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Math Ability and Gendered Self-Perceptions

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MATH ABILITY AND GENDERED SELF-PERCEPTIONS

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Math Ability and Gendered Self-Perceptions

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Gender stereotypes continue to be prevalent in American society and have the potential to influence the self-perceptions of both males and females. One stereotype that has been particularly persistent is the belief that mathematics is a masculine subject and that males are inherently better at math than females. Despite increasing evidence showing males and females to be equally competent in the subject, previous studies have indicated that females frequently underestimate their abilities to succeed in mathematics.

This study uses data from the National Education Longitudinal Study of 1988 (NELS: 88) and the Education Longitudinal Study of 2002 (ELS: 2002). Both studies were conducted by the National Center for Education Statistics of the U.S. Department of Education, and include nationally representative samples of high school sophomores. Ordinary least squares (OLS) regression is used to examine how strongly gender predicts self-perceived math ability, and the extent to which this relationship has changed over time. Secondly, OLS regression is used to determine whether or not the strength of gender as a predictor of self-perceived math ability varies among different racial/ethnic groups. Finally an analysis of covariance (ANCOVA) is used to further illustrate and explain the variation in self-perceived math ability between males and females of different racial/ethnic groups.

The results of this study indicate that from 1990 to 2002, the effect of gender on the self-perceived math ability of females has remained largely unchanged, with females continuing to underestimate their ability as compared to males. The findings also show that race/ethnicity does influence the extent to which females underestimate their math ability, with African-American females being less likely than white, Asian, or Hispanic females to have self-perceptions reflective of the math-gender stereotype.

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1 INTRODUCTION

Many gender stereotypes continue to be prevalent in American culture. These stereotypes have the potential to shape both our expectations of others, as well as our self-perceptions. One such stereotype is the view of mathematics as a “masculine” subject and the “persistent belief...that males both outperform and have a higher inherent aptitude for mathematics than females” (Ding, Song, and Richardson 2006: 279). It is a stereotype that is well-known and, despite abundant evidence showing there to be no biological difference in ability, frequently accepted by both males and females. It has the potential to influence the expectations of parents and teachers, as well as shape the self-confidence of females. According to Hyde, (2005: 590) “mathematically talented girls may be overlooked by parents and teachers because these adults do not expect to find mathematical talent among girls... In short, girls may find their confidence in their ability to succeed in challenging math courses or in a mathematically oriented career undermined by parents’ and teachers’ beliefs that girls are weak in math ability.”

Numerous past studies have shown females to perceive their math ability to be lower than males, regardless of actual ability. This lower self-perception is likely to influence females’ educational and career choices, contributing to the substantial gender discrepancy that continues to exist in math-related occupations. Understanding the role of this cultural stereotype in impacting self-perceptions of ability is critical if we hope to encourage females to be confident in mathematics, and eventually eliminate the effect of the math-gender stereotype on self-perceived math ability.

This study first examines the influence of gender on self-perceived math ability and determines whether or not its influence has declined in recent years. It then considers the influence of one's racial/ethnic background in shaping the relationship between gender and self-perceived math ability. The following questions will be addressed: Has a growing awareness of the stereotype and the increased push to support girls in mathematics made a difference in girls' self-perceived math ability? Or do girls continue to underestimate their abilities as compared to boys? Is the belief that males have a greater inherent ability and outperform females in mathematics held equally among different racial/ethnic groups? Or is it a stereotype of the dominant white culture in the U.S. that is not necessarily shared by racial/ethnic minorities? How do self-perceptions of math ability vary among females of different racial/ethnic groups? These questions will be addressed by testing the following hypotheses:

Hypothesis 1: *Females will underestimate their math ability as compared to males of equal ability.*

Sub-Hypothesis 1.1: *The extent to which females underestimate their math ability will have decreased between 1990 and 2002.*

Hypothesis 2: *The extent to which females underestimate their math ability as compared to males of equal ability will vary by racial/ethnic group.*

Sub-Hypothesis 2.1: *White females will underestimate their math ability as compared to white males of equal ability.*

Sub-Hypothesis 2.2: *Asian females will underestimate their math ability as compared to Asian males of equal ability.*

Sub-Hypothesis 2.3: *African-American females will not underestimate their math ability as compared to African-American males of equal ability.*

Sub-Hypothesis 2.4: *Hispanic females will underestimate their math ability as compared to Hispanic males of equal ability.*

Further explanation and theoretical justification for each hypothesis will be provided in the following section, which offers a review of existing literature on the subject of gender and self-perceived math ability.

2 LITERATURE REVIEW

2.1 Hypothesis 1: Gender and Mathematics

A great deal of research exists on issues related to gender and mathematics. This research often focuses on the cultural perception of mathematics as masculine, as well as on determining whether or not a difference actually exists in the math ability of males and females. Early research, such as the 1980 study by C.P. Benbow and J.C. Stanley, often found that males do outperform females in mathematics. Benbow and Stanley (1980: 1262) studied nearly 10,000 junior high school students and found "a substantial sex difference in mathematical reasoning ability...in favor of boys." The authors concluded that their results "favor the hypothesis that sex differences in achievement in and attitude toward mathematics result from superior male mathematical ability, which may in turn be related to greater male ability in spatial tasks" (Benbow and Stanley 1980:1264).

Many studies, however, refute Benbow and Stanley's findings and question the perceived notion that males have a greater inherent math ability than females, instead showing any gender differences in math performance to be minimal or nonexistent. A study by Fennema and Sherman (1977) for example, tested sex-related differences in mathematics achievement using a sample of 1,233 high school students from four different schools. They administered questionnaires to measure attitudes towards mathematics, as well as mathematics ability. The authors found that differences in math ability between the sexes were not significant, but that "mathematics confidence was significantly higher in males than in females" (Fennema and Sherman 1977: 67).

The authors conclude that although females have as much mathematical potential as males, “the study of mathematics appears not to be sex-neutral” and that this difference in confidence is likely due to a socio-cultural influence that “makes the study of mathematics seem inappropriate for girls” (Fennema and Sherman 1977: 69).

In addition, Ding, Song, and Richardson (2006) tested the claim that males outperform females in mathematics with a longitudinal study examining both math grades and standardized test scores. They found that there was no significant gender difference in standardized-test math performance, and that the females in their sample actually had higher math grades than the males in both middle school and high school. “These results challenge the stereotyped attributions of biological or cognitive differences in gender regarding mathematical performance” (Ding et al. 2006: 292).

Despite a lack of difference in actual performance, females remain subject to the stereotype that mathematics is a masculine domain, which has the potential to influence their self-perceptions and self-concepts. The influence of gender stereotypes on an individual’s sense of self is explained by both identity theory and expectation states theory. According to identity theory, the self is a “collection of identities, each of which is experienced through social interaction” (Burke 1989). These identities emerge through interactions with others, and expectations for behavior are established “with respect to various roles and positions in society” (Burke 1989). An identity is formed through the internalization of these expectations.

In particular, an individual’s gender identity is shaped by the conceptualization of what is “masculine” as opposed to “feminine” (Burke 1989). These conceptualizations shape behavior and self-perceptions, and can create "pressures and constraints to act in socially acceptable ways" (Burke 1989). One common gender belief in the United States is the stereotype that mathematics is a masculine domain. This cultural belief may therefore pressure females to act in the appropriate "female" manner by perceiving their mathematical ability to be inferior to males.

Expectation states theory also offers an explanation for the influence of gender stereotypes on self-perceptions. This theory focuses on "social relational contexts in which individuals are oriented toward accomplishing a shared and/or socially valued task or goal" (Ridgeway and Correll 2004: 518). In these situations, which are often work or education related, members compare their own status to the perceived status of others to determine performance expectations. An individual whose status is perceived as high will be "assumed by self and others to be more competent at the group's task" (Meeker and Weitzel-O'Neill 1977: 95).

In the United States, men are often viewed as having a higher status than women, which contributes to differences in performance expectations (Meeker and Weitzel-O'Neill 1977). This difference is particularly evident when gender is "effectively salient," such as in a gender-stereotyped situation (Ridgeway and Correll 2004: 518). In these situations, self-expectations, as well as expectations of others become shaped by cultural gender beliefs, independent of actual ability. As a result, "even when men and women perform objectively similarly in contexts in which hegemonic beliefs are salient, the men are more likely to be judged by themselves and others as having somewhat more ability at the task than the women" (Ridgeway and Correll 2004: 519). The gendered nature of mathematics, for example, makes these hegemonic beliefs salient "in a way that disadvantages women compared to equally able men" (Ridgeway and Correll 2004: 527). Therefore, due to the perceived difference in status, females will be more likely than males to underestimate their mathematics ability.

Research findings concerning the extent to which individuals' self-perceptions of ability are influenced by the gendered nature of mathematics have been mixed, although most show at least some effect of the math-gender stereotype. Hyde, Fennema, Ryan, Frost, and Hopp (1990) conducted a meta-analysis of 70 past studies on the subject, and found belief in the stereotype by both males and females to be minimal but existent. The authors conclude that, although gender differences in self-perceptions were small, "the consistent pattern is for females to hold more negative attitudes" (Hyde et al. 1990:312). The authors also add that it is difficult to determine the true magnitude of even a small difference in self perception of math ability when that difference is compounded over "the span of years in which mathematics is learned" (Hyde et al. 1990:312). This observation indicates that it may be possible for even a slight gender difference in self-perception of math ability to have significant effects when the belief is held by an individual over a period of many years.

Singer and Stake (1986: 341) studied the self-perceived math ability of a small sample of predominately white college students attending a "mid-sized, urban, public university." The subjects participated in both surveys and interviews over the course of the two-year longitudinal study. Singer and Stake (1986) found that women "tended not to endorse the perception of mathematics as a male domain and indicated no more math anxiety than men" (Singer and Stake 1986: 345). These findings indicate that "women are perhaps becoming more positive about the potential value of mathematics in their lives" (Singer and Stake 1986: 348). The authors acknowledged, however, that their sample was not nationally representative and that their findings were in contradiction to "the bulk of recent research (which) indicates that women's math attitudes are still somewhat less positive than those of men" (Singer and Stake 1986: 348).

Marsh, Byrne, and Shavelson (1988) for example, examined the effect of gender on both math and verbal self-concepts. The study looked at just under 1,000 eleventh and twelfth grade students, selected from two suburban high schools. Verbal and math self-concept variables were created from a combined measure of three different self-concept instruments, and verbal and math ability were determined based on school grades (Marsh et al. 1988:368). The researchers found that girls had a higher verbal self-concept than did boys, while boys had a higher math self-concept.

The "critical question, however, was whether sex differences in math and verbal self-concepts are larger than can be explained by corresponding sex differences in math and verbal achievements…which would suggest that the sex stereotypes influence academic self-concepts" (Marsh et al. 1988:376). The authors found that although girls had higher verbal achievements than did boys, this difference did not fully explain the difference in verbal self-concept. Even when controlling for verbal ability, verbal self-concept remained higher among girls than boys. On the other hand, boys were found to have a higher math self-concept than were girls, despite the fact that girls actually had slightly higher math grades. "Correcting math self-concepts for math achievements actually increased the sex differences in math self-concepts favoring boys rather than decreasing it, (which) might reflect the influence of sex stereotypes" (Marsh et al. 1988:376).

Also, a nationwide study by the American Association of University Women in 1990 examined "the differences between girls' and boys' perceptions of themselves and their futures…(and) the relationship of math and science skills to the self-esteem and career goals of boys and girls" (AAUW 1991: 6). The survey found that the enthusiasm for math and science declines for both boys and girls from elementary to high school, but that the "most dramatic" decline is among girls. The survey also found that "adolescent boys…are much more confident than young girls about their abilities in math" (AAUW 1991: 11). More positively, however, the results from the study indicate that perceptions of gender are slowly changing. Most children responded that they expect women to hold a job outside of the home, and many girls indicated that they think they can enter a number of careers that have typically been considered male domains (AAUW 1991).

Finally, Shelley Correll (2001) used data from the National Education Longitudinal Study of 1988 to study the influence of gendered self-perceptions on career path decisions of high school students. Correll used the NELS: 88 data-set to examine differences in self-perceived math ability between males and females. She found that "males assess their mathematical competence higher than females of equal mathematical ability" (2001: 1715) and concluded that "gendered beliefs about mathematics impact individuals' assessment of their own mathematical competence, which…leads to gender differences in decisions to persist on a path toward a career in science, math, or engineering" (Correll 2001: 1691).

Although norms are slowly changing regarding gender and mathematical ability, math continues to be viewed by many people as a predominately masculine field, subtly encouraging young females to accept this view. I therefore hypothesize that *females will underestimate their math ability as compared to males of equal ability*. Given the increased amount of research pointing to social and cultural factors as major influences on self-perception, as well as an increasing reluctance to accept differences in achievement as biological, however, I also hypothesize that *the influence of gender on self-perceived math ability will have decreased over time.*

<u>2.2 Hypothesis 2: Role of Race/Ethnicity</u>

In addition to the role of gender in affecting an individual's self perceived math ability, I am interested in how belief in the math-gender stereotype is influenced by one's race or ethnicity. Specifically, do females across different racial/ethnic groups all tend to underestimate their math ability, or is belief in the math-gender stereotype characteristic of some groups but not others? A variety of past research examines the relationship between race/ethnicity and academic expectations and success, but little has been done that specifically analyzes how belief in the stereotype that mathematics is a masculine domain varies among racial/ethnic groups.

The research of Blair, Blair, and Madamba (1999: 539) for example, used data from the National Educational Longitudinal Study of 1988 and examined the "potential influence of ethnic differences in cultural values, particularly those related to the valuation of educational success," on the educational achievement of various racial and ethnic groups. The authors suggest that "ethnic group-specific cultural values" may affect various elements of education, including "gendered attitudes concerning boys' and girls' educational attainment" (Blair et al. 1999: 542).

Although the authors found only slight support that cultural characteristics are associated with educational success, they did find that ethnic groups often hold unique cultural values that influence how children are socialized. According to Blair et al. (1999), Hispanic households are often "more patriarchal than egalitarian" and "promote adherence to traditional family roles" (Blair et al. 1999: 542). African-American families, on the other hand, were found more likely to be egalitarian, but with parental discipline that is "sometimes strict, relative to other ethnic groups" (Blair et al. 1999: 542). Finally, many Asian-American families were found to value "a strong commitment to the group, as opposed to the individual, which is seemingly contrary to the dominant American culture" emphasizing individuality (Blair et al. 1999: 542). These variations in cultural beliefs are likely to differentially impact one's identity formation and behavioral expectations, including norms and stereotypes regarding gender.

A second study on the subject of race and academic achievement was conducted by Stevenson, Chen, and Uttal (1990: 508). Their study attempted to provide "information about why so many black and Hispanic children…are failing to achieve in school." Through the use of in-depth interviews, the authors examined differences in beliefs related to education among black, white, and Hispanic mothers who had children attending elementary school in the Chicago area.

The authors found that neither a devaluation of education nor a lack of parental support could explain why black and Hispanic children have lower levels of achievement, as compared to white children. They found that both black and Hispanic mothers, as well as white mothers, placed a great deal of importance on their children's education (Stevenson et al. 1990). In addition, black mothers were the most likely to emphasize the importance of helping children with their school work, and also estimated that they spent the most amount of time providing such help (Stevenson et al. 1990). Finally, black and Hispanic mothers were more likely than white mothers to support educational changes such as an increased amount of homework and longer school days (Stevenson et al. 1990).

Although the authors were unable to account for the lower achievement levels of black and Hispanic children, their findings do suggest that parents of different ethnic groups have distinctive views regarding education. Children of different racial/ethnic groups may therefore be socialized to hold unique cultural beliefs that will then influence their own views on education, including differences in gender expectations and self-perceptions of academic ability.

Given the results of these studies showing just a sample of the many differences that can exist among cultural beliefs regarding education, *I hypothesize that the extent to which females underestimate their math ability as compared to males of equal ability will vary by racial/ethnic group.* Specifically, *I first hypothesize that white females will* *underestimate their math ability as compared to white males of equal ability.* This hypothesis is based on the research supporting my first hypothesis (c.f. the findings of Marsh, Byrne, and Shavelson (1988), AAUW (1991), and Correll (2001)), indicating that females tend to underestimate their math ability when compared to males of equal ability. This same pattern will likely hold true when white students are examined individually, given that white students made up the majority of the subjects in these studies, and that whites may be less likely than other racial/ethnic groups to have cultural beliefs that are unique from the cultural norm.

Research by Sinclair, Lowery, and Hardin (2006) also supports this hypothesis. Sinclair et al. (2006: 529) examined the extent to which members of various ethnic groups "self-stereotype," or "apply cultural stereotypes to the self." The authors looked particularly at the existence of academic self-stereotyping in a sample of African-American, European-American, and Asian-American college students attending UCLA. The authors conducted a series of experiments in which they unobtrusively made either the participant's gender or ethnic identity salient, then asked participants to "evaluate how both people in general and close others viewed their math and verbal ability as well as how they viewed their own math and verbal ability" (Sinclair, Lowery, and Hardin 2006: 530). The authors found that self-stereotyping largely depends on the perceived expectations of close others (e.g., peers, teachers, family), as opposed to the expectations of people in general, and that the perceptions of close others varies by racial/ethnic group.

European-Americans were found to perceive close others as holding stereotyped expectations regarding their math and verbal abilities, and to self-stereotype accordingly. Regardless of whether gender or ethnicity was made salient, European-Americans self-stereotyped their perceptions to correspond with the cultural stereotype that males are better at math than females (Sinclair et al. 2006). This finding is consistent with my hypothesis that gender will have an influence on the self-perceived math ability among whites, reflective of the math-gender stereotype. It also illustrates the importance of interaction with close others in shaping an individual's sense of self, as explained by identity theory.

Secondly, *I hypothesize that Asian females will underestimate their math ability as compared to Asian males of equal ability.* The study by Sinclair et al. (2006) found that, similar to European-Americans, Asian-Americans perceived close others to hold stereotyped expectations of their academic abilities and self-stereotyped their own perceptions as well. As a group, Asian-Americans "demonstrate exceptional achievement patterns" and both men and women receive particularly high grades and standardized test scores, especially in the area of mathematics (Sue and Okazaki 1990: 914). According to Sinclair et al. (2006), however, Asian-American women are still affected by the stereotype that mathematics is a masculine domain when gender is made salient, as would be predicted by expectation states theory.

Sinclair et al. (2006) found that the stereotyped expectations changed for Asian-American women, depending on whether their gender or ethnic identity was made salient. When ethnicity was made salient, women evaluated their verbal ability as lower and their math ability as higher. Conversely, when gender was made salient, women evaluated their verbal ability as higher and their math ability as lower (Sinclair et al. 2006). However, because Asian-American males are likely to rate their mathematic ability as high regardless of gender or ethnic identity salience, I believe that gender will have an influence on the self-perceived math ability of Asians, and that females will perceive their ability to be lower as compared to males.

Next, *I hypothesize that African-American females will not underestimate their math ability as compared to African-American males of equal ability.* This hypothesis is also supported by the research of Sinclair et al. (2006). African-Americans did view people in general as holding the stereotyped belief that African-Americans are less able to excel in academics than whites. In contrast to European-Americans and Asian-Americans, however, they did not perceive close others to share these beliefs and "did not report stereotype-consistent self-evaluations" (Sinclair 2006: 536). This finding was true regardless of whether ethnicity or gender was made salient, indicating that stereotypic beliefs regarding academic ability are less likely to be part of the identity of African-Americans.

The authors attribute this difference to a number of possible influences. They suggest that because "African-Americans endure a particularly vicious form of prejudice, which includes the stereotype that they are generally intellectually inferior," they may be more likely to view these stereotypes as "illegitimate" (Sinclair et al. 2006: 535). The authors refer to a variety of research indicating that African-Americans "benefit from a social network in which stereotypes are collaboratively challenged" (Sinclair et al. 2006:

535). The strength of this social network, as well as the perception that close others do not hold stereotyped beliefs support my hypothesis that African-Americans will be resistant to the cultural stereotype that males are better at math than females, decreasing the likelihood that females will underestimate their math ability.

This difference in the acceptance of stereotypes is also accounted for in terms of expectation states theory by Ridgeway and Correll (2004). According to these authors, gender beliefs vary among communities in the United States, including different racial/ethnic communities. For example, the hegemonic belief that "men are generally more competent than women" is not held equally by all ethnicities (Ridgeway and Correll 2004: 514). In particular, the African-American community has been found to hold gender beliefs that are often in contrast to dominant gender stereotypes, and tend to view women as more competent relative to men (Ridgeway and Correll 2004).

Expectation states theory, then, expects that these "shared alternative gender beliefs, rather than the hegemonic form, … will become sufficiently salient to measurably affect (an individual's) self-other expectations and thus (his) behavior and evaluations in the situation" (Ridgeway and Correll 2004: 520). This theory supports my hypothesis that African-American females will not underestimate their math ability as would be predicted by hegemonic gender beliefs, but instead adhere to alternative gender beliefs, which "ascribe fewer competence differences to men and women than do hegemonic beliefs" (Ridgeway and Correll 2004: 520).

Research by Saunders, Davis, Williams, and Williams (2004) also supports this hypothesis. Saunders et al. (2004:81) surveyed 243 African-American sophomores to examine “gender differences in the relationship between self-perceptions and academic outcomes.” According to the authors, African-American males and females “experience the school environment very differently” (Saunders et al. 2004: 82). Males are more likely to fall behind in school, have behavioral problems, and question the relevancy of a high-school education. These negative experiences often lead to “academic alienation and disengagement” and “an associated loss of confidence in one’s academic ability and skills and overall sense of self- worth” (Saunders et al. 2004: 82).

African-American females, on the other hand, are more often rewarded in school and given “more positive messages about their academic abilities and performance” (Saunders et al. 2004: 88), allowing them to develop their academic skills. They are also more likely to be socialized to believe that completing a high school education will be valuable and rewarding. Saunders et al. (2004: 87) concluded that, in their study, females had “significantly higher grade point averages than the males,” and “reported higher levels of academic self-efficacy and importance of school completion to self.” These findings contribute to my hypothesis that African-American females will not underestimate their math ability as compared to males of equal ability.

Finally, *I hypothesize Hispanic females will underestimate their math ability as compared to Hispanic males of equal ability.* This hypothesis is based largely on the research of Julio Cammarota (2004) who examined differences in the challenges faced by Hispanic males and females, specifically in the area of school achievement. Cammarota conducted in-depth interviews with 40 first- or second- generation Hispanic youth between the ages of 17 and 24. According to Cammarota (2004: 54), all Hispanic students have higher than average rates of high school attrition, but females in particular face "gender discrimination within the home and society at large."

Cammarota (2004: 55) found that Hispanic females often received "mixed messages" regarding their educational achievement. For example, their mothers "simultaneously tell them to become self-reliant yet place primary importance on becoming (women of the home)." Also, the peer culture of Hispanic females often places "higher values on pursuing the traditional gender roles of 'girlfriend, wife, and mother' over professional or career success" (Cammarota 2004: 55). Although Cammarota concluded that Hispanic females are increasingly moving beyond these traditional gender roles and achieving higher levels of academic success, this change has been very gradual. I believe that traditional gender expectations will continue to be salient, contributing to the likelihood that Hispanic females will underestimate their math ability.

This hypothesis is also supported by a 2000 study by the American Association of University Women. This study examined the challenges Hispanic females face trying to balance academic achievement with traditional gender values. These traditional values often place a high level of significance on family, and "emphasize or highly esteem traditional roles for women as wives and mothers" (AAUW 2000: 24). These cultural values can make it "difficult for a young woman to craft an identity that is both Latina and academically successful" (AAUW 2000: 28). Given the struggles of many Hispanic females to incorporate educational achievement into their sense of selves, it is likely that their self-perceptions will be reflective of the stereotype that males outperform females in mathematics.

To contribute to and expand on the existing literature, this study uses a relatively new data-set to examine whether or not females continue to believe in the math-gender stereotype. The research retests the findings of Shelley Correll (2001) using the NELS: 88 data-set, and compares them to results from a 2002 data-set, using the same type of analysis. By both confirming her results and comparing them to a newer data-set, this study determines the extent to which gendered self-perceptions of math ability have changed over time. It then examines the self-perceived math abilities of females from different racial/ethnic groups individually to determine whether the math-gender stereotype is held universally, or varies according to cultural beliefs.

3 METHODS

3.1 Data

To test my hypotheses, I used data from the National Education Longitudinal Study of 1988 (NELS: 88) and the Education Longitudinal Study of 2002 (ELS: 2002). Both the NELS: 88 and ELS: 2002 data were collected by the U.S. Department of Education's National Center for Education Statistics (NCES) in an attempt to "monitor the transition of a national sample of young people as they progress…through high school and on to postsecondary education and/or the world of work" (NCES 2008). The NELS: 88 and ELS: 2002 data are appropriate for this study for several reasons. First, the format and content of the surveys used to collect the data were highly similar, allowing for a clear comparison between the two points in time. Also, each data-set contains information regarding actual math ability as well as self-perceived ability, both of which are necessary for this study.

The ELS: 2002 survey is a longitudinal study first administered by the NCES to a sample of 15,362 high school sophomores selected from 752 schools in the year 2002. Follow-up surveys were administered to the students in both 2004 and 2006. The NELS: 88 survey is also a longitudinal study conducted by the NCES. It was originally administered to a sample of 24,599 eighth-graders from 1,052 schools in the year 1988, with follow-up surveys administered to a subset of the original sample approximately every two years until the year 2000. For both data-sets, the sample was selected from a "nationally representative, two-stage stratified probability sample…The first stage of selection was schools, which were selected with probability proportional to size" (NCES

2008). In the second stage, students were randomly selected within each of the participating schools. The response rate for ELS: 2002 was approximately 68 percent for schools and 87.3 percent for students. For NELS: 88, the school response rate was 69.7 percent and the student response rate was 93.4 percent (NCES 2002). I use the 2002 sophomore data from ELS: 2002 and the 1990 sophomore data from NELS: 88 to test my first hypothesis, examining the impact of societal stereotypes on self-perceptions at two distinct points in time. My second hypothesis, regarding the role of race/ethnicity in this relationship, focuses solely on the ELS: 2002 sophomore data.

The questionnaires in both 1990 and 2002 asked sophomores to respond to a number of topics including "school, work, and home experiences; educational resources and support; the role in education of their parents and peers; neighborhood characteristics; educational and occupational aspirations; and other student perceptions" (NCES 2008). The surveys were administered by NCES project staff and took place in the schools, in a pencil and paper format. In addition to the student questionnaire, sophomores in both 1990 and 2002 completed standardized cognitive tests designed to measure achievement in mathematics and English.

3.2 Dependent Variables

To measure my dependent variable, *self-perceived math ability*, I created a scaled variable comprised of items from the student questionnaires. In order to test my first hypothesis, I created this variable for both the 1990 and the 2002 survey. Unfortunately, the wording of the items used to measure self-perceived math ability changed somewhat between the 1990 version and the 2002 version of the questionnaire, so the items making up my dependent variable differ slightly between the two years. The implications and intent of the questions, however, are very similar, making comparison possible. Also, I standardized each dependent variable to account for the unequal response categories between the two survey years. By standardizing the variables, they each have a mean of 0 and a standard deviation of 1. It is therefore possible to use the available items and make an accurate comparison between the two points in time.

From the 1990 questionnaire I created my dependent variable using the following three items: “Mathematics is one of my best subjects,” “I have always done well in mathematics,” and “I get good marks in mathematics”. Responses to these items are coded on a six-point scale as 1) False, 2) Mostly False, 3) More False than True, 4) More True than False, 5) Mostly True, and 6) True. These are the same three items that Correll (2001) used in her research on gender and mathematical self-assessment. The items are strongly correlated and create a unidemensinal, reliable scale (standardized Cronbach’s alpha value=.911).

From the 2002 questionnaire, I use five items to create a measure of *self-perceived math ability*: “I can do an excellent job on math tests,” “I can understand difficult math texts,” “I can understand difficult math classes,” “I can do an excellent job on math assignments,” and “I can master math skills.” Possible responses to these questions were coded on a four-point scale as 1) Almost Never, 2) Sometimes, 3) Often, and 4) Almost Always. These items are also strongly correlated and create a unidemensinal, reliable scale (standardized Cronbach’s alpha value=.933).

3.3 Independent Variables

For both my first hypothesis, regarding changes in the influence of the math-gender stereotype over time, and my second hypothesis, regarding the role of race/ethnicity in impacting one's self-perceived math ability, *gender* is the independent variable. Both hypotheses are examining the effect of a student's gender in influencing his or her self-perceived math ability. In order to be used in a regression analysis, gender was treated as a dummy variable with *male* as the reference category coded as 1, and *female* coded as 0. For the second hypothesis, *race/ethnicity* was also recoded into a series of dummy variables (one dichotomous variable for each racial/ethnic group), and is treated as an independent variable to determine the combined effect of race/ethnicity and gender on self-perceptions of ability.

3.4 Control Variables

In addition to the independent and dependent variables, I also included several control variables in my analyses. I began by controlling for the students' actual math ability, as determined by the standardized math assessment given as part of the ELS: 2002 and NELS: 88 surveys. In order to examine the effect of the math-gender stereotype on self-perceptions of ability, actual math ability must be controlled for to ensure that differences in perceptions of ability are not merely a reflection of differences in actual ability.

Also, I controlled for the measures that Correll (2001) identifies in her research as other possible sources of influence on students' self-perceived math ability. These include *verbal ability* (as it is likely that students make relative comparisons in assessing their math and verbal abilities), *socio-economic status*, and in my first hypothesis, *race/ethnicity,* which was recoded into a series of dichotomous dummy variables in order to be used appropriately in the analysis.

I control for verbal ability using the standardized measure of verbal achievement that is calculated in the cognitive portion of the surveys. I control for SES by using a composite variable that the NCES created for each data-set using a combination of family's total income, mother's and father's education level, and mother's and father's occupation. Like Correll (2001: 1694), I did not include variables such as the type of high school the student attends and differences in family structure because "males and females are distributed roughly equally across these groups…(creating) considerable similarity in the structural location and resources available to male and female youth."

3.5 Analysis

Using the data from the 1990, NELS questionnaire, I first retested Correll's findings in order to confirm her results regarding gender and self-perceived math ability. While Correll (2001) used structural equation modeling (SEM) to test her hypotheses, this analysis uses ordinary least squares regression (OLS). Because OLS is a technique that is also appropriate for testing this type of hypothesis but differs slightly from SEM in its focus, using OLS provides additional explanation and confirmation of Correll's findings. However, in her article Correll (2001: 1705) states that her models "were also estimated using OLS…and no substantive differences in estimates were found" so I expected my results from the NELS data-set to remain similar to Correll's.

I next examined the effect of gender on self-perceived math ability for the sophomores in the ELS: 2002 data-set using OLS regression, and then compared my 2002 results with my findings from the NELS: 88 data. To make this comparison, I determined whether the independent variable, *gender,* had increased or decreased in strength as a predictor of the dependent variable, *self-perceived math ability*, and whether or not this difference was statistically significant. By comparing the results of the 1990 sophomores with the findings from the 2002 sophomores, I was able to examine how belief in the math-gender stereotype and its influence on the self-perceptions of females had changed between the years 1990 and 2002.

Finally, this study examines the influence of race/ethnicity on gendered self-perceptions of math ability. Although Correll (2001) controlled for the effect of race/ethnicity in her research, she did not examine self-perception within each group individually. Given the results of past research investigating the influence of cultural factors on academic success (c.f. the findings of Blair et al. (1999), Stevenson et al. (1990), Sinclair et al. (2006), Ridgeway and Correll (2004), Saunders et al. (2004), Cammarota (2004), AAUW (2000)), it is likely that different racial/ethnic groups also have differing perceptions of gender norms, including unique cultural perceptions of mathematics as a masculine subject. This study determines the extent to which the stereotype that males are better than females at math is held by members of different racial/ethnic groups.

To explore this idea, I used the ELS: 2002 data with the same dependent variable, *self-perceived math ability,* and looked individually at the four racial/ethnic groups with the highest number of respondents: whites, African-Americans, Hispanics, and Asians. By using a regression analysis to examine how strongly gender predicts self-perceived math ability within each group separately, I determined whether or not belief in the stereotype varies by racial/ethnic background.

Finally, I conducted an analysis of covariance (ANCOVA) in order to examine the differences among the groups on the dependent variable more closely, and to further clarify the regression results. The dependent variable for this analysis was still *self-perceived math ability.* The independent variables were *race/ethnicity* and *gender,* and the control variables were those used in the regression analyses. The results of the ANCOVA allowed me to compare the mean scores on the dependent variable among males and females of each of the different racial/ethnic groups in order to analyze more closely how self-perceptions of males and females vary across the different groups.

4 RESULTS

4.1 Descriptive Statistics

As a first step in testing my hypotheses, I examined the descriptive statistics for each variable. For the race/ethnicity variable in the NELS: 88 data-set, the majority of respondents, 70.0 percent, were white, while 12.5 percent were Hispanic, 9.2 percent were African American, and 7.2 percent were Asian. This distribution is similar to the ELS: 2002 data-set in which 55.8 percent were white, 15.0 percent were Hispanic, 13.4 percent were African American, and 10.2 percent were Asian. Due to the low frequency of Native Americans and Native Alaskans in the samples (one percent or less), they were not included in this analysis. For the NELS: 88 data-set, the majority of respondents, 52.7 percent were female, while 47.3 percent were male. For the ELS: 2002 data-set, males and females were nearly equally distributed, with females making up 50.1 percent of the sample and males 49.9 percent.

Descriptive statistics for the remaining variables are shown in the following two tables. Table 4.1 below shows the variables from the NELS: 88 data-set and Table 4.2 shows the variables from the ELS: 2002 data-set. For both the NELS: 88 and the ELS: 2002, self-perceived verbal ability has a higher mean score than self-perceived math ability, as well as a smaller standard deviation, indicating that the scores are less dispersed. The same is true for the standardized math and standardized verbal scores, with verbal scores tending to be higher and less dispersed than the math scores.

Table 4.1: Descriptive Statistics for *SES, Math Score, Verbal Score, Self-Perceived Math Ability*, and *Self-Perceived Verbal Ability* (NELS: 88, N= 7,914))

	N	Minimum	Maximum	Mean	Std. Deviation
Socio Economic Status	10472	-2.838	2.762	.01115	.794499
Mathematics Standardized Score	10261	16.37	72.76	44.8170	13.82114
Verbal Standardized Score	8575	10.55	51.16	33.9014	9.98067
Self-Perceived Math Ability	10217	1.00	6.00	4.0467	1.58370
Self-Perceived Verbal Ability	10226	1.00	6.00	4.3321	1.26471
Valid N (listwise)	7914				

Table 4.2: Descriptive Statistics for *SES, Math Score, Verbal Score, Self-Perceived Math Ability*, and *Self-Perceived Verbal Ability* (ELS: 2002, N= 11,466)

	N	Minimum	Maximum	Mean	Std. Deviation
Socio-economic status	16252	-2.12	1.97	.0366	.74951
Mathematics Standardized Score	15976	12.523	69.719	38.06719	11.872327
Verbal Standardized Score	15976	10.199	49.085	29.92629	9.688288
Self-Perceived Math Ability	11726	1.00	4.00	2.5198	.84404
Self-Perceived Verbal Ability	11523	1.00	4.00	2.7116	.79709
Valid N (listwise)	11466				

I also looked at the mean scores on my dependent variable, *self-perceived math ability,* for males and females across the various racial/ethnic groups. Table 4.3 shows the mean score on this variable when no control variables are taken into account. The table includes only the four racial/ethnic groups that are included in this study from the ELS: 2002 data-set. Higher scores in the table indicate higher self-perceptions of ability, with possible scores ranging from 1.0 to 4.0. The table below shows that Asians tend to have the highest self-perceptions of math ability, and Hispanics tend to have the lowest. For all groups, however, females perceived their math ability lower than males, with Hispanic females averaging the lowest self-perception score and Asian males averaging the highest. The difference between males and females is smallest for African-Americans and greatest for Asians and whites.

Table 4.3: Mean Scores on the Dependent Variable, *Self-Perceived Math Ability* (ELS: 2002, N= 11,053)

Race/Ethnicity	Gender	Mean	Std. Deviation	N
Asian	Female	2.5341	.83018	578
	Male	2.7860	.79749	564
	Total	2.6585	.82354	1142
African American	Female	2.4553	.81473	719
	Male	2.5634	.82556	575
	Total	2.5033	.82100	1294
Hispanic	Female	2.3622	.77304	796
	Male	2.5480	.85368	753
	Total	2.4525	.81826	1549
White, Non-Hispanic	Female	2.4029	.84135	3689
	Male	2.6512	.84659	3379
	Total	2.5216	.85287	7068
Total	Female	2.4169	.82891	5782
	Male	2.6413	.84248	5271
	Total	2.5239	.84286	11053

After examining the descriptive statistics for each variable, I next confirmed a relationship between the variables at the bivariate level. Table 4.4 below contains the correlations for each variable from the NELS: 88 data set, and Table 4.5 below contains correlations for each variable from the ELS: 2002 data set.

Table 4.4: Bivariate Correlations for All Variables (NELS: 88)

		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. Math Standardized	Pearson Correlation	1	.753**	.429**	-.251**	-.206**	-.206**	.273**	.053**	.217**	.362**
	Sig. (2-tailed)		.000	.000	.000	.000	.000	.000	.000	.000	.000
	N	15976	15976	15976	15976	15976	15976	15976	15976	11523	11726
2. Reading Standardized	Pearson Correlation	.753**	1	.429**	-.208**	-.193**	-.193**	.295**	-.074**	.306**	.199**
	Sig. (2-tailed)	.000		.000	.000	.000	.000	.000	.000	.000	.000
	N	15976	15976	15976	15976	15976	15976	15976	15976	11523	11726
3. Socio-Economic Status	Pearson Correlation	.429**	.429**	1	-.129**	-.225**	-.225**	.256**	.019*	.183**	.150**
	Sig. (2-tailed)	.000	.000		.000	.000	.000	.000	.015	.000	.000
	N	15976	15976	16252	16252	16252	16252	16252	16252	11523	11726
4. African-American	Pearson Correlation	-.251**	-.208**	-.129**	1	-.165**	-.165**	-.441**	-.002	.023*	-.007
	Sig. (2-tailed)	.000	.000	.000		.000	.000	.000	.782	.012	.455
	N	15976	15976	16252	16252	16252	16252	16252	16252	11523	11726
5. Hispanic	Pearson Correlation	-.206**	-.193**	-.225**	-.165**	1	1.000**	-.473**	-.002	-.029**	-.031**
	Sig. (2-tailed)	.000	.000	.000	.000		.000	.000	.759	.002	.001
	N	15976	15976	16252	16252	16252	16252	16252	16252	11523	11726
6. Asian	Pearson Correlation	-.206**	-.193**	-.225**	-.165**	1.000**	1	-.473**	-.002	-.029**	-.031**
	Sig. (2-tailed)	.000	.000	.000	.000	.000		.000	.759	.002	.001
	N	15976	15976	16252	16252	16252	16252	16252	16252	11523	11726
7. White	Pearson Correlation	.273**	.295**	.256**	-.441**	-.473**	-.473**	1	-.004	.025**	.003
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000		.602	.007	.778
	N	15976	15976	16252	16252	16252	16252	16252	16252	11523	11726
8. Gender	Pearson Correlation	.053**	-.074**	.019*	-.002	-.002	-.002	-.004	1	-.032**	.137**
	Sig. (2-tailed)	.000	.000	.015	.782	.759	.759	.602		.001	.000
	N	15976	15976	16252	16252	16252	16252	16252	16252	11523	11726
9. Self-Perceived Verbal Ability	Pearson Correlation	.217**	.306**	.183**	.023*	-.029**	-.029**	.025**	-.032**	1	.377**
	Sig. (2-tailed)	.000	.000	.000	.012	.002	.002	.007	.001		.000
	N	11523	11523	11523	11523	11523	11523	11523	11523	11523	11466
10. Self-Perceived Math Ability	Pearson Correlation	.362**	.199**	.150**	-.007	-.031**	-.031**	.003	.137**	.377**	1
	Sig. (2-tailed)	.000	.000	.000	.455	.001	.001	.778	.000	.000	
	N	11726	11726	11726	11726	11726	11726	11726	11726	11466	11726

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 4.5: Bivariate Correlations for All Variables (ELS: 2002)

		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. Math Standardized	Pearson Correlation	1	.753**	.429**	-.251**	-.206**	-.206**	.273**	.053**	.217**	.362**
	Sig. (2-tailed)		.000	.000	.000	.000	.000	.000	.000	.000	.000
	N	15976	15976	15976	15976	15976	15976	15976	15976	11523	11726
2. Reading Standardized	Pearson Correlation	.753**	1	.429**	-.208**	-.193**	-.193**	.295**	-.074**	.306**	.199**
	Sig. (2-tailed)	.000		.000	.000	.000	.000	.000	.000	.000	.000
	N	15976	15976	15976	15976	15976	15976	15976	15976	11523	11726
3. Socio-Economic Status	Pearson Correlation	.429**	.429**	1	-.129**	-.225**	-.225**	.256**	.019*	.183**	.150**
	Sig. (2-tailed)	.000	.000		.000	.000	.000	.000	.015	.000	.000
	N	15976	15976	16252	16252	16252	16252	16252	16252	11523	11726
4. African-American	Pearson Correlation	-.251**	-.208**	-.129**	1	-.165**	-.165**	-.441**	-.002	.023*	-.007
	Sig. (2-tailed)	.000	.000	.000		.000	.000	.000	.782	.012	.455
	N	15976	15976	16252	16252	16252	16252	16252	16252	11523	11726
5. Hispanic	Pearson Correlation	-.206**	-.193**	-.225**	-.165**	1	1.000**	-.473**	-.002	-.029**	-.031**
	Sig. (2-tailed)	.000	.000	.000	.000		.000	.000	.759	.002	.001
	N	15976	15976	16252	16252	16252	16252	16252	16252	11523	11726
6. Asian	Pearson Correlation	-.206**	-.193**	-.225**	-.165**	1.000**	1	-.473**	-.002	-.029**	-.031**
	Sig. (2-tailed)	.000	.000	.000	.000	.000		.000	.759	.002	.001
	N	15976	15976	16252	16252	16252	16252	16252	16252	11523	11726
7. White	Pearson Correlation	.273**	.295**	.256**	-.441**	-.473**	-.473**	1	-.004	.025**	.003
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000		.602	.007	.778
	N	15976	15976	16252	16252	16252	16252	16252	16252	11523	11726
8. Gender	Pearson Correlation	.053**	-.074**	.019*	-.002	-.002	-.002	-.004	1	-.032**	.137**
	Sig. (2-tailed)	.000	.000	.015	.782	.759	.759	.602		.001	.000
	N	15976	15976	16252	16252	16252	16252	16252	16252	11523	11726
9. Self-Perceived Verbal Ability	Pearson Correlation	.217**	.306**	.183**	.023*	-.029**	-.029**	.025**	-.032**	1	.377**
	Sig. (2-tailed)	.000	.000	.000	.012	.002	.002	.007	.001		.000
	N	11523	11523	11523	11523	11523	11523	11523	11523	11523	11466
10. Self-Perceived Math Ability	Pearson Correlation	.362**	.199**	.150**	-.007	-.031**	-.031**	.003	.137**	.377**	1
	Sig. (2-tailed)	.000	.000	.000	.455	.001	.001	.778	.000	.000	
	N	11726	11726	11726	11726	11726	11726	11726	11726	11466	11726

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

The bivariate correlations indicate support for the relationship between the independent and dependent variables, as well as the importance and association of the control variables. For example, in both the NELS: 88 and the ELS: 2002 gender is significantly correlated with self-perceived math ability in a positive direction indicating that males have higher self-perceptions in mathematics than females. Alternatively, gender is significantly correlated with self-perceived verbal ability in a negative direction, indicating that females have higher self-perceptions of verbal ability than males.

4.2 Hypothesis 1: Regression Results

After establishing the existence of bivariate relationships, I used a series of regression analyses to test my hypotheses. For my first hypothesis, *Females will underestimate their math ability as compared to males of equal ability,* I ran a regression analysis to determine how strongly gender predicts self-perceived math ability for both the NELS: 88 and the ELS: 2002 data-sets. Before interpreting the regression results, however, I first evaluated the results of the F-test for each data-set in order to confirm that the relationship between variables is linear, and that the model significantly predicts the dependent variable. After determining the results of the F-test to be significant for both data sets, I next examined the multicolinearity statistics for each analysis. The tolerance and VIF scores for the variables in each analysis indicate that colinearity among the independent and control variables is likely not a problem, allowing us to assume that each of these predictor variables contributes to the variation in the dependent variable.

Finally, the regression results demonstrate that the overall model accounts for 20.0 percent of the variation in the dependent variable for the NELS: 88 data-set (R^2=.200), and 16.1 percent of the variation in the dependent variable for the ELS: 2002 data-set (R^2=.161). Also, the findings support Hypothesis 1: *Females will underestimate their math ability as compared to males of equal ability,* by demonstrating that the independent variable, *gender* is a significant predictor of self-perceived math ability for sophomores in both 1990 (β=.087) and 2002 (β=.098)[1]. For both years the association is in a positive direction, indicating that females underestimate their ability as compared to males, even when taking the control variables into account. The results of this analysis are given in Table 4.6 below.

Table 4.6: Regression Results, *Self-Perceived Math Ability:*
Comparison between NELS: 88 (N=7,829) and ELS: 2002 (N=11,053)

Variables	NELS: 88	ELS: 2002
Gender	**0.087** (0.010)**	**0.098** (0.009)**
Socio Economic Status	-0.075** (0.012)	0.026** (0.010)
Math Standardized Score	0.576** (0.016)	0.467** (0.013)
Verbal Standardized Score	-0.191** (0.015)	-0.119** (0.013)
Asian	0.007 (0.010)	0.043** (0.012)
Hispanic	0.007 (0.011)	0.043** (0.012)
African American	0.064** (0.011)	0.081** (0.012)
R	0.448	0.410
R^2	0.200	0.161
Adjusted R^2	0.200	0.160

Note: For each variable, the standardized coefficient is shown with the standard error in parentheses.

** Indicates significance at p<.01

[1] When interpreting the significance of the regression results, it is important to recognize the effect of statistical power. In the current analysis, the effect size of the independent variable is small, but given the large sample size and amount of statistical power, the effect size is large enough to rule out random chance as the cause of the observed difference.

In order to establish the influence of the math-gender stereotype, as opposed to a general tendency for females to underestimate their ability as compared to males, I also conducted a regression analysis with *self-perceived verbal ability* as the dependent variable for both the NELS: 88 and ELS: 2002 data-sets[2]. For sophomores in 1990, gender did have an impact on perception of verbal ability but in the opposite direction, with females tending to overestimate their self-perceptions as compared to males (β=-.109**). For sophomores in 2002, however, gender did not have a significant impact on self-perceived verbal ability when the control variables were taken into account (β=-.014).

These results demonstrate that the tendency for females to underestimate their math ability is a reflection of the math-gender stereotype, and not a universal tendency for females to underestimate their abilities as compared to males. These results also suggest that while there is some societal tendency to stereotype verbal and English skills as feminine, this stereotype does not have the same amount of influence on people's self-perceptions of ability as does the math-gender stereotype. The results of this analysis are given in Table 4.7 below.

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[2] These analyses used *gender* as the independent variable and *SES, race*, and *actual math and verbal abilities* as the control variables. *Self-perceived verbal ability* is a scaled variable created for each data set using items similar to those used to measure *self-perceived math ability,* but worded to apply to English/verbal skills rather than math.

Table 4.7: Regression Results, *Self-Perceived Verbal Ability:*
Comparison between NELS: 88 (N= 7,829) and ELS: 2002 (N=11,053)

Variables	NELS: 88	ELS: 2002
Gender	**-0.109** (0.010)**	**-0.014 (0.009)**
Socio Economic Status	0.070** (0.012)	0.085** (0.010)
Math Standardized Score	0.089** (0.016)	-0.010 (0.014)
Verbal Standardized Score	0.243** (0.015)	0.308** (0.014)
Asian	0.034 (0.010)	0.056** (0.010)
Hispanic	0.063 (0.011)	0.053** (0.012)
African American	0.082 (0.011)	0.098** (0.010)
R	0.362	0.330
R^2	0.131	0.109
Adjusted R^2	0.131	0.108

Note: For each variable, the standardized coefficient is shown with the standard error in parentheses.

** Indicates significance at p<.01

After finding support for Hypothesis 1, I tested Sub-Hypothesis 1.1: *The extent to which females underestimate their math ability will have decreased between 1990 and 2002.* The results of the two regression analyses appear to disconfirm this hypothesis, given that the standardized coefficient for gender increased slightly in the ELS: 2002 data-set (β=.098), as compared to the NELS: 88 data-set (β=.087). To further analyze this change, I calculated a z-statistic to evaluate whether or not the difference between the two years was statistically significant. This technique divides the difference between the two coefficients by the estimated standard error of the difference (Paternoster, Brame, Mazerolle, and Piquero 1997; Hay 2003). If the calculated z-statistic is greater than 1.65, the difference between the two coefficients is found to be statistically significant for a one-tailed test at the .05 alpha level (Hay 2003). The results of my calculation show that the difference between the coefficients for 1990 and 2002 was not statistically significant (z=0.124), indicating that the effect of gender on one's self-perceived math ability has not changed between 1990 and 2002.

4.3 Hypothesis 2: Regression Results

To test Hypothesis 2: *The extent to which females underestimate their math ability as compared to males of equal ability will vary by racial/ethnic group,* I conducted a series of regression analyses using the ELS: 2002 data-set. The dependent and control variables used for these analyses were the same as those used in the test of hypothesis one. The difference, however, was that I conducted a separate regression analysis for each of the four racial/ethnic groups examined in the study. For each analysis, the F-test was significant and tolerance and VIF scores indicate that colinearity among the independent variables is not a concern. The R^2 values are fairly low for all models, however, indicating that factors beyond those included in this study contribute to self-perceptions of math ability.

Despite the low R^2 values, the results of the regression indicate that gender does have a significant impact on self-perceived math ability for whites (β=.104**), Asians (β=.133**), and Hispanics (β=.069**). Females in each of these groups underestimated their math ability as compared to males, even when the control variables are taken into account. Interestingly, gender was not a significant factor in predicting self-perceived math ability for African-Americans (β=.045). This result suggests that African-American females do not underestimate their math ability as compared to African-American males. This difference between African-Americans and other racial/ethnic groups provides support for my second hypothesis, as well as its four sub-hypotheses: White, Asian, and Hispanic females underestimate their math abilities as compared to males of equal ability, while African-American females do not. Table 4.8 below contains the results of each regression analysis:

Table 4.8: Regression Results, *Self-Perceived Math Ability:* Comparison across Racial/Ethnic Groups (ELS: 2002, N=11,053)

Variables	Asians	Whites	Hispanics	African Americans
Gender	**0.133** (0.027)**	**0.104** (0.011)**	**0.069** (0.023)**	**0.045 (0.027)**
Socio Economic Status	.049 (0.026)	0.026* (0.013)	0.040 (0.026)	-0.047** (0.032)
Math Standardized Score	0.379** (0.035)	0.463** (0.017)	0.453** (0.037)	0.314** (0.046)
Verbal Standardized Score	-0.042 (0.037)	-0.102** (0.017)	-0.177** (0.036)	-0.133** (0.042)
R	0.401	0.430	0.369	0.241
R^2	0.161	0.185	0.136	0.058
Adjusted R^2	0.158	0.184	0.134	0.055

Note: For each variable, the standardized coefficient is shown with the standard error in parentheses.
** Indicates significance at p<.01
*Indicates significance at p<.05

4.3.1 Hypothesis 2: ANCOVA Results

After establishing that the effect of gender on self-perceived math ability does vary according to race/ethnicity, I conducted an analysis of covariance (ANCOVA) to examine the differences in self-perception more closely. This analysis held constant the effects of actual ability and socio-economic status and determined how the mean score on the dependent variable, *self-perceived math ability,* varied among males and females in each of the racial/ethnic groups. For example, the difference in self-perception between males and females is highest for Asians and whites, and white females tend to perceive their mathematics ability lower than any other group in the study.

In addition, the results of the ANCOVA show that when the control variables are taken into account, African-Americans perceive their mathematics ability higher than the other three racial/ethnic groups for both males and females. Also, as would be expected from the regression analyses, the difference between males and females for African-Americans is considerably smaller than the difference for any other group. These results expand on the regression results regarding African-Americans by demonstrating that the non-significance of gender as a predictor of self-perceived math ability is a reflection of cultural resistance to the math-gender stereotype, and not simply due to low self-perceived math ability of African-American males as well as females. The results of the ANCOVA are shown in Table 4.9 below.

Table 4.9: ANCOVA Results for Dependent Variable, *Self-Perceived Math Ability (ELS: 2002, N=11,053)*

				95% Confidence Interval	
Race/Ethnicity	Gender	Mean	Std. Error	Lower Bound	Upper Bound
Asian	Female	2.429[a]	.032	2.365	2.492
	Male	2.633[a]	.033	2.569	2.698
African American	Female	2.699[a]	.029	2.641	2.757
	Male	2.763[a]	.033	2.699	2.827
Hispanic	Female	2.566[a]	.028	2.511	2.621
	Male	2.681[a]	.029	2.625	2.737
White	Female	2.378[a]	.013	2.352	2.403
	Male	2.559[a]	.014	2.532	2.585

a. Covariates appearing in the model are evaluated at the following values: F1 Socio-economic status composite, v.2 = .0860, Math IRT estimated number right = 39. 15608, Reading IRT estimated number right = 30.88643.

Both the regression analyses and the ANCOVA results indicate that females perceive their math ability as lower than males, even when the effects of actual ability and other possible intervening variables are held constant. These findings suggest that the math-gender stereotype does have a negative influence on the self-perceived math ability of girls. The influence of the stereotype, however, varies among racial/ethnic groups demonstrating the significance of unique cultural beliefs. The implications of these findings are addressed in the following section.

5 DISCUSSION AND CONCLUSION

5.1 Math and Gender

This study shows that there are gender differences in self-perceived math ability, with females perceiving their math ability as lower than males even when the effects of actual math achievement and other possible intervening variables are held constant. This finding supports Hypothesis 1: *Females will underestimate their math ability as compared to males of equal ability.* This relationship was found to be true of mathematics ability but not verbal ability, indicating that the tendency for females to underestimate their ability is reflective of the cultural math-gender stereotype, and not a universal tendency for females to perceive their abilities as lower than males. In addition, the influence of gender on self-perceived math ability was significant for sophomores in 1990 (using the NELS: 88 data-set) as well as sophomores in 2002 (using the ELS: 2002 data-set).

These findings are supported by both identity theory and expectation states theory. First, identity theory holds that one's gender identity is shaped by the conceptualization of what is "masculine" as opposed to "feminine" (Burke 1989). Culturally, mathematics continues to be a gender-stereotyped field, shaping the gender identity and self-perceptions of both males and females. Because mathematics is conceptualized as masculine, females are less likely than males to include mathematical ability in their sense of identity.

Next, expectation states theory holds that self-expectations are largely shaped by one's perceived status, regardless of actual ability (Meeker and Weitzel-O'Neill 1977 and Ridgeway and Correll 2004). In the United States, males are often perceived as having a higher status than females, particularly in gender-stereotyped situations. Therefore, when asked about a gender-stereotyped subject such as mathematics, females are likely to view their status as lower than males and to shape their self-expectations and perceptions of ability accordingly. As this theory would predict, my findings show that females perceive their math ability as lower than males, despite controlling for actual ability.

In addition to confirming the previous findings of Correll (2001) and others (c.f. the findings of Fennema and Sherman (1977), Hyde et al. (1990), Marsh et al. (1988), AAUW (1991)), the current study also expands on the existing literature in a number of ways. First, by comparing the findings of two nationally representative data-sets, I am able to look at how self-perceptions of ability for high school sophomores changed over time. Despite increasing evidence demonstrating that no significant difference exists between males and females in inherent mathematics ability, (c.f. the findings of Marsh et al. (1988), Singer and Stake (1986), Hyde et al. (1990), Ding et al. (2006)) the current study finds that the strength of gender as a predictor of self-perceived math ability did not decrease or change significantly between 1990 and 2002. This finding disconfirms Sub-Hypothesis 1.1: *The extent to which females underestimate their math ability will have decreased between 1990 and 2002.*

This unexpected result may be an indication that the evidence showing females and males to be equally competent in mathematics has yet to have an influence on the math-gender stereotype or on self-perceptions of ability. It may also indicate that programs aimed at encouraging girls in math have been ineffective. According to the American Association of University Women (2004: iii), "a wide array of programs and strategies has been promoted and funded by governmental and nongovernmental organizations" designed to promote "gender equity" in math and science. In the last ten years, the AAUW and the National Science Foundation have "invested nearly $90 million to fund more than 400 projects specifically aimed at increasing the participation of girls and women" in math and science-related fields (AAUW 2004: iii). The finding that girls continue to underestimate their math ability seems to indicate that these programs are not achieving their goal. Further research is necessary to determine whether the programs themselves are ineffective, or whether the programs have had success on a smaller level, but have not been made available to the majority of young girls.

<u>5.2 Role of Race/Ethnicity</u>

This study also contributes to the existing literature by examining the influence of one's racial/ethnic background in shaping gendered self-perceptions of math ability. The results of the regression and ANCOVA analyses provide support for Hypothesis 2: *The extent to which females underestimate their math ability as compared to males of equal ability will vary by racial/ethnic group,* as well as its four sub-hypotheses (Hypothesis 2.1, 2.2, 2.3 and 2.4). While white, Asian, and Hispanic females were found to underestimate their math ability as compared to males of equal ability, African-American females were not.

This finding is consistent with past literature (c. f. the findings of Sinclair (2006)) showing African-Americans to resist self-stereotyping according to dominant cultural beliefs. It is also supported by expectation states theory and the research of Ridgeway and Correll (2004: 520) showing that the self-perceptions of African-Americans are often shaped by alternative gender beliefs that “ascribe fewer competence differences to men and women than do hegemonic beliefs.” African-American females are therefore less likely than females of other racial/ethnic groups to perceive their status as lower than males, making it less likely that they will underestimate their abilities.

5.3 Limitations and Ideas for Future Research

The current study has a number of possible limitations that should be acknowledged and could be addressed in future research. First, the current analysis examined only the four racial/ethnic groups with the highest number of respondents. Groups with a low sample size such as Native Americans were not included in the analysis. Future studies should make an effort to use data that includes a larger sample of these groups in order to broaden our understanding of the role of race/ethnicity in influencing perceptions of gender stereotypes.

Also, individuals within the groups that were included (white, Asians, Hispanics, and African-Americans) are likely very diverse, but were grouped into only four major categories. It would be important for future research to look at each group more closely and attempt to determine how self-perceptions vary not only between groups, but also within each racial/ethnic group.

Next, the most recent data-set that was used in this analysis was from 2002. In order to fully examine how the influence of gender in determining self-perceived math ability has changed over time, it would be valuable to analyze an even newer data-set.

In addition, the current study was limited to high school sophomores. It would be beneficial for future research to look at whether or not self-perceived math ability varies among different age groups. For example, future studies could examine at what age gender begins to have an influence on self-perceived math ability, and if the impact of gender increases or decreases with age. Many existing studies on the topic focus solely on students without addressing how self-perceptions may change later in adulthood.

Finally, the regression models used in the current analysis produced fairly low R^2 values, indicating that many factors beyond those included in this study have an influence on self-perceived math ability. Future research aimed at identifying these factors would allow us to more fully address the relationship between gender and self-perceived math ability.

Despite these limitations, however, the results of the current study have several important implications. This study has demonstrated that gender stereotypes have the potential to influence our self-perceptions. Specifically it has shown that females perceive their math ability significantly lower than males of equal ability, a viewpoint reflective of the math-gender stereotype. This study has also shown that self-perceptions vary among different racial/ethnic groups, illustrating that unique cultural beliefs have the potential to mediate the influence of the math-gender stereotype. Both of these findings demonstrate that we must make an effort to identify the means by which gender stereotypes are perpetuated, as well as the ways individuals and groups have been able to resist their influence.

It is likely that school, community, neighborhood, family, and peer influences all contribute to shaping our self-perceptions (Scott 2007). Efforts to improve mathematics-confidence in girls, then, must take a multidimensional approach. We can begin by giving increased recognition to the achievements and successes of females in mathematics in an attempt to expose the math-gender stereotype as a belief that has no basis in reality. We must also evaluate the effectiveness of teaching methods and programs aimed at encouraging young girls in math, providing additional support for those that have been successful, and redesigning those that have not met their goals. Overcoming our stereotyped view of mathematics will require continual effort by schools, parents, and individuals. This effort to change our cultural stereotype is essential, however, if we hope to improve the self-perceived math ability of females and achieve gender equality in mathematics.

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Appendix

Appendix A Measures and Descriptions

APPENDIX A Measures and Descriptions

ELS: 2002

Measure	Description
Dependent Variable	
Self-perceived math ability :	
Can do an excellent job on math tests (BYS89A)	Asked "How often do these things apply to you?" Coded as *Almost Never* (1), *Sometimes* (2), *Often* (3), *Almost Always* (4)
Can understand difficult math texts (BYS89B)	Asked "How often do these things apply to you?" Coded as *Almost Never* (1), *Sometimes* (2), *Often* (3), *Almost Always* (4)
Can understand difficult math class (BYS89L)	Asked "How often do these things apply to you?" Coded as *Almost Never* (1), *Sometimes* (2), *Often* (3), *Almost Always* (4)
Can do an excellent job on math assignments (BYS89R)	Asked "How often do these things apply to you?" Coded as *Almost Never* (1), *Sometimes* (2), *Often* (3), *Almost Always* (4)
Can master math class skills (BYS89U)	Asked "How often do these things apply to you?" Coded as *Almost Never* (1), *Sometimes* (2), *Often* (3), *Almost Always* (4)
Self-perceived verbal ability :	
Can understand difficult English texts (BYS89C)	Asked "How often do these things apply to you?" Coded as *Almost Never* (1), *Sometimes* (2), *Often* (3), *Almost Always* (4)
Can understand difficult English class (BYS89F)	Asked "How often do these things apply to you?" Coded as *Almost Never* (1), *Sometimes* (2), *Often* (3), *Almost Always* (4)
Can do excellent job on English assignments (BYS89I)	Asked "How often do these things apply to you?" Coded as *Almost Never* (1), *Sometimes* (2), *Often* (3), *Almost Always* (4)
Can do excellent job on English tests (BYS89K)	Asked "How often do these things apply to you?" Coded as *Almost Never* (1), *Sometimes* (2), *Often* (3), *Almost Always* (4)
Can master skills in English class (BYS89M)	Asked "How often do these things apply to you?" Coded as *Almost Never* (1), *Sometimes* (2), *Often* (3), *Almost Always* (4)

Measure	Description
Independent Variable	
Gender (F1SEX)	Categorical variable measured at the nominal level. Taken from base year derived variable BYSEX, if available. F1SEX was imputed if otherwise missing. Recoded as *Male* (1), *Female* (0)
Race/Ethnicity (F1RACE)	Student's reported race\ethnicity. This is a categorical variable measured at the nominal level. The original variable was recoded into a series of dummy variables for use in the regression analyses. F1RACE was imputed if otherwise missing.
Measure	**Description**
Control Variable	
Math IRT estimated number right (BYTXMIRR)	The math IRT (item response theory) estimated number right score is an estimate of the number of items students would have answered correctly had they responded to all 72 items in the ELS: 2002 math item pool. The ability estimates and item parameters derived from the IRT calibration can be used to calculate each student's probability of a correct answer for each of the items in the pool. These probabilities are summed to produce the IRT estimated number right score.
Reading IRT estimated number right (BYTXRIRR)	The reading IRT (item response theory) estimated number right score is an estimate of the number of items students would have answered correctly had they responded to all 51 items in the ELS: 2002 reading item pool. The ability estimates and item parameters derived from the IRT calibration can be used to calculate each student's probability of a correct answer for each of the items in the pool. These probabilities are summed to produce the IRT estimated number right score
Socio-Economic Status (F1SES2)	Standardized composite variable consisting of: Father's education level (F1FATHED) Mother's education level (F1MOTHED) Father's occupation (F1OCCUFATH) Mother's occupation (F1OCCUMOTH) Family Income (BYINCOME)

APPENDIX A Measures and Descriptions

NELS: 88

Measure	Description
Dependent Variable	
Self-perceived math ability:	
Mathematics is one of respondent's best subjects (F1S63D)	Asked to "Choose the answer that is best for you." Coded as *False* (1), *Mostly False* (2), *More False than True* (3), *More True than False* (4), *Mostly True* (5), *True* (6)
Respondent has always done well in mathematics (F1S63J)	Asked to "Choose the answer that is best for you." Coded as *False* (1), *Mostly False* (2), *More False than True* (3), *More True than False* (4), *Mostly True* (5), *True* (6)
Respondent gets good marks in mathematics (F1S63Q)	Asked to "Choose the answer that is best for you." Coded as *False* (1), *Mostly False* (2), *More False than True* (3), *More True than False* (4), *Mostly True* (5), *True* (6)
Self-perceived verbal ability:	
English is one of respondent's best subjects (F1S63E)	Asked to "Choose the answer that is best for you." Coded as *False* (1), *Mostly False* (2), *More False than True* (3), *More True than False* (4), *Mostly True* (5), *True* (6)
Respondent learns things quickly in English classes (F1S63B)	Asked to "Choose the answer that is best for you." Coded as *False* (1), *Mostly False* (2), *More False than True* (3), *More True than False* (4), *Mostly True* (5), *True* (6)
Respondent gets good marks in English (F1S63G)	Asked to "Choose the answer that is best for you." Coded as *False* (1), *Mostly False* (2), *More False than True* (3), *More True than False* (4), *Mostly True* (5), *True* (6)
Measure	**Description**
Independent Variable	
Gender (F1SEX)	Categorical variable measured at the nominal level. Taken from base year derived variable BYSEX, if available. F1SEX was imputed if otherwise missing. Recoded as *Male* (1), *Female* (0)

Measure	Description
Control Variable	
Race/Ethnicity (F1RACE)	Student's reported race\ethnicity. This is a categorical variable measured at the nominal level. The original variable was recoded into a series of dummy variables for use in the regression analyses. F1RACE was imputed if otherwise missing.
Math IRT estimated number right (F12XMIRR)	The math IRT (item response theory) estimated number right score is an estimate of the number of items students would have answered correctly had they responded to all 72 items in the ELS: 2002 math item pool. The ability estimates and item parameters derived from the IRT calibration can be used to calculate each student's probability of a correct answer for each of the items in the pool. These probabilities are summed to produce the IRT estimated number right score.
Reading IRT estimated number right (F12XRIRR)	The reading IRT (item response theory) estimated number right score is an estimate of the number of items students would have answered correctly had they responded to all 51 items in the ELS: 2002 reading item pool. The ability estimates and item parameters derived from the IRT calibration can be used to calculate each student's probability of a correct answer for each of the items in the pool. These probabilities are summed to produce the IRT estimated number right score