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ABSTRACT

This study examined the influence of gender and various background and personality factors on science anxiety. Students (50 women, 37 men) took the Science Anxiety Scale (Mallow, 1994), provided information about high-school and college academic accomplishments, described gender-role stereotyping in the home, evaluated their science teachers and experiences, and completed indicates of personality. These latter measures included Fear of Negative Evaluation (Leary, 1990), Perfectionism (Burns, 1980), Self-Handicapping (Jones & Rhodewalt, 1991), and attributional style (measured via the Multidimensional-Multiattributional Causality Scale; Lefcourt, von Baeyer, Ware, & Cox, 1979). Students with high science anxiety took fewer science courses in college, had lower SAT-Q scores, and reported that their high school science teachers were not helpful. Those with science anxiety were more perfectionistic, suggesting that science anxiety may stem from a desire to avoid tasks that do not always ensure success, rather than dislike or lack of ability. Math and science preparation for men and women was equal, although women reported better grades and science experiences. Men showed more self-handicapping and reported external attributional styles to context and luck. The findings regarding genderand anxiety-linked differences are discussed in terms of women and men's differential interpretations of their abilities, the influence of parental gender typing on pursuit of science, the tendency for men to blame external agents for their lack of success, and the gender-appropriateness of studying science. (Contains 67 references.) (Author/ASK)

Running head: SCIENCE ANXIETY

Science Anxiety as a Function of Personality, Gender Roles, Experience with Science

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Abstract

This study examined the influence of gender and various background and personality factors on science anxiety. Students (50 women, 37 men) took the Science Anxiety Scale (Mallow, 1994), provided information about high-school and college academic accomplishments, described gender-role stereotyping in the home, evaluated their science teachers and experiences, and completed indices of personality. These latter measures included Fear of Negative Evaluation (Leary, 1990), Perfectionism (Burns, 1980), Self-Handicapping (Jones & Rhodewalt, 1991), and attributional style (measured via the Multidimensional-Multiattributional Causality Scale; Lefcourt, von Baeyer, Ware, & Cox, 1979). Students with high science anxiety took fewer science courses in college, had lower SAT-Q scores, and reported that their high school science teachers were not helpful. Those with science anxiety were more perfectionistic, suggesting that science anxiety may stem from a desire to avoid tasks that do not always ensure success, rather than dislike or lack of ability. Math and science preparation for men and women was equal, although women reported better grades and science experiences. Men showed more Self-Handicapping and reported external attributional styles to context and luck. The findings regarding gender- and anxiety-linked differences are discussed in terms of women and men's differential interpretations of their abilities, the influence of parental gender typing on pursuit of science, the tendency for men to blame external agents for their lack of success, and the gender-appropriateness of studying science.

Science Anxiety as a Function of Personality, Gender Roles, Experience with Science

Matches, COBOL, antifungal antibiotics, pulsars, Vitamin A, K-mesons, cepheid variable stars, radium, mobile genes, and Kevlar: these inventions and discoveries have in common a group of scientists who share one distinguishing feature--all were women. Despite such impressive achievements, women's contributions in science have not kept pace with their advancements in other fields. Although a variety of social and political reasons have contributed to slow growth of representation of women in science, one primary cause is that women have negative views of the self-efficacy of studying science, and lack confidence about their abilities to master scientific concepts (Acker & Oatley, 1993; Lips, 1992; Mallow, 1994). Consequently, few women obtain advanced degrees in science and hold jobs in scientific and science-related fields, such as engineering (Seymour, 1995; Smith, 1992; Trankina, 1993). A number of explanations have been offered for to account for women's lack of interest and in, and pursuit of, science. These explanations have focused on differential cognitive strengths of men and women, attributions about abilities, the gender-appropriateness of certain fields, socialization and modeling at home, school, and through the media, and transient and stable anxiety toward science. Indeed, it is probable that all of these sources contribute to women's lack of achievement in science, although the relative impact of each is unknown.

Cognitive Abilities

Gender differences cognitive ability are probably not the root of gender differences in science achievement, although there are some cognitive abilities that may influence facility with scientific concepts. Most gender differences in cognitive abilities, including higher SAT-Verbal scores for men (Hyde & Linn, 1988) and a slight (two-point) IQ advantage of men (Furnham & Rawles, 1995), are meaningless on a practical level. On the other hand, math ability is typically needed for science, and those who excel in math are usually male (Feingold, 1988; Halpern, 1997; Holden, 1987). Moreover, spatial ability, particularly mental rotation, appears to be one cognitive capability at which men are reliably superior to women (Voyer, Voyer, & Bryden, 1995). Mental rotation may contribute to gender differences in math and science ability, as this skill is important to these fields, and may account for men's superior performance in physics (Räsänen, 1991). Although the magnitude of the few cognitive gender differences that exist may be statistically significant, these may not be large enough on a practical level to constitute a strong influence in preventing women from succeeding in math and science, and from entering scientific fields (Archer, 1996). Furthermore, mental rotation abilities can be improved with training and practice (Halpern, 1986).

Math and science abilities of girls and boys are equal during early school years, and girls have more science and math interest (Fouad & Smith, 1996) and better grades than boys up until high school (Paulsen & Johnson, 1983; Smith, 1992). However, by the latter years of high school, girls score lower than boys on standardized math tests (Kimball, 1989; Stricker, Rock, & Burton, 1993). The sexes begin to diverge in science and math interests and achievement at the beginning of high school, and this difference becomes pronounced in further education (Holden, 1987). The deviation of men's and women's interest and ability in science may be due to a number of factors, including different interpretations of academic success and the perceived utility of pursuing science.

Self-Perception and Attributions for Science Abilities

Attribution patterns for girls' success in both math (Kimball, 1989; Seymour, 1995) and science (Smith, 1992) change as girls get into high school, typically moving from ability (which is stable) to effort (which is unstable). In turn, the perception that increased effort will be needed to succeed at these subjects may affect the subjective utility or "outcome expectancy" for studying science and math, which decreases among high-school women but increases for high-school men during this period (Fouad & Smith, 1996). Extracurricular activities related to math and science diverge during high school also, and non-school experiences influence science and math interests (Fouad & Smith, 1996). Thus, the conceptualization of science as difficult and as a subject that requires extreme effort, rather than an interesting and helpful field, is common by the time women leave high school (Kahle, Parker, Rennie, & Riley, 1993; Ledbetter, 1993). Given that female students have earned higher grades than men up through high school, and that they have had obvious success with all school subjects, including science, why is strong performance not interpreted as indicative of high ability?

Regardless of their actual math and science performances, women are much less self-confident in their capabilities with these domains (Kimball, 1989; Trankina, 1993), and report much more science anxiety than do men (Mallow, 1994). Confidence in a particular domain does increase interest (Fouad & Smith, 1996; Lent, Lopez, & Bieschke, 1991) and liking of academic subjects is predictive of actual ability and achievement (Paulsen & Johnson, 1983; Williams, 1994). The link between self-perceptions and ability is strong, although these links may be mediated by preferences, attitudes, persistence, and expectancies (Beyer, 1995). For example, high ability in math (as assessed by the SAT) does not predict pursuit of scientific careers as strongly as lack of math anxiety, suggesting that beliefs and attributions about abilities may be more important than performance in determining whether a woman will engage in scientific endeavors (Chipman, Krantz, & Silver, 1992).

Attributions regarding performance differ for men and women in many domains, not just science and math, as women often underestimate their ability and are inaccurate in predictions of their future capabilities, particularly in masculine domains (Beyer, 1990; Beyer & Bowden, 1997). Even if women do not lack confidence in their abilities, they may indicate that they do in order to seem modest about their successes (Heatherington, Daubman, Bates, Ahn, Brown, & Preston, 1993). Women also interpret criticisms of any given performance as indicative of their overall abilities, and such sensitivity leads to diminished interest (Atlas, 1994). Men, on the other hand, often discount critical information in self-evaluations of their capabilities (Roberts, 1991), usually because they expect (and are expected) to succeed at any task they attempt if they persist (Levy & Baumgardner, 1991). Reasons for success and failure in science also vary according to gender, as an external attribution for success and internal attribution for failure in science is likely for women (Acker & Oatley, 1993; Seymour, 1995; Terborg & Ilgen, 1975; Trankina, 1993). Further, when people do not perform as they expect, the attribution for their performance is unstable. Thus, when women unexpectedly perform well, the attribution for their success is to an unstable cause (such as luck), but if they match their already-low expectation the subsequent attribution is stable, perhaps to lack of ability (Beyer & Bowden, 1997).

<u>Sex-Role Socialization by Parents, Teachers, and the Media</u>

People expect different behaviors and abilities according to gender (Swim & Sanna, 1996). In particular, parents' conceptions of gender-related abilities of men and women, and their consequent gender-typed expectations of their children, serve as mechanisms by which children come to understand how to behave (Eagly, 1987; Jacobs & Eccles, 1992). In general, parents show few gender-related socialization differences with regards to encouraging general achievement; however, both mothers and fathers encourage gender-consistent activities in their children (Lytton & Romney, 1991). Given that certain school subjects and their related activities are gender-typed, parents may consequently encourage their children differentially and view them as differentially capable in certain domains. For example, science, computer science, and math are seen as masculine, whereas art, literature, and education are seen as feminine (Acker & Oatley, 1993; Colley, Comber, & Hargreaves, 1994; Cooper, Hall, & Huff, 1990; Potts & Martinez, 1994). Moreover, the traditional feminine role includes dependency and a focus on interpersonal relations, which conflict with a characterization of science ability (Smith, 1992). Thus, it is not surprising that parents do not encourage daughters nor see them as able in masculine domains (including science and math), but do see their daughters as more interested in the humanities, and view them as more socially capable (see Beyer, 1995, for a complete review). These parental beliefs affect children's self-perceptions of capability (Fouad & Smith, 1996), and may be a more important determinant of children's conceptions than other sources of information, such as actual performance in school (Jacobs & Eccles, 1992). The gender-typed views of parents have long-range consequences, because many students report that parents are very important in their decisions regarding careers (Holden, 1987), which also follow from gender-typical course choices in high school (Eccles, 1987).

The school social climate can also implicitly or explicitly encourage or discourage science studies for girls (Rennie & Dunne, 1994). Like parents, teachers may view science as incongruent with the feminine sex role (Kahle et al., 1993), perhaps because many elementary school teachers are women who have experienced difficulty and anxiety with science. Furthermore, teachers believe that boys have more ability than girls in math and science (Jussim & Eccles, 1992; Shepardson & Pizzini, 1992), and perceive that girls' achievement in these areas is due to effort rather than innate capability (Jussim & Eccles, 1992). These perceptions impact classroom interactions (Rech, 1996; Seymour, 1995), as teachers ask girls few difficult questions in science and math classes, call on girls less often than boys (Cherian & Siweya, 1996), involve boys in demonstrations, and direct their lectures and comments more often to boys (Kahle et al., 1993). Thus, interest in science may be stimulated in boys, and discouraged in girls. Moreover, teacher expectations can become real under certain circumstances (see Madon, Jussim, & Eccles, 1997, for review), as those whom teachers believe are stronger in science actually perform better (Jussim & Eccles, 1992).

Adult role models also strongly influence children's beliefs about appropriate behaviors and aspirations, and children are more likely to engage in activities at which people of their gender succeed (Signorella & Jamison, 1986). Proportionally, few women are scientists (Mallow, 1994; Smith, 1992; Trankina, 1993) or science teacher/professors (Acker & Oatley, 1993); thus, there are few women scientists to serve as role models. Moreover, children's exposure to models that are not gender-role consistent are more difficult to understand and remember (Bigler & Liben, 1990). The lack of women scientists to emulate may be counteracted by the achievement levels of parents, particularly mothers. Women mimic the educational aspirations of their mothers (but not their fathers), and are likely to further their education past college if their mothers hold post-baccalaureate degrees (Isaac, Malaney, & Karras, 1992). Few, however, attain such levels of education, and fewer of these are women in science; therefore, it is unlikely that girls can model their mothers' scientific achievements.

The media also reflect and contribute to notions of gender-role appropriate behavior, as social roles portrayed in the media help delineate gender roles for children (Fitch, Huston, & Wright, 1993). Gender stereotyping is prevalent among all types of media, from children's stories (McArthur & Eisen, 1976), through "superhero" comic books (Young, 1993), to children's cartoons (Brownlow & Durham, 1997), and commercials (Rajecki, Dame, Creek, Barrickman, Reid, & Appleby, 1993). In general, girls and women are shown as socially positive, but not as authorities, and are not portrayed as knowledgeable, data-citing experts (Brownlow & Zebrowitz, 1990). Even when seen using science, women are merely tangential to male figures (Brownlow & Durham, 1997).

Clearly a number of sources--from appropriateness of studying science, to tacit and explicit expectations about abilities in science, to attributions for successes with science--influence attitudes toward science. Regardless of their source, negative attitudes toward science are linked to science anxiety, which in turn decreases likelihood of pursuing and achieving in science (Mallow, 1994). This study examined how gender, gender-role socialization, experience with science, academic/social background, and relatively stable personality variables differ as a function of science anxiety. We also studied the relationship of gender and science anxiety to attributional style. We predicted that women, particularly those with poor science experiences and strong feminine gender-typing, would show the most science anxiety, and that experience and success with science at the high school and college level would not attenuate these effects, because of an attributional style that explains success as unstable and due to external forces.

Method

Participants

A total of 166 college students (81 men and 85 women) enrolled in one of several classes (entry-level science courses [n = 42], mid- and upper-level science courses reserved for those students who were declared science majors [n = 55], or general psychology classes [n = 69]) took the Science Anxiety Scale (Mallow, 1994) during a science lab or a psychology class at the beginning of the semester, before any exams or lab activities in any courses. The Science Anxiety Scale includes 44 statements regarding academic tasks (half of which are focused on science activities exclusively), and each is rated on a 5-point scale (with endpoints labeled 1 "not at all" to 5 "very much") according to how much anxiety each provokes. Sample items include "having your professor watch you perform a science experiment in the lab" and "memorizing a chart of historical dates." Summation of the science items yields a science-anxiety measure, and addition of responses to the other items produces a general academic anxiety index. All students who took the Science Anxiety Scale were contacted and asked to participate further, and 87 students (50 women, 37 men) agreed to do so.[1] Of these, 38 were not planning on majoring in a science, 13 were planning to major in science (and were taking entry-level major courses, but had not yet declared the major), and 36 were majoring in a science.

Dependent Measures

Masculinity/Femininity. Adherence to masculine or feminine gender-typing ideals was assessed via subscales on the Personality Research Form ANDRO Scale (Berzins, Welling, & Wetter, 1978). A total of 35 items appear on the scale, including "I try to control others rather than permit them to control me" and "I would prefer to care for a sick child myself rather than hire a nurse," and respondents indicated true or false to each item. Two scores, one for masculinity and one for femininity, were obtained for each participant by totaling responses consistent with the gender role stereotype of masculinity or femininity.

Socialization of Sex Roles. The Socialization of Sex Roles Scale (adapted from Catalyst, 1992, in Myers, 1993) measures a person's gender-role socialization based on information about gender-type behavior acquired in the home. There were two scales, a scale for men and a scale for women, and these include statements such as "big boys don't cry" and "a woman's place is in the home," respectively. Respondents indicate whether they heard the statement while growing up, and if they believed they might say the statement to their children. Thus, two scores result by summing the number of gender-role consistent statements heard in the past and predicted for the future.

Fear of Negative Evaluation. The Fear of Negative Evaluation Scale (FNE; Leary, 1990) measures fear and anxiety about negative evaluation obtained from others. The FNE contained items such as "I am afraid that others will not approve of me" and "I often worry that I will say or do the wrong things." Each item was judged on a 5-point bipolar scale (with endpoints labeled 1 "very low" to 5 "very high"), and a total was obtained.

Self-Handicapping. The Self-Handicapping Scale (Jones & Rhodewalt, 1991) examines how people create barriers to success so that when failure occurs an external attribution can be made. Items on the scale include "I tend to put things off until the last minute" and "someday I might 'get it all together'." Each item was rated on a 6-point scale (with scale anchors labeled 0 "disagree very much" to 5 "agree very much"), with eight reverse scored items, and a sum was acquired.

Multidimensional-Multiattributional Causality. Attributional style was measured through the Multidimensional-Multiattributional Causality Scale (MMCS; Lefcourt, von Baeyer, Ware, & Cox, 1979). The MMCS delineates two types of attributional styles, internal and external, and further distinguishes whether internal attributions are made to ability or effort, and whether external attributions are made to luck or situational context. The MMCS consists of 48 items such as "whenever I receive good grades, it is always because I have studied hard for that course" and "some of my bad grades may have been a function of bad luck, being in the wrong course at the wrong time." Each question is assessed on a 5-point scale (with scale endpoints listed as 1 "disagree" to 5 "agree"). The questions are divided equally between success and failure situations, and among these success and failure situations are an equal number of questions that determine attributions to ability, effort, luck, and context. This scale thus produces 15 separate attributional indices, including (1) a total score for overall tendency to make attributions of all kinds; (2) a score for internal and external attributions, collapsed across the four types of attributions and the success and failure dimension; (3) a measure for each type of attribution, collapsing across success and failure; and (4) an attributional index for each type of attribution for both success and failure.

Perfectionism. The Perfectionism Scale (PER; Burns, 1980) was used to evaluate perfectionism, which is behavior that is geared toward orderliness and striving to do tasks perfectly, or not doing the tasks at all if perfection is not possible. The scale included items such as "if I cannot do something really well, there is little point in doing it at all" and "failing at something important means I'm less of a person." The participants rated indices on a 5-point scale (with endpoints listed as +2 "I agree very much" to -2 "I disagree strongly").

Academic background and home environment. Participants listed their gender, age, major (or intended major), noted the occupations of both parents (which were classified as either involving science or math or not), and whether they had ever owned science-related paraphernalia (such as telescopes or chemistry sets). Participants used 5-point bipolar scales with anchors labeled 1 "never" to 5 "often" to indicate how much they visit science-oriented places, such as museums and planetariums, and how often they watch science-oriented television shows, such as Beakman's World. A second page of this background questionnaire required disclosure of academic information.[2] This information included how many science and math courses were taken in both high school and college, college GPA (for non-freshmen), and SAT math and verbal scores (assessed by checking a range of 200-400, 401-500, 501-600, 601-700, and 700+). Because previous science experience can either reduce or increase science interest (Ledbetter, 1993), participants evaluated their science experiences for courses taken in high school and college. For science courses taken in both high school (up to four) and college (up to six), participants indicated the grade received, the gender of the instructor, and the effectiveness of the instructor (rated on a 5-point scale from 1 "very ineffective" to 5 "very effective").

Procedure

All participants completed the study with one of three experimenters. After obtaining informed consent, participants completed the scales in one of two orders, counterbalanced within gender. However, the background questionnaire was always administered last, as the specific science-course questions might have cued participants to the purpose of the study. After completing the scales and questionnaires, participants were dismissed, and were later debriefed in a class setting or received a letter with a full description of the purpose of the study.

Results

Overview

In order to examine whether those with high levels of science anxiety were different in regards to background, achievement, and personality from those with lower levels of anxiety, participants were grouped into high and low science anxiety groups based on a median split (Mdn = 43.00). Medians for men participants (Mdn = 41.00) and women participants (Mdn = 43.00) were close, and within-gender median splits produced the same grouping arrangement. The low-anxiety group included 19 men and 24 women, and 18 men and 26 women were given high-anxiety designation. Anxiety was then used as a two-level factor in 2 x 2 (Anxiety x Participant Gender) ANOVAs, and those designated as higher in science anxiety (M = 55.20) did indeed show more science anxiety than those assigned to the low anxiety group (M = 33.21), $F(1, 83) = 144.30$, $p < .001$, although men (M = 45.51) and women (M = 45.68) did not show different levels of science anxiety. The people in the high and low anxiety groups did not differ significantly in age, nor were they unequally distributed according gender and science experience (i.e., majoring in science, planning to major in science, not intending to major in a science), both $\chi^2(2, N = 87) < 2.52$, ns. Various background, achievement, and personality measures were then separately entered into these 2 x 2 ANOVAs, the means from which are shown in Tables 1-4, and Scheffé tests (alpha = .05) were used for post-hoc examination of interactions. Given the large number of analyses, the acceptable p-level for interactions to be considered meaningful was lowered to .025.

Socialization of Sex Roles and Home Environment

Means from 2 x 2 (Gender x Science Anxiety) ANOVAs examining the influence of parental gender-role socialization and the focus on science in the childhood environment according to science anxiety and gender are located in Table 1. Men (M = 8.95) reported hearing more gender-typed statements growing up compared to women (M = 7.00), $F(1, 83) = 9.21$, $p < .005$, and men (M = 6.97) predicted they will socialize their children in a gender-typed way more than women (M = 2.66), $F(1, 83) = 89.87$, $p < .001$. Although there was no influence of gender or science anxiety on recollections of visiting science museums, men (M = 3.59) more than women (M = 2.90) reported watching science-related television shows, $F(1, 83) = 5.63$, $p \leq .02$.

In order to examine whether parental work involving science or math influenced science anxiety as a function of gender, parent occupations were coded as either involving science or math (i.e., lab technician, engineer, CPA) or not (i.e., secretary, history teacher). Chi-square analyses revealed no relationship between gender and science anxiety for those students with one or more parents involved in science or math, $\chi^2(1, N = 62) < 1$, ns. Similarly, students of varying gender and science anxiety did not recall differential ownership of science paraphernalia in the home, $\chi^2(1, N = 70) < 1$, ns.

Academic Preparation and Background

Table 2 displays means from analyses concerning academic achievement and background. Some participants omitted responses to selected questions; thus, df varies in these ANOVAs. For SAT scores, participants indicated a range, which was then assigned a number for calculation. For example, a "1" was assigned for SAT scores in the range of 200-400, and a "2" was for SAT scores in the range of 401-500. For SAT-Q, an effect of anxiety emerged, $F(1, 76) = 3.99$, $p < .05$, as students with low anxiety (M = 2.92) had higher SAT-Q scores than those of higher anxiety (M = 2.54). A Gender x Anxiety level interaction was revealed for SAT-V scores, $F(1, 76) = 11.49$, $p < .001$. Scheffé tests (alpha = .05) indicated that high-anxiety men (M = 1.94) had lower SAT-V scores than did low science-anxiety male students (M = 2.83), but that high science-anxiety women (M = 2.70) had higher verbal abilities than low-anxiety women (M = 2.19). Current GPA was reported by most students who had a formal

GPA at the time of the study ($n = 51$), but not by first-semester freshmen. Women ($M = 3.31$) reported a higher GPA than men ($M = 2.92$), $F(1, 47) = 9.04$, $p < .005$, although it should be noted that GPA did not differ according to science anxiety, suggesting that students who were performing poorly in most of their classes were not necessarily those with the greatest amount of science anxiety.

As seen in Table 2, number of high school science and math courses taken did not differ according to science anxiety levels or gender, demonstrating that high school preparation in areas related to science anxiety did not differ among these groups. Not surprisingly, however, students with low science anxiety ($M = 4.14$) reported taking more college science courses than those with high science anxiety ($M = 2.44$), $F(1, 79) = 4.89$, $p < .05$, although number of college math courses taken did not differ according to gender or anxiety. It should be recalled that students majoring in science were not more likely to be science-anxious than those not majoring in science, although these students probably took more science course. As well, many science majors require considerable math preparation; therefore, it is unlikely that the low science-anxious students were avoiding science courses in college because they were not required to take them for a major.

Evaluation of first science experiences included first high school and college science grades (on a 4-point academic scale), ratings of the effectiveness of the first high school and college science instructor, and an aggregate rating of perceived high school science teacher effectiveness, which was formed by collapsing across those ratings of high school science teachers that were significantly correlated, rs(82) = .34 to .51, ps < .01. Results from the ANOVAs concerning subjective evaluations of high school and college science experiences provide some insight as to why some students have more science anxiety than others. As can be seen in Table 2, grades in the first high school science course and the corresponding rating of the teacher's effectiveness at transmitting science concepts were not influenced by participant gender or level of science anxiety. Although the analysis for teacher effectiveness ratings for the second high school science course taken also showed no significant differences, women did report higher grades in this course than did men ($\underline{M}$s = 3.50 and 3.11 for women and men, respectively), $\underline{F}(1, 76) = 4.70$, $\underline{p} < .05$. Teacher effectiveness ratings for some courses were correlated (which is not surprising given that some of the teachers may have been the same), and were then combined and subjected to the 2 x 2 ANOVA, which showed that students with low science anxiety ($\underline{M} = 4.02$) gave their high school teachers higher effectiveness ratings than those students with high science anxiety ($\underline{M} = 3.54$), $\underline{F}(1, 79) = 4.51$, $\underline{p} < .05$. Most (62%) high school science teachers, particularly the first teacher, were men; however a 2 x 2 chi-square indicated that having a male as the first high school teacher did not vary according to gender and level of science anxiety, $\chi^2(1, \underline{N} = 86) < 1$, ns.[4] Most students who had taken a college science course ($\underline{n} = 59$) had a male professor for that course, and grades and professor effectiveness ratings for that first course were not impacted by gender or science anxiety.[5]

Masculinity, Femininity, Personality, and Attributional Style

Means from 2 x 2 ANOVAs utilizing Perfectionism, Self-Handicapping, Masculinity, Femininity, and Fear of Negative Evaluation are located in Table 3. Not surprisingly, Masculinity scores were higher for men ($\underline{M} = 11.97$) than women ($\underline{M} = 10.28$), $\underline{F}(1, 83) = 5.12$, $\underline{p} < .05$, although Femininity scores did not differ between men and women. Fear of Negative Evaluation was not affected by gender or science anxiety level. However, highly science-anxious students ($\underline{M} = 4.75$) were more perfectionistic than those with low levels of anxiety ($\underline{M} = 2.16$), $\underline{F}(1, 83) = 4.87$, $\underline{p} < .05$, and men (M = 61.35) reported a greater tendency to self-handicap than did women (M = 56.30), $F(1, 83) = 4.06$, $p < .05$.

Examination of the means from MMCS analyses, located in Table 4, reveals little relationship between science anxiety and attributional styles, although many gender differences in attributional style were found. Specifically, men more than women had an external attributional style, $F(1, 83) = 8.62$, $p < .005$, and this was the case for both types of external attributions: to context, $F(1, 83) = 8.04$, $p < .01$, and to luck, $F(1, 83) = 8.05$, $p < .01$. Moreover, the tendency for men more than women to make attributions to context and luck appeared for failure situations, $Fs(1, 83) = 6.91$ and 8.07, both $ps < .01$, for context and luck, respectively. External attributions to context for successes varied as a function of both gender and science anxiety, $F(, 183) = 6.96$, $p \leq .01$, and Scheffé tests (alpha = .05) revealed that low-anxiety men (M = 8.68) more than high science-anxiety men (M = 6.83) made attributions to context for their successes. Successes attributed to luck also showed a gender difference, with men more than women believing that luck could account for their successful academic achievements, $F(1, 83) = 4.59$, $p < .05$.[6]

Discussion

This study demonstrated how social, academic, and personality factors all differ among people varying in levels of science anxiety. Students with high levels of science anxiety were perfectionistic, reported that they had ineffective high school science teachers, avoided science in college, and had lower SAT-Q scores. Women were not uniformly more science anxious and had a relatively similar background to men with regards to science experiences, although they had higher science grades in high school and did report less stringent sex-role socialization in the home. Women and men did, however, differ on several personality dimensions (Self-

Handicapping, masculinity, various attributional styles) that may explain their differential pursuit of science overall. However, our distribution of high-science anxiety students across gender and across intents for having science involved in future career plans allowed us to isolate effects of gender and anxiety, without covarying these. The resulting patterns of gender differences on various measures therefore may not have been as strong as expected, owing to this delineation. Given that women typically have stronger science anxiety than do men (Mallow, 1994), past research locating gender differences in liking and pursuit of science, and concomitant factors associated with these, may have been the result of science anxiety differences rather than gender. However, this study did show that students varying in both gender and science anxiety showed some evidence of differential socialization, background and achievement, and personality.

Men more than women indicated that they had been socialized according to traditional gender-role stereotypes, and predicted that they would employ the same type of socialization for their own children. Despite such gender-typed socialization, men did not report that their parents took them to more science museums and provided more science paraphernalia around the home, and their parents were not more likely to be employed in science as compared to women. It is not surprising that these latter indices showed no gender differences, as parents of the students in this sample (generally affluent college students) probably inspire achievement in their children, and gender-linked differential socialization is unlikely for encouraging high levels of accomplishment in general (Lytton & Romney, 1991). Moreover, no questions on the scale for men pertained to cognitive abilities of women and men, as questions focused on socialization of agentic qualities (such as "the strong survive" and "hide your fears"), although the scale for women included overt statements about women's cognitive abilities and place in the work force (e.g., "girls can't do math" and "a woman's place in the home"). Thus, higher indications of gender-typed socialization for men may have reflected hearing about, and planning to talk about, the need for agentic qualities (i.e., "never admit defeat"), but for women this scale may have tapped socially-inappropriate, extreme views (such as "girls grow up to be mommies, nurses, and teachers"). It should be noted, however, that an examination of means for women on the socialization measure clearly shows that high-anxiety women were more strongly socialized according to gender-stereotypes than were low-anxiety women, albeit not significantly so. Further examination of the impact of gender-role socialization on science anxiety for men and women will require scales that better measure socialization practices.

Men did report watching more science-oriented television shows, although the rubric of "science-oriented" television is large, and could very well encompass cartoons with a heavy emphasis on technology, which are aimed at boys and revolve around male figures (Brownlow & Durham, 1997; Potts & Martinez, 1994). Despite the science focus, these shows may not appeal to girls because there are few female role models in them, and even those that portray women using science probably do not positively influence girls, because models that are not gender-role consistent are more difficult to understand and remember (Bigler & Liben, 1990) unless repeated consistently (Gash & Morgan, 1993; Raskin & Israel, 1981). The tendency to watch shows revolving around science and technology may also vary with the propensity to play technology-oriented computer games, which are strongly gender-typed and appeal to boys more than girls (Cooper et al., 1990).

Math and science preparation in high school was equal for men and women, although an analysis of the nature and difficulty of these courses was not possible given that only course titles were provided. As well, evaluations of the first high school science course and the corresponding grade did not differ according to gender. However, women did report higher GPAs and better grades in one high school science course. Those who had higher levels of science anxiety, however, had lower SAT Quantitative scores, took fewer science courses in college, had lower SAT Verbal scores (if men), and, most importantly, reported that their high school science teachers were ineffective. For these students, it is possible that their science anxiety was justified, given their previous academic difficulties, and the track record in science may have been the cause of both the anxiety and desire to avoid majoring in science. Women did not show more anxiety than men, and that their academic preparation with regards to science and math were not lacking in relation to that of men. Thus, women with high anxiety may have misinterpreted their prior academic accomplishments, perhaps because they were not confident of their abilities in this traditionally-masculine domain (Beyer, 1990; Beyer & Bowden, 1997; Levy & Baumgardner, 1991). This lack of confidence may predicate dislike (Lent et al., 1991), which also affects achievement (Beyer, 1995; Chipman et al., 1992), although the high-anxiety women in this study were not the students who reported low achievement. Nonetheless, any criticism of ability at any point may have been more influential for women in determining their efficacy with science, as women take more seriously critiques of their abilities than do men (Roberts, 1991). Teacher behavior may have reinforced diminished efficacy beliefs, as teachers of girls who show great success in math predict lower achievement for those same girls in the future (Kimball, 1989). Even if a teacher did have positive beliefs about student's ability, the teacher's attitude will not cause change in the student <u>if</u> that student has a low self-efficacy for math (Madon et al., 1997).

Science may cause anxiety for reasons unrelated to socialization or interpretation of abilities. Kimball (1989) noted that women may be more troubled by math (often a prerequisite for science study) than men because in learning math, an algorithmic, rote approach that leads to success on class exams is preferred by female students. However, standardized tests (such as the SAT) do not include a preponderance of such items on which women actually perform well (Harris & Carlton, 1993). Moreover, novel tasks are avoided, because these do not lend themselves to answers that can be obtained by hard work alone. Although the women in the current study did not uniformly avoid science or have deficits in math, our high science-anxiety students showed strong evidence of perfectionism. Thus, the students who indicated that science-oriented tasks cause anxiety also reported that they believed that mere effort should lead to excellence, and that failing at something is indicative of weakness. These particular students probably avoid tasks unless those tasks are familiar, and may eschew novel tasks that have a possibility of failure, despite high levels of effort. This learning style may have impacted interpretations of successful accomplishments in math and science, leading students to decide that although these subjects can be mastered, the effort needed to succeed may not be worthwhile without more of a guaranteed (successful) outcome.

Men more than women showed self-handicapping by reporting that they create barriers to success so that when failure occurs, an external attribution can be made. This tendency is consistent with the attributional styles shown by men. Men made external attributions (to both luck and context) for situations where they were successful as well as for those where they were not. However, those men with high science anxiety were less likely to credit their successes to context. For men, a judgment that high school science teachers were ineffective is not surprising, as external sources for success were either not noticed or credited. Men blamed their salient poor experiences with high school science teachers, which is consistent with research showing that an attribution to external sources is made when men do not perform well, particularly when good performance is expected (Beyer & Bowden, 1987). Our data revealed that women did not show a uniformly internal attribution pattern, particularly for failures, which conflicts with literature describing how women blame their own inabilities when they fail at something.[6] The tendency for women to make an internal attribution in light of failure is acute when women work within masculine domains, such as science (Acker & Oatley, 1993; Terborg & Ilgen, 1975; Trankina, 1993). Two plausible reasons can account for these results. First, the women in this study did not show a pattern of academic inability at the high-school or college level, as their (reported) grades, GPA, and SAT scores were not low. As noted previously, however, women typically do not interpret their academic successes as predictive and reflective of stable ability. Another reason that women did not uniformly show internal attributions for failure rests with the attribution tendencies of high science-anxiety men, who showed a pattern of attributions that were similar to those made by women, but not low science-anxiety men. Although the interactive relationships of anxiety and gender did not reach significance in most of the MMCS analyses, examination of the responses by high-anxiety men supports the assertion that they were, in essence, responding like women normally do. Moreover, high-anxiety students showed much more perfectionism, suggesting that the propensity for women to blame their failures on their lack of ability may be a function of a more stringent definition of success. Empirical examination of the relationships of science anxiety and attributional tendencies for a broader group of women and men is needed in order to determine whether this explanation is valid.

Our results show that many factors contribute to science anxiety, and that some of these factors may vary with gender. More importantly, the data suggest a general pattern of functioning that discourages certain people (not just women) from entering science fields. Despite that women are obviously able to become scientists, women may avoid science fields not because of anxiety, ability, or socialization, but for practical reasons pertaining to interests and their ultimate personal and professional goals. Jobs and careers are gender-typed (Hodgins & Kalin, 1985), and women may thus choose gender-appropriate work to complement their desired lifestyle. In comparison to men, women place greater importance on combining job and family when considering careers (Lips, 1992). Many women choose fields in which the people with whom they work will be understanding about the importance of having a family and spending time childbearing (Eccles, 1987), and such fields are those predominated by women (Rennie & Dunne, 1994). Women report that they experience discrimination in the traditional, male-oriented science laboratory (Seymour, 1995; Trankina, 1993), and such gender bias may lead women to question their abilities and interests (Ancis & Phillips, 1996). Men's attraction to careers may be a function of potential for high income and status (Lips, 1992), and ability to manifest a socially-dominant orientation that allows them to display their competence and intellect (Pratto, Stallworth, Sidanius, & Siers, 1997), and scientific fields may best afford opportunities to manifest these goals. Thus, even those women who are socialized in an egalitarian manner, who interpret their efforts as indicative of ability, who make accurate attributions for their performances, and who have positive mentors may still choose to avoid science.

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Footnotes

[1] Those students who participated in the second part of the study were not different on anxiety measures than were those students who did not, $t(165) = 1.58$ (for Science Anxiety), and $t(165) = 1.33$ (for General Anxiety), both ns.

[2] Participants were told that they did not have to disclose any information that would make them uncomfortable, and therefore some students omitted responses to certain questions (particularly those concerning grades and SAT scores).

[3] Examination of the gender of the teachers for the courses that were combined revealed a fairly equal distribution of teacher-gender groupings (i.e., all male, all female, mixed) between levels of anxiety and within gender. That is, high-anxiety students did not have a different composition of science teachers compared to low-anxiety students, and there were no differences according to gender.

[4] There is only one female science professor (of eight total science professors) at the school where the study was conducted.

[5] A number of questions (seven, of the 22 science anxiety questions) on the Science Anxiety Questionnaire involve an evaluative component whereby respondents indicate how anxiety-provoking having some person (professor, other student) listen to, and potentially evaluate, scientific knowledge or abilities. Such questions include "in a physics discussion group, reading a chapter on quantum systems and being asked to answer some questions," which are different from non-evaluation questions such as "using a thermometer to record the boiling point of a heating solution." Because people overly concerned with criticism and fearful of negative evaluation lose desire to pursue academic areas where criticism is likely (Atlas, 1994), there was a possibility that science evaluation anxiety, rather than

science anxiety per se, was at the root of the gender and science anxiety differences located. Therefore, a 2 x 2 (Gender x Science Anxiety) ANOVA utilizing a science anxiety index that included only the evaluation items was calculated. Not surprisingly, students classified as low science anxiety ($\underline{M}$ = 11.88) showed less science evaluation anxiety than did those of high anxiety ($\underline{M}$ = 19.95), $\underline{F}(1, 83) = 98.19$, $\underline{p} < .001$. As well, a gender difference emerged, as women ($\underline{M}$ = 16.92) more than men ($\underline{M}$ = 14.81) showed concern for evaluation of science abilities, $\underline{F}(1, 83) = 4.64$, $\underline{p} < .05$. The scale was then recalculated to omit the evaluation items, a new median split was obtained, and 2 x 2 ANOVAs utilizing all the dependent measures were performed. The overall pattern of data did not change appreciably using these new median splits as a grouping factor, as only one effect located previously (the anxiety difference in evaluation of the effectiveness of science high school teachers) was no longer significant. One new main effect (for anxiety on the number of high school math courses taken) was revealed. Thus, the evaluative component of the Science Anxiety Scale produces gender differences, but does not seem to account for gender and anxiety differences on other measures.

[6] These findings are particularly surprising given that students from the same population have taken the MMCS in other studies, and those studies have repeatedly shown that these women tend to make internal attributions to failure more than do men.

Table 1

Socialization of Sex Roles and Home Environment as a Function of Sex and Science Anxiety.

	Participant Sex					
	Men			Women		
	Science Anxiety Level					
	Low	High	Total	Low	High	Total
Socialization of Sex-Roles from Childhood[a]	8.89	9.00	8.95	6.50	7.46	7.00
Socialization of Sex-Roles Predicted for Future[a]	6.68	7.28	6.97	2.29	3.00	2.66
Science Museum Visits	4.00	3.50	3.76	3.58	4.08	3.84
Science Show Viewing[a]	3.63	3.56	3.59	2.71	3.08	2.90

Note. Higher numbers indicate a larger score for the traits listed, or a higher frequency for behavior, measured on a 5-point scale. Significant effects are noted by superscripts [a] for Participant Sex, and [b] for Science Anxiety Level. In all analyses $n = 87$.

Table 2

Academic Preparation, Achievement, and Background as a Function of Sex and Science Anxiety

	Participant Sex					
	Men			Women		
	Science Anxiety Level					
	Low	High	Total	Low	High	Total
SAT Quantitative[b] (n = 80)	3.17	2.39	2.78	2.71	2.65	2.68
SAT Verbal[ab] (n = 80)	2.83	1.94	2.39	2.19	2.70	2.45
GPA[a] (n = 51)	2.93	2.90	2.92	3.24	3.42	3.31
High School Math Courses Taken (n = 83)	4.11	3.50	3.83	4.00	3.92	3.96
High School Science Courses Taken (n = 83)	4.60	3.69	3.94	3.57	3.92	3.75
College Science Courses Taken[b] (n = 83)	4.05	2.38	3.29	4.22	2.48	3.31
College Math Courses Taken (n = 83)	1.26	1.75	1.49	1.83	1.60	1.71
Grade in First HS Science Course (n = 82)	3.26	3.17	3.22	3.33	3.33	3.33
Teacher Effectiveness First HS Science Course (n = 82)	3.58	3.83	3.70	3.86	3.54	3.69

(table continues)

	Participant Sex					
	Men			Women		
	Science Anxiety Level					
	Low	High	Total	Low	High	Total
Grade in Second HS						
Science Course[a] (n = 80)	3.11	3.11	3.11	3.52	3.48	3.50
Teacher Effectiveness Second						
HS Science Course (n = 80)	3.89	3.28	3.58	3.81	3.70	3.75
Overall Effectiveness of HS						
Science Teachers [b] (n = 83)	4.00	3.42	3.71	4.04	3.63	3.83
Grade in First College						
Science Course (n = 59)	3.12	3.00	3.07	3.33	3.31	3.32
Professor Effectiveneness First College						
Science Course (n = 59)	4.00	3.64	3.86	4.00	3.62	3.84

Note. Higher numbers denote a higher grades (from a 4-point academic scale) or higher instructor ratings (on a 5-point scale). SAT numbers listed correspond to a range given to participants (where 1 = 200-400, and 2 = 401-500). Significant effects are noted by superscripts [a] for Participant Sex, [b] for Science Anxiety Level, and [ab] the interaction.

Table 3

Personality Measures According to Sex and Science Anxiety

	Participant Sex					
	Men			Women		
	Science Anxiety Level					
	Low	High	Total	Low	High	Total
Masculinity[a]	12.53	11.39	11.97	10.38	10.19	10.28
Femininity	9.42	9.28	9.35	10.13	9.12	9.60
Self-Handicapping[a]	60.42	62.33	61.35	54.33	58.12	56.30
Fear of Negative Evaluation	34.53	37.17	35.81	36.38	38.88	37.68
Perfectionism[b]	1.89	4.94	3.38	2.38	4.62	3.54

Note. Higher numbers denote more of the trait in question. Significant effects ($p < .05$) are noted by superscripts [a] for Participant Sex, and [b] for Science Anxiety Level. In these analyses $n = 87$.

Table 4

Means from MMCS Measures According to Participant Sex and Science Anxiety Level

	Participant Sex					
	Men			Women		
	Science Anxiety Level					
	Low	High	Total	Low	High	Total
MMCS Total	58.58	56.28	57.46	53.33	55.04	54.22
MMCS External[a]	27.68	25.83	26.78	20.63	22.65	21.68
Context[a]	15.42	14.06	14.76	11.71	12.88	12.32
Context/Success[ab]	8.68	6.83	7.78	6.25	7.23	6.76
Context/Failure[a]	6.68	7.17	6.92	5.46	5.65	5.56
Luck[a]	13.05	11.67	12.38	8.92	9.77	9.36
Luck/Success[a]	7.68	6.28	7.00	5.17	5.96	5.58
Luck/Failure[a]	5.42	5.39	5.41	3.75	3.81	3.78

(table continues)

	Participant Sex					
	Men			Women		
	Science Anxiety Level					
	Low	High	Total	Low	High	Total
MMCS Internal	30.89	30.44	30.68	32.71	32.38	32.54
Effort	18.00	18.44	18.22	18.92	18.35	18.62
Effort/Success	8.32	9.00	8.65	9.75	9.00	9.36
Effort/Failure	9.68	9.39	9.54	9.63	9.35	9.48
Ability	13.16	12.17	12.68	13.79	14.04	13.92
Ability/Success	8.74	6.94	7.86	8.21	8.42	8.32
Ability/Failure	4.42	5.28	4.84	5.58	5.62	5.60

Note. Higher numbers indicate a larger score on attribution indices. Significant effects are noted by superscripts [a] for Participant Sex, [b] for Science Anxiety Level, and [ab] the interaction. Total $n = 87$.

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