items than men in the Gender Relevant condition. Schmader notes that making gender identity relevant led women to attempt fewer items only if they had higher levels of gender identification. With respect to accuracy (the percentage of items answered correctly out of the total number of items attempted), men were more accurate than women.

In summary, Schmader stated that women showed poorer performance and answered items less accurately than men on a stereotype relevant task when their social identity was linked to their test performance, but only if they considered gender to be an important part of their self-definition. Women who did not feel that gender was central to their self-concept performed equally to men regardless of a manipulation expected to produce stereotype threat.

O'Brien and Crandall (2003) hypothesized that arousal is a substantial component of stereotype threat and, therefore, since arousal decreases performance on a difficult task and increases performance on an easy task, then women in a threat condition should show a decrease in performance on a difficult task and an increase in performance on an easy task when compared to women in a non-threat condition. According to O'Brien and Crandall, operating under the fear and anxiety of confirming a negative stereotype or being categorized as an exemplar of a negative stereotype is sufficient to create arousal. They hypothesize that when the task is complex or difficult, arousal will lead to an increased number of inappropriate responses causing a decline in overall performance. When the task is simple, arousal will lead to an increase in the number of appropriate responses and increasing overall performance. To test this hypothesis they conducted a

study using undergraduate students enrolled in an introductory psychology course. Participants were given a packet of materials which included three math tests and a statement which claimed that previous research had sometimes shown gender differences and sometimes shown no gender differences with respect to mathematics. Participants in the stereotype threat condition were informed that the test they were taking had shown gender differences. (This statement was hypothesized to create threat, thereby creating arousal.) Participants in the non-threat condition were informed that the test they were taking had shown no gender differences. All participants were administered three tests: an easy math test, a difficult math test, and a test to measure math persistence. (The test to measure math persistence dealt with mental math. Participants were instructed to answer twenty-four addition and subtraction problems in their head and to write down the answers.)

The results indicated a three-way interaction between gender, threat, and test difficulty. Women in the stereotype threat condition performed worse on the difficult math test than men in the stereotype threat condition. Women in the stereotype threat condition performed worse on the difficult math test than men and women in the non-threat condition. Men's performance on the difficult math test showed no differences by condition. Women in the stereotype threat condition performed as well as men on the easy math test. Women in the stereotype threat condition performed better on the easy math test than women in the non-threat condition. Men's performance on the easy math test did not vary as a function of gender.

In summary, the O'Brien and Crandall study shows that under stereotype threat women perform better on an easy math test and worse on a difficult math test than

women not exposed to a stereotype threat, and levels of arousal can be used to explain this phenomenon.

Math Anxiety

According to Richardson and Sunin (1972) math anxiety is defined as a feeling of tension and anxiety that interferes with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations. Math anxiety is assumed to affect the level of required mathematics one is willing to pursue and the ability to learn and perform mathematical problem solving. Richardson and Sunin also claim than many people who do not suffer from general anxiety do suffer from mathematics anxiety. Richardson and Woolfolk (1980) have argued that math anxiety is most meaningfully conceptualized as a reaction to both mathematical content (numbers) and to evaluative situations, such as taking a test on mathematics. In particular, as it refers to mathematical content, math anxiety may be associated with feelings of perfectionism, inferiority, concerns about gender roles, and identity.

According to Ashcraft (2002) the most unfortunate consequence of math anxiety is math avoidance. Individuals who are highly anxious about mathematics avoid math at all costs. They may take fewer elective math courses in high school and college, and when they do take math courses they receive lower grades. Those who avoid math are exposed to less math in school and may learn less of what math they do take, resulting in lower scores as measured by standardized tests.

Tobias and Weissbrod (1980) describe math anxiety not as the cause of math avoidance; rather they believe it refers to the panic, helplessness, paralysis, and mental

disorganization that arise among some people when they are required to solve mathematical problems. Tobias and Weissbrod claim that the discomfort varies in intensity depending on the person. This discomfort may arise from feelings of helplessness in problem solving, lack of out of classroom opportunity to practice mathematics, role conflict, or unfortunate experiences with a particular math teacher. Math anxiety may be a critical factor in student's educational and vocational decisions. It may also influence students' achievement of their educational and career goals.

Betz (1978) examined factors that could be related to the prevalence and intensity of math anxiety in college students, and the extent to which levels of math anxiety differ as a function of sex, age, and prior preparation in math. Betz selected participants from three groups. One group of participants was selected from a basic mathematics course (MATH 1), which constituted a review of high school algebra. Participants enrolled in this class were least ready for college level math. They either had less than three years of high school math or did poorly on the math placement test. A second group of participants was selected from a pre-calculus course for students planning to major in engineering, the physical sciences, mathematics or, pre-medicine (MATH 2). These participants tended to have more high school math and scored higher on the placement test than those participants in MATH 1. A third group of participants was selected from a general psychology course. These participants represented several major fields and differed from each other with respect to math background and achievement.

Betz found that participants in the MATH 1 group displayed higher levels of math anxiety than participants in both the MATH 2 and in the general psychology group. However, there was no difference between participants' level of anxiety in the MATH 2

and the general psychology group. Overall female participants reported higher levels of math anxiety than males. Females in the MATH 1 group and the general psychology group reported higher levels of math anxiety than males in the MATH 1 and general psychology group. However, there were no differences in math anxiety between females and males in the MATH 2 group.

Betz also found higher levels of math anxiety are related to both age and number of years of high school math. The correlation between math anxiety and number of years in high school math was negative for males and females in all three groups. Betz claims that the more prior math preparation students have, the less likely they are to report high levels of math anxiety.

Adams and Holcomb (1986) used a canonical analysis to examine variables that would lead to a better explanation of the relationship between math anxiety and math performance. They selected participants enrolled in an upper level statistics course for graduate majors in education and psychology. All participants were administered the Wonderlic Personnel Test, which measures general ability, the revised Mathematics Attitude Scale, which measures basic attitudes about math, and measures of state anxiety, trait anxiety, and math anxiety. Participants were also administered a basic arithmetic skills test and a basic algebra skills test. They also examined total scores on three problem-oriented, multiple-choice tests administered for a grade during the statistics course.

Adams and Holcomb found that high performance in mathematics was significantly related to skills in mathematics, high general mental ability, skills in algebra, and low math anxiety. High anxiety about mathematics was related to negative

attitudes towards mathematics, poor algebra skills, poor mathematics skills, high state and trait anxiety, and low scores in mathematics.

They also claim that there is one canonical variable that explains the relationship between math anxiety and performance - they call it Mathematics Efficiency. Variables that make up this domain, with loadings in parentheses, include anxiety about mathematics (+), attitude towards mathematics (-), arithmetic skills (-), algebra skills (-), achievement in beginning statistics (-) and state anxiety (+). Mathematics Efficiency is defined as the ability to use one's energy, time and skills in mathematics in an effective manner.

Llabre and Suarez (1985) examined whether stereotyping math as a male domain was associated with levels of math anxiety in males and females, and whether math anxiety differentially predicted math performance in males and females of equal math aptitude. Participants were selected from eight sections of an Introductory Algebra course. This course was designed for students who were not majoring in mathematics or any mathematics related fields, and who had not had more than two years of high school math. The mean score on the mathematics section of the SAT was equivalent for males and females in all eight sections. During the first day of class all participants were randomly administered the *Revised Mathematics Attitude Scale* (RMARS), and the Male Domain Scale (MD) from the *Mathematics Attitude Scale.*

Llabre and Suarez found that females reported higher levels of math anxiety on the math anxiety measure than males. Males tended to stereotype math as a predominantly male domain to a greater extent than females on the attitude scale. They also, unexpectedly, found that females received higher grades in the Algebra class than

males. They concluded that these results indicated that levels of math anxiety may differ between males and females in samples of participants with low levels of math background. With respect to the significant finding that females received higher grades than males, Llabre and Suarez claim that math anxiety may lead to the avoidance of math, however once a student enrolls in a math class, the level of anxiety may not affect their final grade.

Lupkowski and Shumaker (1991) compared the math anxiety level of mathematically talented males and females. They also compared talented students' mean *Math Anxiety Rating Scale* scores to other samples of participants from previous math anxiety studies using the same scale as a measure of math anxiety. The participants totaled an average combined SAT score of 1200 at age 16, and were attending an early college entrance program for mathematically and scientifically talented students. The mean G.P.A. of these participants was 3.22.

Lupkowski and Shumaker found that participants in the talented program displayed lower levels of math anxiety. They also found that there was no difference in levels of math anxiety between males and females in the talented group.

Lupkowski and Shumaker found that when compared to other samples of participants, the talented participants tended to be less math anxious than typical college students. They also found that when mean anxiety scores were compared to participant's anxiety scores from a study that examined levels of math anxiety by major, the talented participants tended to be less math anxious than participants with Humanities majors. However, the talented participants tended to be more math anxious than college students majoring in Physics. Lupkowski and Shumaker claim that these findings indicate that

students who have high math ability and high achievement in mathematics tend to show lower levels of math anxiety.

Statement of the Problem

As stated in the literature review, stereotype threat refers to a disruption of cognitive processing that occurs when people are in danger of confirming a negative stereotype about a group to which they belong. For example, whenever black students perform an explicitly scholastic or intellectual task, they face the threat of being judged by and confirming a negative stereotype about their intellectual ability and tend to show a decrease in performance (Steele & Arnonson, 1995). Rather than being limited to black people, stereotype threat has been demonstrated to occur in any situation where it is possible for people, whether they are black or white, male or female, to confirm a negative stereotype about the group to which they belong (Steele & Arnonson, 1995). Stereotype threat usually occurs in those individuals who tend to be either highly identified with the academic domain being tested and/or highly identified with the group which is being stereotyped (Spencer, Claude, & Quinn, 1999; Steele & Arnonson, 1995). Highly identified individuals may feel more pressure to disconfirm the stereotype, thereby causing more cognitive disruption. Stereotype threat has been found to increase negative thoughts and emotions about the academic area being tested and may cause individuals to engage in self-handicapping, i.e. they may search for external explanations of their poor performance. (Keller, 2002).

Also stated in the literature review, math anxiety is a feeling of tension and fear that interferes with people's cognitive ability to solve mathematical equations or manipulate numbers. Math anxiety can be related to lack of experience with mathematics or negative experiences involving ridicule from teachers, family members, and friends (Betz, 1978). Other factors include the implementation of time constraints and not

understanding math "language" (Tobias & Weissbrod, 1980). Some theorists believe that math anxiety may not even be actual anxiety, but feelings of hostility and resentment portrayed in the form of math anxiety (Ashcraft, 2002). Whether anxiety or resentment, these negative emotions have an effect on the cognitive processing of mathematical problems. Women are more likely to report math anxiety than males; however, in some cases women who report high levels of math anxiety may outperform males who do not report high levels of math anxiety (Llabre & Suarez, 1985). Women who report having careers in math-related fields have more negative thoughts about the area of mathematics than males in math-related career fields.

Stereotype threat and math anxiety are similar in several ways. Stereotype threat appears to cause a decrease in performance whenever it is activated (Arnonson et al. 1999; Keller, 2002; Quinn & Spencer, 2001). Math anxiety can also cause a decrease in performance (Richardson & Sunin, 1972; Tobias & Weissbrod, 1980). Stereotype threat and math anxiety are both linked to negative thoughts and negative emotions which have the potential to interfere with cognitive processing (Adams & Holcomb, 1986; Ashcraft, 2002; Llabre & Suarez, 1985; Lupokowski & Randall, 1991;).

To preserve self-esteem and personal/emotional comfort, individuals attempt to prevent stereotype threat through the process of *disidentification* and prevent math anxiety through the process of *math avoidance*. Disidentification can lead to the adoption of a negative attitude toward the stereotyped activity. This negative attitude can lead to not caring about the activity, which leads to the rejection of academic achievement. Math avoidance leads to the avoidance of math at all costs. Individuals who avoid math tend to

take fewer math classes and learn less in the math classes they do attend, which could lead to poor scores on standardized tests.

Stereotype threat and math anxiety clearly have a negative impact on minorities, including women (Arnonson et al, 1999; Betz, 1978; Spencer et al, 1999; Steele & Arnonson, 1995;). Although stereotype threat with respect to math can be invoked in white people when compared to Asians, it has been most commonly invoked in women. Math anxiety is more prevalent in women.

Stereotype threat and math anxiety both appear to affect individuals who identify highly with their racial or gender group (Arnonson et al, 1999; Keller, 2002; Quinn & Spencer, 2001; Schmader, 2001; Smith & White, 2002). Individuals who are highly identified with a group are more concerned about not confirming the negative stereotype placed on that group. This means that women who are highly identified about their gender would tend to be more susceptible to developing math anxiety.

Stereotype threat and math anxiety also differ in several ways. Stereotype threat is a non-conscious event (Steele & Arnonson, 1999; Oswald & Harvey, 2000). This means that those who are affected by stereotype threat are not aware of its existence or aware that it has an effect on their performance. Instead of blaming poor performance on internal factors such as lack of ability, they tend to blame poor performance on external factors, such as test difficulty or poor instruction. Those individuals who feel competent and have self-confidence in the area of academic achievement are most affected by stereotype threat. In contrast, math anxiety is a conscious event (Adams & Holcomb, 1986; Betz, 1978; Richardson & Sunin, 1972). Individuals who suffer from math anxiety are aware of their feelings of fear and apprehension towards the domain of mathematics.

Rather than attributing poor performance to external factors, they attribute it to internal factors, specifically, lack of ability. Math anxiety is more likely to occur in those individuals who lack self-confidence in their mathematical ability.

The activation of stereotype threat appears to always affect performance, whereas math anxiety does not always affect performance. Some individuals who report suffering from math anxiety still received better grades in a math class than those who reported no anxiety (Llabre & Suarez, 1985).

Stereotype threat also appears to be temporary. According to the literature, it is possible to alleviate stereotype threat by simply stating that the stereotyped group performs just as well as the non-stereotyped group (Smith & White, 2002; Steele & Arnonson, 1995; Spencer et al, 1999). Nullifying stereotype threat has positive effects on performance. Math anxiety is more stable. The alleviation of math anxiety is a long-term process that involves re-teaching math skills as well as "rewiring" an individual's thoughts and feelings towards mathematics.

The preceding considerations raise questions about the relationship between stereotype threat and math anxiety. If a stereotype such as *women are poor mathematicians* is accepted as being accurate, and it affects performance, individuals may cope with the decreased performance in several ways. If they attribute poor performance to internal factors such as, "I am bad at math," they may develop math anxiety; implying that stereotype threat and math anxiety are overlapping processes, where the impact of the stereotype on performance is explained with an internal attribution, and the resulting long-term decrease in performance is defined with respect to math anxiety. It is interesting that decreased math performance in women does not occur

until adolescence, the same time period that growing social cognitive skills make them more aware of negative stereotypes. Another way an individual may cope with the decreased performance is to disidentify with the domain of mathematics and say "Math sucks, I don't care how I do on the math test."

Other individuals may reject the stereotype and believe that they are competent in mathematics; however, these individuals can still temporarily be susceptible to the negative impact of an explicit stereotype threat. These individuals will most likely attribute poor performance to external factors, such as "the test was unfair."

The literature indicates that math anxiety cannot be easily removed, suggesting it is a trait variable in which the person has internalized a stereotype. If so, stereotype threat may not be able to be invoked in those individuals with high levels of math anxiety. If stereotype threat and math anxiety are more distinct, it may be possible to invoke stereotype threat in people who report high levels math anxiety. Another possibility is that stereotype threat and math anxiety are partly overlapping, but not the same, suggesting that stereotype threat can be invoked in individuals with high math anxiety, but not as strongly as it can be in those with low math anxiety.

In addition, gender identification should effect the extent to which stereotype threat can be invoked. Gender identification refers to the degree to which a person identifies with the gender group to which she or he belongs. According to Schmader (2001) stereotype threat occurs as a function of either making a negative social identity explicit or linking that identity explicitly to one's performance on a task. While *all* women might recognize their membership in the social category "woman," there is likely to be variation in the extent to which they consider this category membership to be a

central part of their self-identity. Individuals who consider their womanhood to be an important source of identity should have a stronger motivation to maintain a positive image of that identity and, therefore should experience greater threat at the suggestion that their group is somehow inferior to other groups. When faced with threats to their identity, those who are highly identified are more likely to engage in behavioral and psychological strategies designed to protect and maintain that social identity. One possible strategy according to Keller (2002) is the strategy of self-handicapping. According to Keller self-handicapping is seeking external explanations for poor performance. Other psychologists refer to self-handicapping as the self-serving bias (Dixon, 1995).

The purpose of the study is to examine the combined effects of math anxiety and stereotype threat on performance. This comparison will involve testing rival hypotheses. If (hypothesis 1) stereotype threat and math anxiety are more independent processes, then: (a) women who report low levels of math anxiety and are exposed to an explicit stereotype threat condition will show worse performance than women who report low levels of math anxiety placed in a threat-removed condition, and women who report high levels of math anxiety and are exposed to an explicit stereotype threat condition will show worse performance than women who have high levels of math anxiety and placed in a threat removed condition. In other words, I expect a main effect for threat.

If (hypothesis 2) stereotype threat and math anxiety have a high degree of overlap (b) women with low levels of math anxiety will do worse in a threat condition, but women who report high levels of math anxiety and are exposed to an explicit stereotype threat condition will perform the same as women who report high levels of math anxiety

and are placed in a threat removed condition. This result is hypothesized because the threat has been internalized and cannot be removed by manipulating situational factors. In other words, we expect an interaction effect when a threat affects only in those with low levels of math anxiety.

Several additional hypotheses address the stereotype threat and math anxiety relationship. In the threat group: (c) The higher the level of math anxiety the more likely an individual will attribute poor performance to internal factors. Individuals who report higher levels of anxiety have been found to possess inadequate mathematics ability therefore they may be more likely to attribute poor performance on the math test to lack of mathematics ability. (d) The higher the level of math anxiety the less likely an individual will attribute poor performance to external factors. Individuals who report low levels of math anxiety have been found to possess adequate mathematics ability, therefore they may be more likely to attribute poor performance on the math test to external factors, rather than relate poor performance to mathematics ability. (e) The higher one's gender identification, the more likely the individual will attribute poor performance to external factors. Individuals who highly identify with their gender group may be more likely to attempt to maintain a positive self-image, thus blaming poor performance on the math test to external factors. (f) Women who report high identification with their gender group will perform worse when exposed to a stereotype threat condition compared to women who report low identification with their gender group and are exposed to a threat condition. Women who highly identify with their gender group may be more prone to the effects of stereotype threat.

Method

Participants

The sample consists of 131 participants from intermediate level college math classes (finite math and pre-calculus algebra). Some of the participants were sampled from four Introductory Psychology classes. Participants from these Psychology classes reported that they were either currently taking or had previously taken finite or pre-calculus classes. The mean age for participants was 23. They were 33% male and 67% female. They were 41% Black and 57% White; the remaining 2% of participants were of either Asian or Hispanic descent. Of the131 students, 55% were classified as freshmen, 25% were classified as sophomores, 12% were classified as juniors and 8% were classified as seniors. Sixty-five percent (65%) of the students were enrolled in finite math classes and 35% of the students were enrolled in pre-calculus classes.

Instruments

Math anxiety was measured by the *PHOBUS* (Ferguson, 1982). The PHOBUS (Appendix A) is a 30-item measure derived from Richardson & Sunin's (1973) 98-item *Mathematics Anxiety Rating Scale* (MARS). According to Nunnelley (1993) the PHOBUS was developed with the goal of shortening the MARS while retaining the measurement of two factors previously identified by Rounds and Hendel (1980), namely, Numerical Anxiety and Mathematics Test Anxiety. Ferguson also wanted to explore an additional factor not identified by Rounds and Hendel, the factor of Abstraction Anxiety. The PHOBUS was developed using ten items identified as loading on the numerical anxiety scale of the MARS, ten items identified as loading on the mathematics test anxiety scale of the MARS, and ten new items relating to anxiety about mathematics of a

more abstract nature than arithmetic. Examples of anxiety producing situations include *figuring the sales tax on an item that costs $1.00* (numerical anxiety), *signing up for a math course* (mathematics test anxiety), and *being told that everyone is familiar with the Pythagorean Theorem* (abstraction anxiety). Participants respond to each item on a five point likert -scale with 1 indicating low levels of anxiety and 5 indicating high levels of anxiety.

Hadfield and McNeil (1994) studied the relationship between personality types and math anxiety among elementary school teachers. They found that scoring near the feeling end of the feeling-thinking subscale of the Myers-Briggs Type Indicator was a significant predictor of math anxiety.

According to Nunnelley (1993) the PHOBUS has a coefficient alpha of .94 for black and white students and correlates at .78 with the RMARS, which is another brief measure derived from the MARS. Ferguson (1982) reports a two-week test-retest reliability of .82. For the current sample the PHOBUS had a coefficient alpha of .94.

For some analyses participants were classified into high math anxiety, medium math anxiety, and low math anxiety groups. Those who scored one standard deviation below the mean on the PHOBUS were placed in the low math anxiety group. Those who scored one standard deviation above the mean on the PHOBUS were placed in the high math anxiety group. Nineteen percent (19%) of the sample was classified as having low levels of math anxiety, 64.9% as having medium levels of math anxiety and 16% as having high levels of math anxiety.

The extent to which participants view mathematics as a male or female domain was measured by the Male Domain scale (MD) of the *Fennema-Sherman Mathematics*

Attitude Scale (Appendix B) (Fennema & Sherman, 1976). The Male Domain scale is intended to measure the degree to which students view math as a male, neutral, or female domain. It asks about (a) the relative ability of the sexes to do mathematics; (b) the masculinity/femininity of those who perform well in mathematics; and (c) the appropriateness of studying mathematics for the two sexes. It consists of 12 items on a one to five likert scale. High scores indicate an increased tendency to stereotype math as a male domain.

In a study by Llabre and Suarez (1985), women tended to stereotype math as male domain while men did not. Springer (1995) found that men tended to stereotype math as a male domain, while women did not. In the Llabre and Suarez study the participant pool was comprised of undergraduate students, whereas in the Springer study the participant pool was comprised of Psychology graduate students.

According to Fennema and Sherman (1976) the MD scale has a split-half reliability coefficient of .87. For the current sample the MD scale had a coefficient alpha of .84.

Participants were also given a mathematics test. The test was composed of twenty word problems and mathematical equations. All questions came from the *Kaplan GRE Practice Manual* (2003). To make sure the test was challenging for the students, math problems were selected with input from professors in the math department. Professors were given examples of math problems and rated which math problems would be considered challenging for individuals in intermediate level mathematics. Students in intermediate level math classes were chosen to control for level of mathematics preparation.

Participants were also administered questions pertaining to self-handicapping and gender identification. Self-handicapping (Appendix B) was assessed with two items taken from Steele and Arnonson (1995): "How much stress have you been under lately?" and "How tricky /unfair did you find the test?" The scales range from 1 (not at all) to 5 (very much). In addition participants were also asked to respond to a question in reference to making an internal attribution: "The test was hard because I am not good at math."

Gender Identification (Appendix B) was measured by a scale developed by Schmader (2001) which assesses the perceived importance of gender identity to self-definition. This measure consists of four items (worded specific to one's own gender) on a scale ranging from 1 (strongly disagree) to 5 (strongly agree). "Being a woman/man is an important part of my self image," "Being a woman/man is unimportant to my sense of what kind of person I am, "Being a woman/man is an important reflection of who I am," "Being a woman/man has very little to do with how I feel about myself." According to Schmader (2001) the four items have an alpha of .70. For the current sample the scale had an alpha coefficient of .54. Both men and women tended to view gender identity as somewhat important to them.

For some analyses participants were divided into a low gender identification group and a high gender identification group. The mean score on the gender identification scale for the sample was 7.5 and the range was 2-15. Participants who scored above the mean were placed in the high gender identification group and those participants who scored below the mean were placed in the low gender identification group. Fifty-three percent (53%) of participants reported low gender identification and 47% of participants reported high gender identification.

Procedure

The researcher asked professors for permission to come to their classes and solicit participants. This aspect of the data collection process required approximately 20 minutes of class time. The researcher informed participants that she was studying psychological factors related to math and provided them with an informed consent form (Appendix D) stating that their participation was voluntary and that they were free to withdraw from the study at any time without penalty. Participants were then given the *PHOBUS* (Appendix A), and a Demographics Survey (Appendix C).

In the second part of the study, all interactions occurred with a white male researcher who returned to the classrooms one week later. Participants were randomly assigned to a threat condition or a threat -removed condition. People in the threat and threat-removed condition were matched according to their reported level of math anxiety. To place participants in high anxiety, medium anxiety, and low anxiety groups, two classes from part one of the study were used to calculate cutoffs for triads. For the two classes the range of math anxiety scores was 30- 112. Participants who reported levels of anxiety between 30 -72 were placed in the low anxiety group. Participants who reported levels of anxiety between 73-90 were placed in the medium anxiety group. Participants who reported levels of anxiety between 91-130 were placed in the high anxiety group. After their levels of anxiety were determined, all participants were randomly assigned to either the threat or the threat-removed condition. Matching occurred on a class by class basis so that people in the threat and threat - removed group would have similar levels of math anxiety.

On the second visit to the classrooms, the researcher announced to the classes that two math tests were being given. He informed them that one math test was designed in such a way that men perform better than women on the test. The second test was designed in such a way that women perform equal to or better than men. The researcher gave people assigned to the threat condition the math test and verbally stated "*The first test I am giving is the math test that is developed so that men do better than women.*" The researcher gave people assigned to the threat-removed condition the math test and stated, "*Now, I am giving the math test that is developed so that women do equal to or better than men.*" The cover sheet for the math test for those assigned to the threat condition read, "*This math test consists of standardized numerical problems and word problems. This math test has been specially designed to be one in which females perform worse than males. Please try to do as well as possible. You have 15 minutes to complete the test.*" The cover sheet for the math test for those assigned to the threat-removed condition read, "*This math test has been specially designed to be one in which females perform equal or better than males. Please try to do as well as possible. You have 15 minutes to complete the test.*"

After finishing the math test, all participants completed a self-handicapping scale, the Male Domain Scale of the *Fennema-Sherman Mathematics Attitude Scale*, and a Gender Identity measure (Appendix B).

As a manipulation check, after taking the math test, students were asked which version of the math test they were administered, the math test with gender differences or the math test without gender differences. Due to either incorrect reporting on the manipulation check (i.e. reporting they took the math test with gender differences, when

they actually took the test with no gender differences) or skipping the manipulation check, 5 participants were discarded from the analysis.

Results

The results will be examined in three sections. In the first section initial analyses looking at some basic assumptions of the study will be conducted. In the second section the hypothesis will be tested. The third section includes additional analyses involving race and assumptions about gender and mathematics.

Initial Analyses

To begin we tested the basic assumption of the study, that women will score lower on the math test than men and that they will report higher levels of math anxiety than men.

Student's t-test results examining differences between men and women on the math test and on levels of math anxiety are presented in Table 1.

Table 1.

Student's t-test's Examining Differences Between Men (n = 43) and Women (n = 88) on the Math Test and Level of Math Anxiety

	Men		Women			
Variable	mean	sd	mean	sd	df	t-obs
Math Test	**5.8**	2.5	**5.1**	2.4	129	1.36*
Math Anxiety	**79.1**	23.4	**79.1**	23.8	129	-.002

*p <.05

According to Table 1, there was a significant difference between men and women with respect to performance on the math test, but no significant difference between them in levels of math anxiety. Overall men performed better than women on the math test.

Before examining the hypotheses we attempted to determine if there were differences between men and women with respect to being in the threat versus the threat-removed condition. To make the issue more clear, rather than looking for an interaction in a gender X condition ANOVA we computed a one-way analysis of variance (ANOVA) with the math test score as the dependent variable and a combination of gender and stereotype threat condition as the independent variable. The results are presented in Table 2.

Table 2.

Analysis of Variance With a Combination of Gender and Stereotype Threat Condition as the Independent Variable and the Math Test as the Dependent Variable (n = 131)

	Male threat		Female threat		Male no threat		Female no threat		df	Sum of Squares	F-obs
	mean	sd	mean	sd	mean	sd	mean	sd			
Gender/Condition	**5.2**	2.5	**5.3**	2.4	**6.3**	2.5	**5.1**	2.5	3	25.3	1.3

*p<.05

The ANOVA was not significant (F 3, 127) = 1.4, p = .256. There were no significant differences between males in the threat and males in the threat-removed, females in the threat and females in the threat-removed conditions with respect to performance on the math test.

Analyses of Hypotheses

To test hypothesis (a) and (b) a 2 (condition) X 3 (level of math anxiety) analysis of variance (ANOVA) of only women participants was conducted. These results are presented in Table 3.

Table 3.

A 2 (condition) X 3 (level of math anxiety) Analysis of Variance (ANOVA) for Only Women Participants (n = 88)

	Anxiety					
	Low		Medium		High	
Condition	mean	sd	mean	sd	mean	sd
Threat	**7**	3.2	**5.2**	2.3	**4.1**	1.9
Threat-removed	**6.1**	3.1	**4.6**	2.0	**4.5**	1.3

	Sum of Squares	df	F- obs
Anxiety	51.2	2	4.5 *
Condition	1.8	1	.32
Anxiety*Condition	3.9	2	.29
Error	466.6	82	
Total	523.7	87	

*p <.05

The analysis revealed a significant main effect for anxiety (F 2, 85) = 4.5, p = .014. Taking the regression sum of squares and dividing it by the total sum of squares indicates that the difference in anxiety accounts for 9% of the variance on the math test. There was no significant main effect for condition (F 1, 86) = .315, p = .576 and no significant interaction effect (F 2, 85) = .297, p= .744. People with lower levels of math anxiety did better on the math test, but there was no difference between those in the threat and the threat-removed condition with respect to performance on the math test.

The main effect for anxiety was further analyzed with a post hoc Tukey test. The Tukey test indicated that there was a significant difference between the low level anxiety group and the medium level anxiety group at p= .04 and there was a significant difference between the low level anxiety group and the high level anxiety group at p = .02.

The results for hypotheses (c), (d), and (e) can be found in Table 4.

Table 4.

Pearson Correlations for Math Anxiety,Gender Identity and Internal*/External Attributions For All Women (n=88)

	Not good at math (Internal Attribution)	Amount of stress (External Attribution)	Test unfair (External Attribution)
Math Anxiety	.32*	-.09	.13
Gender Identity	.15	-.03	.14

*p <.05

Hypotheses (c), (d), and (e) were tested using zero-order Pearson correlations. This analysis revealed that for women, math anxiety was positively correlated with attributing performance on the math test to internal factors, that is, lack of ability* (r = .32). As a follow up to this finding, a univariate analysis of variance found significant differences between low, medium and high anxiety groups on the internal attribution* (F 2, 85) = 7.2, p = .001. Scheffe post hoc tests indicate that women in the low anxiety group (mean = 1.84) were less likely to attribute performance to low ability than the medium anxiety group (mean = 2.8) and the high anxiety group (mean = 3.24).

There was however, no correlation between the level of women's math anxiety and the extent to which their performance on the math test was attributed to external

factors, that is the test being unfair (r = .13) or their being under high levels of stress (r = .09). There was also no correlation between women's reported level of gender identity and the extent to which their performance on the math test was attributed to the external factors of the test being unfair (r = .14) and amount of stress (r = .03).

When Pearson's correlations were computed for women in the threat condition only, similar results were found. Level of math anxiety was correlated with attributing performance on the math test to internal factors (r = .36) and there was no correlation between level of math anxiety or gender identity with the extent to which women attribute performance on the math test to external factors. For math anxiety the correlations were amount of stress (r = .04) and the test being unfair (r = .18). For gender identity the correlations were amount of stress (r = .08) and the test being unfair (r = .21).

To test hypothesis (f) we ran t-tests examining differences between levels of gender identity and scores on the math test for women placed in the threat condition. The results are presented in Table 5.

Table 5.

Student's t-test Examining Differences Between Levels Of Gender Identity And Scores On The Math Test For Women In The Threat Condition (n = 49)

Gender Identity	Low		High		df	t-obs
	mean	sd	mean	sd		
	5.5	2.8	**5.1**	2.3	47	.515

*p <.05

According to Table 5, there was no significant difference between women who highly identify with their gender and women who do not highly identify with their gender with respect to performance.

Additional analyses

In addition to gender differences, stereotype threat occurs in the context of racial differences. Therefore, we decided to conduct an analysis on race. Student's t-tests examining differences between black and white participants on the math test and levels of math anxiety are presented in Table 6.

Table 6.

t-test for the Math Test and Levels of Math Anxiety Examining Differences Between Black Participant's (n = 53) and White Participants's (n = 74)

	Black		White			
Variable	mean	sd	mean	sd	df	t-obs
Math Test	**4.7**	1.9	**5.9**	2.6	125	3.5*
Math Anxiety	**86.2**	23.4	**73.1**	22.3	125	3.2*

*p <.05

According to Table 6, there was a significant difference between black and white participants with respect to performance on the math test. Overall, white participants performed better on the math test than black participants. There was also a significant difference between black and white participants with respect to reported levels of math anxiety. Overall, white participants reported lower levels of math anxiety than black participants.

Also important to this research topic are people's beliefs about the ability of men and women with respect to the domain of mathematics. We examined this construct with respect to participant's beliefs about the extent to which math is a male domain. We conducted an analysis of variance (ANOVA) with math as a male domain as the dependent variable and level of anxiety as the independent variable for men only. The results are presented in Table 7.

Table 7.

Analysis of Variance With Level of Math Anxiety as the Independent Variable and Math as a Male Domain as the Dependent Variable for Males Only (n = 43)

	Low		Medium		High		(df)	Sum of Squares	F-obs
	mean	sd	mean	sd	mean	sd			
Anxiety	**30.6**	9.4	**27.2**	6.3	**20.0**	7.0	2	374.5	3.9*
Error							40	1891	
Total							43	2266	

*$p < .05$

The ANOVA was significant (F 2, 40) = 3.9, p =.027. Males with high levels of math anxiety were less likely to view math as a male domain.

Post Hoc tests were conducted using the Tukey test. According to the Tukey test there was a significant difference between the low level anxiety group and the high level anxiety group at p= .028 and there was a significant difference between the medium level anxiety group and the high level anxiety group at p= .057.

We also conducted an analysis of variance (ANOVA) with math as a male domain as the dependent variable and level of anxiety as the independent variable for women only. The results are presented in Table 8.

Table 8.

Analysis of Variance With Level of Math Anxiety as the Independent Variable and Math as a Male Domain as the Dependent Variable for Females Only (n = 88)

	Low		Medium		High		(df)	Sum of Squares	F-obs
	mean	sd	mean	sd	mean	sd			
Anxiety	**18.1**	5.2	**22.1**	7.4	**24.7**	7.2	2	387.2	4.0*
Error							85	4110	
Total							87	4497	

*$p < .05$

The ANOVA conducted showed a main effect for anxiety (F 2, 85) = 4.0, p =.022. Women with high levels of math anxiety were more likely to view math as a male domain.

Post Hoc tests were conducted using the Tukey test. According to the Tukey test there was a significant difference between the low level anxiety group and the high level anxiety group at p= .020.

Discussion

The purpose of this study was to investigate the interaction of stereotype threat and math anxiety on women's math performance. There was no effect of stereotype threat with respect to women's math performance, there was an effect for math anxiety, and there was no interaction effect.

Stereotype threat

In this study, it was assumed that women are stereotyped as being less mathematically skilled than men (Betz, 1978). Women who were exposed to an explicitly stated stereotype threat condition displayed no differences in performance on a difficult math test compared to women exposed to an explicitly stated threat-removed condition. Unexpectedly, women exposed to the stereotype threat condition performed just as well as men in both the threat and the threat-removed condition.

One possibility for this negative result is that stereotype threat is a weak effect. Steele and Arnonson's (1995) original study on stereotype threat did not find an interaction effect between threat condition and performance when an ANCOVA was used to analyze the results. In order to obtain an interaction effect Arnonson and Steele (1995) utilized a more sensitive test, constructing weighted contrasts in order to analyze the data. When they conducted a second experiment, the data were also analyzed using weighted contrasts. In a study by Quinn and Spencer (2001) less rigorous statistical analyses were also used in order to obtain an effect for stereotype threat. In a study examining the effects of stereotype threat and arousal conducted, O'Brien and Crandall (2003) used planned comparisons in order to obtain an interaction effect.

In the current study, analyzing the data using weighted contrasts would not have demonstrated a stereotype threat effect. In many cases, those participants in the threat condition performed better on the math test than participants in the threat-removed condition. This result parallels those of Oswald and Harvey (2000), who hypothesized that women who were exposed to a stereotype threat condition, may have been motivated to try harder on a math test.

Another possible explanation for negative results could be that the participants in this study were not members of the population who are subject to experiencing stereotype threat. According to Steele and Arnonson (1995), for stereotype threat to affect performance, one must identify with the domain being tested, in this case mathematics. It is possible that the participants in this study did not identify with the domain of mathematics and were therefore not subject to stereotype threat.

Another possible problem is that the stereotype threat effect requires a type of experimental control that this study did not implement. According to Sackett, Hardison, and Cullen (2004) stereotype threat, if not examined under scrutiny, can easily be misinterpreted. This misinterpretation involves perceiving the removal of stereotype threat as the removal of pre-existing differences between black students' and white students' performance. According to Sackett et. al., Steele and Arnonson (1995) controlled for pre-existing differences in their study. These pre-existing ability differences were controlled by equating participants on the basis of their SAT scores. After ability was controlled, Steele and Arnonson (1995) showed that when placed in a threat condition, black student's performed worse than white student's. In a threat-removed condition black student's and white students performed equally, but the threat-

removed results are a function of statistical control in this design. Actually, in the real world there are performance differences between black and white students. Even if those differences are increased in a threat condition, they are never removed.

Rather than black students versus white students we studied women versus men with respect to math performance. Instead of statistically controlling for ability, we attempted to control for ability by assuming students in finite math and pre-calculus classes possessed equal mathematical skills. However, the math professors at AUM have informed us that finite math and pre-calculus classes include a combination of students who display varying levels of mathematical ability. It could be that the threat versus threat-removed effect did not show up because our design lacked statistical control for ability. Of course, this finding does not explain why women in the threat condition scored higher on the math test than women in the threat-removed condition

A related critique of Arnonson and Steele's (1995) study is that their findings in the laboratory setting might not reflect the effects of stereotype thereat in applied settings. This study was conducted in more of an applied setting, with testing occurring in the classroom. With testing occurring in this natural setting, several factors could have affected the obtained results. There was no incentive for students to perform well on the test; therefore they may not have cared about their test performance. Their participation was voluntary and in some cases occurred at the end of the class period. It is possible that students may have wanted to leave when asked to complete the math test, which may have lead to hasty responses.

Math Anxiety

Consistent with findings reported by Adams and Holcomb (1986), the results indicated that women who reported lower levels of math anxiety performed better on the math test than women who reported medium and high levels of math anxiety. According to Adams and Holcomb (1986), good performance in mathematics is related to low anxiety about mathematics, adequate skills in mathematics, and high general mental ability. High Anxiety about mathematics is related to negative attitudes toward mathematics, poor mathematical skill, and high state and trait anxiety.

According to Adams and Holcomb (1986), negative thoughts about one's ability to perform in mathematics is linked to one's level of math anxiety and it affects the motivation to excel in the area of mathematics. It is, therefore, possible that women who reported high levels of math anxiety may not have been motivated to do well on the math test. If math anxiety is a trait variable, women who reported high levels of math anxiety may not have put forth adequate energy into developing their math skills throughout their educational career, causing them to be less competent, and more anxious. Lack of competence could in turn increase math anxiety, creating a vicious cycle.

According to Pajares and Miller (1995), students' confidence to solve mathematical problems is a powerful predictor of their ability to solve math problems. They found that those students' who reported high self-efficacy in the area of mathematics solved math problems more accurately than students' who reported low self-efficacy in the area of mathematics. This result may also account for the obtained results in the current study given that some of the PHOBUS questions are efficacy questions, for example "being asked to discuss the proof of a theorem about triangles."

Women who reported high levels of math anxiety were also more likely to attribute performance on the math test to internal factors, such as lack of ability. This is consistent with reports from Tobias and Weissbrod (1980) that performing poorly in mathematics may be due to beliefs about one's capability in the area of mathematics. Even though performance on a mathematics test may not be sex-linked, it may be linked to explanations of success and attributions. Women, who report higher levels of math anxiety, appear to internalize poor performance.

There was no relation between level of math anxiety and attributing poor performance to external factors such as the math test being unfair and the amount of stress that participants were experiencing. It was expected that women who reported low levels of math anxiety would attribute performance on the math test to external factors. However, it is possible that these women believed they performed well on the math test. Perhaps these women would have made an external attribution if they had been given a reason to believe that they performed poorly on the math test.

Gender Identity

It was predicted that women who highly identify with their gender group would be more prone to the stereotype thereat attribution that women are not good at math. This high-identifiacation0 might make them more likely to engage in self-handicapping strategies and accept external attributions of performance. In contrast, findings in this study did not indicate a correlation between gender identification and the extent to which women attributed poor performance on the math test to external factors. Of course, as noted earlier, we did not create the poor performance attribution.

For our final hypothesis we found that among women in the threat condition there was no significant difference in performance between those women who highly identified with their gender and those who did not highly identify with their gender, which again contradicts findings from Schmader (2002). With an alpha level of .54, the gender identity scale may not have been a good measure of gender identity. It may also be that math anxiety is more important than gender identity in determining performance differences on a math test, indicating that it is possible for women to be highly identified with their gender group and report lower levels of math anxiety. The researchers would also like to note, however, that in the current study we found that the correlation between level of gender identity and math anxiety for women was $r = .28$ which was significant at $p = .02$.

Additional Analyses

Additional analyses revealed a significant difference between black and white participants with respect to performance on the math test, which supports findings by Steele and Arnonson (1995) that there are differences between black and white students' academic performance. There was also a difference between black and white participants with respect to reported levels of math anxiety. Overall black participants reported higher levels of math anxiety than white participants.

Other analyses involved examining level of math anxiety and the tendency to view math as a male-oriented domain. For the men, those with lower levels of math anxiety were more likely to view math as a male domain. For the women, the opposite pattern occurred. Women who reported high levels of math anxiety were more likely to view math as being a male domain. This pattern makes sense according to the social

psychology concept of the self-serving bias introduced by Miller and Ross (1975). This concept assumes that people attribute success to internal factors and failure to external factors, in this case, low math anxious men attributing math skills to their gender and high math anxious women agreeing that women are not skilled in math. Alternatively, men who report high levels of math anxiety can salvage some self-esteem by not viewing math as a male trait, while women who report low levels of math anxiety will attribute success to internal factors and reject the notion that math is a male skill. These findings may provide an explanation for the conflicting results reported by Llabre & Suarez (1985) and Springer (1995). It is possible that Llabre & Suarez's undergraduate participants were more math anxious and Springer's graduate psychology participants were less math anxious.

Limitations

Several limitations occurred in the current study. Some of the instruments used in the study, specifically the gender identity measures (alpha = .54) and the self-handicapping measures (alpha = .21), had low alpha reliability levels. Due to these low alpha levels it is not clear whether or not the obtained results are a valid indicator of the constructs being tested. If these instruments had higher alpha levels there is a possibility that we may have found better correlations among the variables.

Another limitation is the small sample size. It is possible that with a larger sample size some of the insignificant findings may have been significant. For example, when analyzing performance between women in the threat and the threat-removed condition with respect to levels of math anxiety, there were only 8 participants in the low math

anxiety - threat condition and 11 participants in the low math anxiety- threat-removed condition.

In developing the math test the researchers should have piloted the math test in order to determine the extent of its usefulness. We assumed that the test items were difficult enough to provoke stereotype threat, but not so difficult that they were viewed as impossible. In retrospect, the test should have consisted of easier items. If easier items had been chosen participants may have attempted and correctly answered more items, than they actually did in the current study or felt they had a better chance of succeeding early on while taking the math test.

Although the study used a perception manipulation in order to increase motivation, perhaps a tangible incentive, such as extra credit for superior performance on the math test might have helped. In the current study the researchers also controlled for math preparation, but did not control for math ability. Math ability could have been controlled for by using participants obtained ACT or SAT scores or by obtaining participants current math grades.

Even though the current research indicated that math anxiety was correlated with math performance, this study was not designed to measure causality; therefore we cannot say whether math anxiety causes poor performance, whether poor performance causes math anxiety, or whether both variables are an effect of other variables such as general low academic efficacy feelings.

Future Research

Additional research on the stereotype threat phenomenon is still needed. It would be good to understand specifically under what conditions stereotype threat occurs and does not occur. Once an effect is reliably produced, different aspects of the experimental design could be dismantled in a systematic fashion to better understand the specific factors that produce the stereotype threat effect.

Participant's personality traits, as defined by a test such as the Multidimensional Personality Questionnaire could also be measured (Patrick, Curtin, & Tellegen, 2003). The MPQ measures eleven personality traits which include well being, social potency, achievement, social closeness, stress reaction, alienation, aggression control, harm avoidance, traditionalism and absorption. It is possible that individuals who possess personality traits such as, low achievement, high stress reaction, and high traditionalism may be more prone to the effects of stereotype threat or may be immune to the effects of stereotype threat. Measuring personality traits may also provide some insight as to how math anxiety affects individuals.

It would also be interesting to approach this type of study phenomenologically. Instead of providing participants with items that provide them with choices, they could answer open-ended questions about what they are experiencing while taking a math test. This technique may provide some insight to the cognitive experiences that occur when individuals are exposed to a threat or a threat-removed condition with respect to performance.

Conclusion

In conclusion, based on the current findings, it is believed that ability differences with respect to mathematics do in fact exist between men and women as well as between black and white participants. However, these ability differences cannot be solely explained by the phenomenon of stereotype threat. These ability differences could be the result of several factors, including, but not limited to personal experiences within the area of mathematics, opportunity to develop adequate mathematical preparation and self-efficacy in the domain of mathematics. Stereotype threat is difficult to reproduce in an academic setting, and without understanding what circumstances and/or under what specific conditions stereotype threat occurs, the extent to which or even if stereotype threat affects math performance among women is not clear.

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Appendix A

PHOBUS

The items in this questionnaire refer to events related to mathematics that may cause you to experience negative feelings.

Please use the following scale indicating the extent to which you experience the event as negative

A= not at all
B= a little
C= moderate
D= much
E= very much

1. Determing the amount of change you should get back from a purchase involving several items
2. Listening to a salesman show you how you would save money by buying his higher proceed item because it reduces long term expenses
3. Listening to a person explain how he figured out your share of expenses on a trip, including meals, transportation, etc.
4. Reading your W-2 form showing your annual earnings and taxes
5. Figuring the sales tax on an item that costs more than $1.00

6. Hearing friends make bets on games as they quote the odds
7. Juggling class times around registration time to determine the best schedule
8. Deciding which courses to take in order to come out with the proper number of credit hours for full –time enrollment
9. Working on a concrete, everyday application of mathematics that has meaning to you, such as figuring how much money you can spend on recreation after paying bills
10. Figuring the monthly budget

11. Signing up for a math course
12. Walking into a math class
13. Raising your hand in a math class to ask a question
14. Thinking about a final examination in a math class
15. Thinking about an upcoming math examination one day before

16. Thinking about an upcoming math examination one hour before
17. Waiting to have a math test returned
18. Realizing that you have a certain number of math classes to take in order to fulfill the requirements of your major
19. Receiving your final math grade in the mail
20. Being given a "pop" test in a math class

21. Having to work a math problem that has X's and Y's instead of 2's and 3's
22. Being told that everyone is familiar with the Pythagorean Theorem
23. Realizing that my psychology professor has just written some algebraic formulas on the chalkboard
24. Being asked to solve the equation X2-5x + 6 = 0
25. Being asked to discuss the proof of a theorem about triangles

26. Trying to read a sentence full of symbols such as: A = {x: | x-2 | = ∋∋∋∋∋, I} . !
27. Listening to a friend explain something they have just learned in calculus
28. Opening a math book and not seeing any numbers, only letters, on an entire page
29. Reading a description from the college catalog of the topics to be covered in a math class
30. Having someone lend me a calculator to work a problem and not being able to tell which buttons to push to get the answer

Appendix B

Fennema- Sherman Math Attitude Scale (Male Domain)

The following questions ask about attitudes concerning mathematics.

Please use the following scale to answer the questions:

A= strongly disagree
B= disagree
C= neutral
D= agree
E= strongly agree

1. Females are as good as males in mathematics
2. Studying mathematics is just as appropriate for women as for men
3. I would trust a woman just as much as I would trust a man to figure out important calculations
4. Girls can do just as well as boys in mathematics
5. Males are not naturally better than females in mathematics
6. Women are certainly logical enough to do well in mathematics
7. It's hard to believe a female could be genius in mathematics
8. When a woman has to solve a math problem, it is feminine to ask a man for help
9. I would have more faith in the answer for a math problem solved by a man than by a woman
10. Girls who enjoy studying math are a bit peculiar
11. Mathematics is for men, arithmetic is for women
12. I would expect a woman mathematician to be a masculine type of person

Self-Handicapping Scale

The following questions ask about attitudes about the math test previously completed. Please indicate your answer by circling the number using the following scale:

A= not at all
B= a little
C= moderate
D= much
E= very much

1. How much stress have you been under lately?
2. How tricky or unfair did you find the test?
3. The test was harder because I am not good at math

Gender Identification Scale

The following questions ask about the importance of your gender to you. Please indicate your answer by circling the number using the following scale:

A= strongly agree
B= moderately agree
C= neutral
D= moderately disagree
E= strongly disagree

1. Being a woman /man is an important part of my self-image.
2. Being a woman/man is unimportant to my sense of what kind of person I am. Being a woman /man is an important reflection of who I am.
3. Being a woman/man has very little to do with how I feel about myself.
4. Being a woman/man has very little to do with how I feel about myself.

Appendix C

Demographics Survey

The following survey is part of a research study on the attitudes of college students towards mathematics and situations involving mathematics. The information obtained will be used for research purposes only and all responses will remain anonymous.

Thank you for your participation.

1. Sex: ____ Male _____Female

2. Race: ___ African American ___ Caucasian
___ American Indian/Eskimo ___ Asian/Pacific Islander
___ Latino ___Other

3. List all mathematics courses taken in college: _____
_____
_____
_____

4. Class Standing: ___ Freshmen ___ Sophomore
___ Junior ___ Senior
___ Other

5. College Major: _____

6. Date of Birth: _____

Appendix D
Auburn University at Montgomery

Informed Consent

Meagan Houston (graduate student researcher)
Dr. Peter Zachar (Faculty supervisor)

I am a graduate student at Auburn University Montgomery, and I am inviting you to participate in a study which will be used for the completion of my Master's degree. I am studying psychological factors related to math. You are being asked to participate because you are currently enrolled in a mathematics course. If you agree to participate in this part of the study, you will be asked to complete a measure of attitudes and feelings towards mathematics, and a demographics survey. This part of the study will take 20 minutes. I also ask that you help me finish the study by agreeing to participate in the second part. If you agree to participate in the first part of the study, the researcher will return in one week to conduct the second part of the study. The new data collected form the second part of the study will be based on the responses you provide today. The second part of the study will take 25 minutes to complete.

Your participation is voluntary and you may withdraw from this study at any time. There are no risks from participating in this study. Through your participation you will also learn more about how the research process works. Your responses to the questionnaire(s) will remain confidential. Your date of birth and the last four digits of your social security number will be used to identify your questionnaire so we can match the responses you provide today with the responses you provide in two weeks. Your confidentiality will be maintained at all times. Only group analysis will be performed and no individuals will be identified. No individual responses will be provided to the math instructor and your participation will not negatively impact your obtained grade in your current math class.

If you grant me permission by signing this document, the anonymous data you and others provide will be part of my final thesis report. It may also be submitted for publication in a psychological journal.

Your decision whether or not to participate in this study will not prejudice your future relations with Auburn University Montgomery.

For any questions you have that I do not answer at this time, or concerns about your participation in this study, please contact Dr. Peter Zachar, at Auburn University Montgomery at *(pzachar@mail.aum.edu)*, (334) 244-3311 or Meagan Houston at *houston23@charter.net* , (334) 220-6918

Thank you very much for your time and willingness to participate in this study.
Meagan Houston
Psychology Graduate Student
Auburn University at Montgomery

YOU ARE MAKING A DECSION WHETHER OR NOT TO PARTICIPATE. YOUR SIGNATURE INDICATES THAT YOU HAVE DECIDED TO PARTICIPATE, HAVING READ THE INFORMATION PROVIDED ABOVE.

Signature of Participant _____ Date _____

Witness _____ Date _____

This study has been approved by the AUM Human Subjects committee. It poses no risks, and protects participant's confidentiality.