PSYCHOLOGICAL AND SOCIAL BARRIERS TO WOMEN'S PARTICIPATION IN MATHEMATICS AND PHYSICAL SCIENCE

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Abstract

Despite recent efforts in the United States to increase the participation of women in advanced educational training and professional fields linked to applied mathematics and technology, women are still underrepresented in these fields of study and work. This is even true among women gifted in mathematics. Why? Many possible causes have been proposed by interested researchers. This paper focuses on a set of social and psychological factors that my colleagues and I have been studying for the last 20 years. It begins with a brief review of the gender differences in educational and occupational choices among the gifted - focusing particularly on math-related fields. It then summarizes a model to account for these differences, reviews the available evidence to support the hypotheses generated by the model, discusses the role that socialization agents may play in perpetuating these gender differences.

Despite recent efforts in the United States to increase the participation of women in advanced educational training and professional fields linked to applied mathematics and technology, women are still underrepresented in these fields of study and work. This is even true among women gifted in mathematics. Why? Many possible causes have been proposed by interested researchers. Discussing all of these is beyond the scope of a single talk. So today I'll focuses on the set of social and psychological factors that my colleagues and I have been studying for the last 20 years. I'll begin with a brief review of the gender differences in these patterns among the gifted. I will then summarize a model to account for these differences, review the available evidence to support the hypotheses generated by the model, discuss the role of socialization agents may be playing in perpetuating these gender differences. I will focus in particular on recent findings regarding the under representation of gifted women in maths and physical science. The fact that gifted women are underrepresented in these fields is especially worrisome since these women clearly have sufficient intellectual talent to participate as fully as their male peers in these educational and vocational settings.

Gender Differences in Educational and Occupational Patterns

In reviewing the educational and occupational patterns of gifted men and women, I have relied heavily on two sets of data: the longitudinal data compiled on Terman's gifted population and the cross-sectional and longitudinal data being compiled by researchers associated with the Study of Mathematically Precocious Youth originally based at Johns Hopkins University.

Terman's Gifted Population

In 1921, Terman began a longitudinal study of approximately 1,450 gifted boys and girls 7 to 15 years old. The original sample contained 831 males and 613 females. These individuals have been recontacted several times; extensive demographic, intellectual, and social-developmental data were gathered at each contact. Because the researchers have been able to relocate approximately 80 percent of the original sample at each new wave of data collection, this longitudinal study provides the richest and most complete set of data available on the life-span development of gifted males and females. Although bound by its historical period, it provides the best data available for comparing the educational and occupational patterns of gifted males and females.

Gender differences in the educational and educational patterns of Terman's sample first emerged when the sample was in college. These women and men chose very different fields at both the graduate and undergraduate level (Terman & Oden, 1947), in particular, with relation to physical science and engineering: The men were 8-15 times more likely than the women to earn degrees in engineering; similarly the men were 3 times more likely than the women to earn degrees in physical science. In contrast, the women were 3-9 more likely than the men to earn degrees in education and the humanities. There were also substantial differences in the amount of education obtained by the females and males in this study. While the men and women were equally likely to earn their bachelor's degree, the men were more likely than the women to complete graduate degrees.

Differences in occupational patterns are even more extreme (Oden, 1968). The most striking difference lies in the proportion of men and women who reported having an occupation: only 42% of the women were employed during most of their adult years compared to 96% of the men. These women and men also tended to be employed in gender-role stereotypic jobs. The women were especially likely to be underrepresented in high status jobs of all kinds, and in the fields of science and engineering (less than 1% of the women compared to 15% of the men. In contrast, the were over represented in the fields of precollege teaching (27% versus 4% of the males), and social welfare (6% compared to 0%). Clearly these gifted women were greatly underrepresented in the fields of math and physical science despite their exceptional talent.

Johns Hopkins Study of the Gifted

Over the past 20 years, Julian Stanley and his colleagues at Johns Hopkins University have been studying mathematically and verbally precocious children. During this period, several thousand junior high school-aged children drawn from regional and national talent searches have been given aptitude tests and questionnaires tapping attitudes, career plans, interests, and values. Many of these children have been or are currently being retested in order to chart their educational development.

Perhaps the most interesting aspect of the data emerging from these studies is their similarity to the findings of the Terman studies, especially given the social changes that have occurred during the last 50 years. Just as was true in the Terman study, fewer females than males have emerged as gifted in mathematics in each of the Johns Hopkins studies (Benbow & Stanley, 1982, 1983). Furthermore, the boys in the Johns Hopkins samples have consistently scored higher than the females on the SAT-Math test (the test used by the Johns Hopkins team to assess mathematical talent)(Benbow & Stanley, 1982, 1983). Finally, the girls have scored as well as the boys on the SAT-Verbal test (the test used to assess verbal talent). Thus, as was true of the Terman sample, giftedness in math is more common and more extreme among boys. In contrast, verbal precocity appears more equally distributed between the sexes (Fox & Cohn, 1980).

The pattern of gender differences in educational pursuits is also quite similar across the two studies despite the lapse of 50 years. In fact, differences that were not apparent until college in the Terman sample are evident in the Johns Hopkins samples by junior high school. This difference is best characterized in terms of the under representation of girls in "extra" educational settings, especially settings associated with math and science. The Johns Hopkins teams have consistently found that gifted girls were less likely than gifted boys to be enrolled in accelerated and/or special math and science programs (Benbow and Stanley, 1982; Stanley, 1976), to respond positively to an invitation to join a gifted math and science program (George and Denham, 1976; Stanley, 1976), and to enter college early (Stanley, 1976). In addition, in follow-ups of the boys and girls who enrolled in the Johns Hopkins Summer Enrichment courses, the girls were less likely to remain on an accelerated math track (Fox and Cohn, 1980), enrolled in fewer physics courses (Benbow and Stanley, 1982; Benbow and Minor, 1986), were less likely to take AP courses in the sciences and less likely to take advanced placement exams or college board achievement tests in chemistry and physics (Benbow and Minor, 1986), expressed less interest in majoring in science or engineering in college than the boys (Benbow and Stanley, 1984) and reported liking physics and chemistry less in high school (Benbow and Minor, 1986), and finally were significantly less likely to major in the physical sciences and engineering in college, to seek post graduate training in physics, computer science, and engineering, and to aspire to a career in physical science and engineering, particularly a research career in these fields (Benbow, 1988). These difference exist despite the fact that these girls, like the girls in the Terman study, did just as well as the boys in their high school math and science courses.

Conclusions

As is true for the population at large (Eccles, 1984), gifted females are less likely to study and to enter occupation related to applied mathematics, physical science and engineering. One might argue that the under representation of females in the sciences is a natural consequence of the pattern of gender differences on the aptitude measures taken by both Terman and the Johns Hopkins team. This is an unwarranted conclusion for several reasons. First, both of these studies focused on gifted children. Thus, even though the females may have had less math aptitude than their male peers, they certainly had sufficient aptitude to become important contributors to the scientific professions. The critical question was pointed out by Lila Braine in her response to Benbow's 1988 article in Brain and Behavioral Science - to quote "WHY ARE WOMEN VIRTUALLY ABSENT FROM FIELDS FOR WHICH THEY CLEARLY HAVE THE REQUISITE MATH SKILLS?" Second, while aptitude differences were positively related to the subsequent mathematical training of gifted boys in the Johns

Hopkins programs, aptitudinal differences were unrelated to the gifted girls' decisions regarding both enrollment in subsequent accelerated math classes (Fox and Cohn, 1980) and intended college major (Benbow and Stanley, 1984). Furthermore, the gender differences in high school physics enrollment and in intended college major were significant even with the differences in math aptitude controlled (Benbow and Stanley, 1982, 1984; Benbow and Minor, 1986; Benbow, 1988).

Given these concerns, it is quite likely that social forces and personal beliefs play a significant role in perpetuating these gender differences in the educational and vocational patterns of gifted individuals. And, although institutional barriers and discriminatory practices undoubtedly account for some of the differences, psychological and social developmental processes are also important (see Eccles, 1984; Eccles and Hoffman, 1984). These processes are the focus of the remainder of this talk. Neither the potential causal impact of aptitudinal differences on male and female achievement patterns nor the possible causes of gender differences in performance on aptitude tests will be discussed.

Psychological Influences on Educational and Vocational Choices

In particular I will focus on a general model of achievement-related choices developed by my colleagues and I over the past several years (Eccles, Adler, Futterman, Goff, Kaczala, Meece, and Midgley, 1983 and Meece et al., 1982). Given the importance attached to gender role by many investigators in this field (e.g. Fox and Cohn, 1980; Nash, 1979), special attention will be paid to the ways in which gender-role socialization may be affecting gifted individuals' educational and occupational decisions.

A Model of Achievement-Related Choices

Over the past 20 years, my colleagues and I have studied the motivational and social factors influencing such long and short range achievement goals and behaviors as career aspirations, vocational and avocational choices, course selections, persistence on difficult tasks, and the allocation of effort across various achievement-related activities. Given the striking differences in the educational and vocational patterns of intellectually able, as well as gifted, males and females, we have been particularly interested the motivational factors underlying males' and females' educational and vocational decisions. Frustrated with the number of seemingly disconnected theories proliferating to explain gender differences in these achievement patterns, we developed a comprehensive theoretical framework to guide our research endeavor. Drawing upon the theoretical and empirical work associated with decision-making, achievement theory, and attribution theory (see Atkinson, 1964, Crandall, 1969, and Weiner, 1974), we have elaborated a model of achievement-related choices. This model, depicted in Figure 1, links educational, vocational, and other achievement-related choices most directly to two sets of beliefs: the individual's expectations for success and the importance or value the individual attaches to the various options perceived by the individual as available. The model also specifies the relation of these beliefs to cultural norms, experiences, aptitudes, and to those personal beliefs and attitudes that are commonly assumed to be associated with achievement-related activities by researchers in this field (Eccles et al., 1983). In particular, the model links achievement-related beliefs, outcomes, and goals to causal attributional patterns, to the input of socializers (primarily parents and teachers), to gender-role beliefs, to self perceptions and self concept, and to one's perceptions of the task itself. Each of these factors are assumed to influence both the expectations one holds for future success at the various achievement-related options and the subjective value one attaches to these various options. These expectations and the value attached to the various options, in turn, are assumed to influence choice among these options.

For example, let us consider course enrollment decisions. The model predicts that people will be most likely to enroll in courses that they think they will do well in and that have high task value for them. Expectations for success depend on the confidence the individual has in his/her intellectual abilities and on the individual's estimations of the difficulty of the course. These beliefs have been shaped over time by the individual's experiences with the subject matter and by the individual's subjective interpretation of those experiences (e.g. does the person think that her/his successes are a consequence of high ability or lots of hard work?). The value of a particular course is also influenced by several factors including the following: Does the person like doing the subject material?; Is the course required?; Is the course seen as instrumental in meeting one of the individual's long or short range goals?; Have the individual's parents or counselors insisted that the course be taken or, conversely, have other people tried to discourage the individual from taking the course?; Is the person afraid of the material to be covered in the course?

Three features of our model are particularly important for understanding gender differences in educational and vocational decisions: The first of these is our focus on achievement-related choices as the outcome of interest. We believe that individuals continually make choices, both consciously and nonconsciously, regarding how they will spend their time and their efforts. Many of the most significant gender differences in vocational aspirations and occupational choices, occur on achievement-related behaviors that involve the element of choice, even if the outcome of that choice is heavily influenced by socialization pressures and cultural norms. Conceptualizing gender differences in achievement patterns in terms of choice takes one beyond the question of "Why aren't women more like men?" to the question "Why do women and men make the choices they do?". Asking this latter question, in turn, legitimizes the choices both women and men make and suggests several new variables as possible mediators of the gender differences we observe in individuals' educational and occupational choices. By legitimizing the choices of both men and women, it allows us to look at the gender differences from a choice perspective rather than a deficit perspective.

Conceptualizing gender differences in achievement-related behaviors in terms of choice highlights a second important component of our perspective; namely, the issue of what becomes a part of an individual's field of possible choices. Although individuals do choose from among several options, they do not actively, or consciously, consider the full range of objectively available options in making their selections. Many options are never considered because the individual is unaware of their existence. Other options are not seriously considered because the individual has inaccurate information regarding either the option itself or the individual's possibility of achieving the option. For example, a girl may have inaccurate information regarding the full range of activities an engineer can do or inaccurate information regarding the financial assistance available for advanced educational training. Still other options may not be seriously considered because they do not fit in well with the individual's gender-role schema. Assimilation of the culturally defined gender-role schema can have such a powerful effect on one's view of the world that activities classified as part of the opposite sex's role are rejected, often nonconsciously, without any serious evaluation or consideration.

Understanding the processes shaping individuals' perceptions of their field of viable options is essential to our understanding of the dynamics leading women and men to make such different occupational and educational decisions. Yet there is very little evidence regarding these processes and their link to important work choices. Socialization theory provides a rich source of hypotheses; few of which have been tested. For example, one effect of role models may be legimatizing novel and/or non-traditional gender-role options. Parents, teachers, and school counselors can also influence students' perceptions of their field of options through the information and experiences they provide the students regarding various options. Finally, peers can affect the options seriously considered by either providing or withholding support for various alternatives. These peer effects can be both quite direct (e.g. laughing at a girl when she says she is considering becoming a nuclear physicist), and very indirect (e.g. anticipation of one's future spouse's support for one's occupational commitments).

The third important feature of our perspective is the explicit assumption that achievement-related decisions, such as the decision to enroll in an accelerated math program or to major in education rather than engineering, are made within the context of a complex social reality that presents each individual with a wide variety of choices; each of which has both long range and immediate consequences. Furthermore, the choice is often between two or more positive options or between two or more options that each have both positive and negative components. For example, the decision to enroll in a physics course is typically made in the context of other important decisions such as whether to take advanced English or a second foreign language, whether to take a course with one's best friend or not, whether it's more important to spend one's senior year working hard or having fun, etc. Too often theorists have focused attention on the reasons why capable women do not select the high status achievement options and have failed to ask why they select the options they do. This approach implicitly assumes that complex choices, such as career and course selection, are made in isolation of one another; for example, it is assumed that the decision to take advanced math is based primarily on variables related to math. We explicitly reject this assumption, arguing instead that it is essential to understand the psychological meaning of the roads taken as well as the roads not taken if we are to understand the dynamics leading to the differences in men's and women's achievement-related choice.

Consider, as an example, two gifted high school students: Mary and Barbara. Both young women enjoy mathematics and have always done very well. Both have been identified as gifted in mathematics and have been offered the opportunity to participate in an accelerated math program at the local college during the next school year. Barbara hopes to major in journalism when she gets to college and has also been offered the opportunity to work part time on the city newspaper doing odd jobs and some copy editing. Mary hopes to major in biology in college and plans a career as a research scientist. Taking the accelerated math course involves driving to and from the college. Since the course is scheduled for the last period of the day, it will take the last two periods of the day as well as 1 hour of after-school time to take the course. What will the young women do? It all likelihood, Mary will enroll in the program because she both likes math and thinks that the effort required to both take the class and master the material is worthwhile and important for her long range career goals. Barbara's decision is more complex. She may want to take the class but may also think that the time required is too costly, especially given her alternative opportunity at the city paper. Whether she takes the college course or not will depend a lot on the advice she gets at home and from her counselors. If they stress the importance of the math course then its subjective worth to her will increase. If its subjective worth increases sufficiently to outweigh its subjective cost, then Barbara will probably take the course despite its cost in time and effort.

In summary, we assume that achievement-related choices, are guided by the following: (a) one's expectations for success on the various options, (b) by the relation of the options both to one's short and long range goals and to one's core self identity and basic psychological needs, (c) by the individual's gender-role schema, and (d) by the potential cost of investing time in one activity rather than another. All of these psychological variables are influenced by one's experiences, by cultural norms, and by the behaviors and goals of one's socializers and peers. Let me now discuss each of these variables in more detail as they relate to the achievement-related decisions of gifted men and women. It should be noted, however, that although there are sound theoretical reasons for suggesting these links, in most cases the essential empirical work remains to be done.

Expectations for Success/Confidence in One's Ability

Expectations for success and confidence in one's abilities to succeed have long been recognized by decision and achievement theorists as important mediators of behavioral choice (e.g., Atkinson, 1964; Bandura, 1977; Lewin, 1938; Parsons, Ruble, Hodges, & Small, 1976; Weiner, 1974). There have been numerous studies demonstrating the link between expectations and a variety of achievement-related behaviors including educational and vocational choices among both average and gifted populations. For example, Hollinger (1983) documented a fairly strong relationship between gifted girls' confidence in their math abilities and their aspirations to enter math-related vocations such as engineering and computer science. Similarly, Terman (1926) found a positive relationship between gifted students' subject matter preferences and their ratings of the ease of the subject for themselves.

But do males and females differ in their expectations for success at various academic subjects and in various occupations? For the population at large, females from about age 10-12 report lower expectations for their performance and less confidence in their ability in mathematics than boys; females also score lower on measures of math efficacy than males (Betz & Hackett, 1981; Brush, 1980; Dweck & Licht, 1980; Nicholls, 1875; Eccles, 1989; Eccles et al., 1984) In addition, these differences in self-perception are one of the mediators of the gender differences in occupational decisions. The answers is less clear with regard to the gifted population. For example, on the one hand, Fox (1982) found that highly-motivated gifted girls have lower self-confidence than equally highly-motivated gifted boys; similarly, Terman (1926) found that gifted girls were more likely to underestimate their intellectual skills and knowledge while gifted boys were more likely to overestimate theirs. On the other hand, Tidwell (1980) found no gender differences on measures of general self-concept; similarly, both Tidwell (1980) and Tomlinson-Keasey and Smith-Winberry (1982) found no gender differences on measures of Locus of Control (a construct often linked to self confidence and personal efficacy beliefs; e.g. Bandura, 1977). There is also little evidence to support the hypothesis that gifted girls are less confident than gifted boys of their math and science ability. For example, Benbow and Stanley (1982) found no substantial gender difference in gifted students' estimates of their math and science competence; similarly, although the gifted students in his study did prefer courses that they thought were easier for them, the boys and girls in Terman's study (1926) did not differ in their perceptions of the ease of mathematics. Finally, Schunk and Lilly (1982) found gender difference in gifted children's expectations for success on a laboratory math task.

Given this mixed set of results, it is not clear that gifted girls are typically less confident of their intellectual abilities than are gifted boys. Although it is true than the differences, when they are found, do support this conclusion, the differences, even when they exist, are quite small. Furthermore, the mediating role of these differences in explaining the gender differences in educational and vocational choices has not been demonstrated. It is possible, however, that researchers have been assessing the wrong expectancies. Typically, the students are asked to report on their confidence about succeeding on an upcoming task or course. They are not asked how confident they are that they could succeed in particular professions or in particular advanced training programs. They are also not asked how much effort they think it will take to succeed in various professions or advanced training programs. It could be that gifted girls are less confident than gifted boys of their prospects for success in these more abstract, distant activities. It is also possible that gifted girls are as confident as gifted boys are in their ability to succeed but assume that it will take a lot more effort to succeed than their male peers assume it will take. As noted earlier, either of these beliefs could mediate a gender difference in the educational and vocational decisions of gifted individuals, especially given the gender stereotyping of high status occupations. Clearly more research is needed before these hypotheses can be evaluated.

Values as Mediators of Achievement-Related Choices

Value is the second major component of our expectancy/value model of achievement-related choices. We predict that decisions regarding course enrollments, college majors, and occupational choice are influenced by the value individuals attach to the various achievement-related options they believe are available to them. Furthermore, subjective value is hypothesized to have at least as much influence as expectations for success on educational and vocational choices. Finally, given the probable impact of gender-role socialization on the variables assumed to be associated with subjective task value, gender differences in the subjective value of various achievement-related options are predicted to be important mediators of gender differences in achievement-related choices in both typical and gifted populations. Our own data support this hypothesis. In a longitudinal study of the math course enrollment decisions of high aptitude, college-bound students, gender differences in students' decisions to enroll in advanced mathematics were mediated primarily by gender differences in the value the students' attached to mathematics (Eccles, Adler, and Meece, 1984). More specifically, the girls were less likely than the boys to enroll in advanced mathematics primarily because they felt that math was less important, less useful, and less enjoyable than did the boys.

Since value means many things to different social scientists and since value has received so little systematic attention until recently, I would like to elaborate on our interpretation of value and its link to achievement-related choices before reviewing the empirical literature. Like others (e.g. Crandall, 1969; Crandall, Katkovsky, and Preston, 1962; Raynor, 1974; and Stein and Bailey, 1973), we assume that task value is a quality of the task that contributes to the increasing or declining probability that an individual will select it. We have defined this quality in terms of four components: (1) the utility value of the task in facilitating one's long range goals or in helping the individual obtain immediate or long range external rewards ; (2) intrinsic interest in the task; (3) attainment value or the value an activity has because engaging in it is consistent with one's self-image; and (4) the cost of engaging in the activity. The last two of these are especially important for any consideration of the impact of gender roles on the value people attach to various activity choices. So let me say a little bit more about each of these.

Attainment value. We conceptualize attainment value in terms of the needs and personal values that an activity fulfills. As they grow up individuals develop an image of who and what they are. This image is made up of many component parts including (a) conceptions of one's personality and capabilities, (b) long range goals and plans, (c) schema regarding the proper roles of men and women, (d) instrumental and terminal values (Rokeach, 1973), (e) motivational sets, (f) ideal images of what one should be like; and (g) social scripts regarding proper behavior in a variety of situations. Those parts of an individual's self-image that are central or critical to self-definition should influence the value the individual attaches to various educational and vocational options; these differential values, in turn, should influence the individual's achievement-related choices (Eccles, Adler, and Meece, 1984; Markus, 1980; Parsons and Goff, 1980). For example, if helping other people is a central part of Individual B's image, then B should place higher value on "helping" occupations than on "non-helping" occupations.

Essentially, I am arguing that personal needs, self images, and values operate in ways that both reduce the probability of engaging in those activities or roles perceived as inconsistent with one's central values and increase the probability of engaging in roles or activities perceived as consistent with one's definition of self. More specifically, we believe that individuals perceive tasks in terms of certain characteristics that can be related to their needs and values. For example, a difficult task requiring great effort for mastery may be perceived as an achievement task; if it also involves pitting one's performance against others, it may be perceived as a competitive task. Other tasks may be perceived in terms of nurturance, power, or ascethetic pleasure. Participating in a particular task will require the demonstration of the characteristics associated with the task. Whether this requirement is seen as an opportunity or a burden will depend on the individual's needs, motives, and personal values, and on the individual's desire to demonstrate these characteristics both to him/herself and to others. To the extent that females and males have different self-images, various activities will come to have different subjective value for females and males. And, to the extext that females and males place differential subjective value on various educational and vocational options, they should also differ in their educational and vocational choices. This hypotheses is discussed in more detail later.

Perceived Cost. The value of a task also depends on a set of beliefs that can best be characterized as the cost of participating in the activity. Cost is influenced by many factors, such as anticipated anxiety, fear of failure, and, of particular importance in the discussion of long term educational and vocational choices, the loss of time and energy for other activities.

People have limited time and energy. They can not do everything they would like. They must choose among activities. To the extent that one loses time for Activity B by engaging in Activity A and to the extent that Activity B is high in one's hierarchy of importance, then the subjective cost of engaging in A increases. Alternatively, even if the attainment value of A is high, the value of engaging in A will be reduced to the extent that the attainment value of B is higher and to the extent that engaging in A jeopardizes the probability of successfully engaging in B.

Gender-Roles and Task Value

This analysis has a number of important implications for our understanding of gender differences in the educational and vocational choices of gifted, as well as more typical, individuals. Because socialization shapes individuals' goals and values, women and men should acquire different values and goals through the process of gender-role socialization. Through their potential impact on subjective task value, these gender differences in value structure can affect educational vocational choices in several ways.

For one, gender-role socialization could lead males and females to have different hierarchies of core personal values (such as their terminal and instrumental values, Rokeach, 1973). Consequently, tasks embodying various characteristics should have different subjective values for men and women. For example, both boys and girls stereotype mathematicians and scientists as loners who have little time for their families or friends because they work long hours in a laboratory on abstract problems that typically have limited immediate social implications (Boswell, 1979). If the analysis developed in the previous section is correct such a profession should hold little appeal to someone who rates social values high and thinks it is very important to devote time and energy to one's family. Because gifted females rate social values higher than gifted males (Fox and Denham, 1974), gifted females should be less likely to aspire to a career as a mathematician or scientist than gifted males.

Several studies provide support for the hypothesized link between personal values and achievement-related choices. Dunteman, Wisenbaker, and Taylor (1978) studied the link between personal values and selection of one's college major using a longitudinal, correlational design. They identified two sets of values both that predicted students' subsequent choice of major and differentiated the sexes: the first set (labeled thing-orientation) reflected an interest in manipulating objects and understanding the physical world; the second set (labeled person-orientation) reflected an interest in understanding human social interaction and a concern with helping people. Students who were high on thing-orientation and low on person-orientation were more likely than other students to select a math or a science major. Not surprisingly, females in their study were more likely than males to be person-oriented and to major in something other than math or science; in contrast, the males were more likely than the females both to be thing-oriented and to major in math and science.

Men and women could also differ in the density of their goals and values. There is some evidence suggesting that men are more likely than women to exhibit a single-minded devotion to one particular goal, especially their occupational goal. In contrast, women in both gifted and typical populations seem more likely than men to be involved in, and to value, competence in several activities simultaneously (Baruch, Barnett, and Rivers, 1983; Fox, Pasternak, and Peiser, 1976: Maines, 1983; McGinn, 1976; Terman and Oden, 1947). For example, in his study of doctoral students in mathematics, Maines (1983) asked the students what they worried about. The men were most concerned about their professional status and about their mentors' estimates of their professional potential. In contrast, the women were most concerned about the impact of their graduate training on their families and their other interests; they felt that graduate training was taking too much time and energy away from other activities that they valued just as much as their graduate training. This discrepancy could reflect differing density patterns for the hierarchy of goals and personal values held by these men and women. That is, the women appeared to place high attainment value on several goals and activities; in contrast, the men appeared more likely to focus on one main goal: their professional development. If this is true then the psychological cost of engaging in their primary goal in terms of time and energy lost for other important goals would certainly be less for these men than for their female colleagues.

Gender role socialization could lead males and females to place different value on various long range goals and adult activities. The essence of gender roles (and of social roles in general) is that they define the activities that are central to the role. In other words, they define what one should do with one's life in order to be successful in that role. If success in one's gender role is a central component of one's identity, then activities that fulfill this role should have high value and activities which hamper efforts at successfully fulfilling one's gender role should have lower subjective value. Gender roles mandate different primary activities for men and women. Women in the United States are supposed to support their husbands' careers and raise their children; men are supposed to compete successfully in the occupational world in order to confirm their masculinity and to support their families. To the extent that a gifted woman has internalized this cultural definition of the female role, she should rank order the importance of various adult activities differently than her gifted male peers. In particular, she should rate the parenting and the spouse-support roles as more important than a professional career role and she should be more likely than her gifted male peers to resolve life's decisions in favor of these family roles. In contrast, gifted men, like men in general, should rate family and career roles as equally important. In fact, since they can fulfill their family role by having a successful career, gifted men, like men in general, should expect these two sets of roles to be compatible. Consequently, aspiring after a high status, time consuming career should not pose less of a conflict for gifted men and such careers should have high subjective value not only because of the rewards inherent in these occupations but also because they fulfill the male gender role mandate.

The analysis developed in this section suggests the differential involvement of women and men in math and science-related occupations may result, in part, from differences in their interest patterns and their personal values (for example, being thing-oriented versus being person-oriented). Furthermore, this analysis suggests that the differential involvement of women and men in high status, time-consuming occupations requiring long periods of pre-professional training may result, in part, from differences in men's and women's psychological investments in their family roles versus their professional roles. These gender differences in psychological investment in family versus professional roles are assumed to result from a complex set of both psychological and sociological forces including the internalization of gender roles, the individual's assessment of what jobs and roles are realistically available, and both overt and subtle forms of discrimination operating in educational and occupational institutions. Consequently, women may choose to limit their investment in the professional role because they want to maximize their investment in their family roles or because they think that their opportunities in the professional role are restricted by discriminatory forces beyond their control, or both. Since in the United States careers in math and physical science are assumed to be very time consuming and inflexible, women with traditional gender-role identities may be reluctant to enter these fields because they believe the time demands are incompatible with the demands associated with raising a family.

An adequate test of these hypotheses requires not only the demonstration of a gender difference in interest patterns and value hierarchies; it also requires a demonstration of the proposed causal link between these beliefs and the educational and vocational choices gifted men and women make. By and large, these causal links have not been assessed in either gifted or more typical populations. Thus, as was true for expectations of success, the essential research has yet to be done. However, even though the causal relations implicit in this analysis have not been adequately studied, several large scale studies of the gifted have assessed gender differences in personal values and interests. In general the data are consistent with the analysis in this section. The details of these studies are outlined below.

Gender Differences in the Values and Interests of the Gifted

Both the Terman study and the SMYF studies have assessed interests, values, and goals on a large number of gifted individuals. These studies suggest that gifted boys and girls have different interests, values, and goals from an early age. Although gifted boys and girls appeared more similar in their values and interests than comparison groups of boys and girls drawn from the general population, the gifted girls in both studies had more stereotypically feminine interest patterns than the gifted boys. When asked their favorite school subjects the girls rated English, foreign languages, composition, music, and drama higher than the boys; in contrast the boys rated the physical sciences, physical training, U.S. history, and sometimes mathematics higher than the girls (Benbow and Stanley, 1984; George and Denham, 1976; Terman, 1926, 1930). The gender differences in interest in mathematics were typically quite weak if present at all. In contrast, the gender differences in interest in physics and applied mathematical fields like engineering are quite consistent and fairly large (Benbow and Minor, 1986, Benbow, 1988).

Similarly, when asked their occupational interests and/or anticipated college major, girls rated domestic, secretarial, artistic, biological science, and both medical and social service occupations and training higher than the boys while the boys expressed more interest than the girls in both higher-status and business-related occupations in general, and in the physical sciences, engineering, and the military in particular (Benbow and Stanley, 1984; Fox, Pasternak, and Peiser, 1976; Terman, 1926, 1930). Finally, when asked their leisure time activities and hobbies, similar differences in interest patterns emerged. At all ages, the females both liked and reported spending more time than the boys reading, writing, and participating in a variety of activities related to arts and crafts, domestic skills, and drama; in contrast, the males spend more time engaged in sports, working with machines and tools, and involved with scientific, math-related, and/or electronic hobbies (Fox, 1976; McGinn, 1976; Terman, 1926, 1930; Terman and Oden, 1947).

Gender-stereotypic patterns of differences also emerged on tests of personal values, occupational values, and personality traits. The Allport-Vernon-Lindsey Scale of Values was given to many of the children participating in the studies at Johns Hopkins. The gifted girls typically scored higher than the gifted boys on the scales tapping social and aesthetic values; in contrast, the boys typically scored higher than the girls on the scales tapping theoretical, economic, and political values (Fox, 1976; George and Denhan, 1976; McGinn, 1976). Similarly, on the Strong-Campbell Vocational Interest test, the girls scored higher than the boys on social and aesthetic interests. Both of the boys and girls, however, scored equally high (and quite high) on investigative interests (Fox, Pasternak, and Peiser, 1976; George and Denham, 1976; McGinn, 1976).

It is also of interest to note that the boys evidenced a more unidimensional set of interest than the girls on the Strong-Campbell Vocational Interest test; that is, the boys scored high on investigative interests and low on most other interests. In contrast, the girls scored higher than average on several interest clusters (McGinn, 1976). A similar discrepancy emerged when gifted boys and girls were asked to rate several occupations on a Semantic Differential Scale. The boys gave positive ratings only to traditional male scientific and mathematical professions; the female professions and homemaker role were rated negatively. In contrast, the girls gave both male and female typed professions a positive rating. In addition, they gave the homemaker role as positive a rating as their most preferred professional occupations; in contrast, the gifted boys responded rather negatively to the homemaker role.

A similar pattern emerged on the most recent data from the Terman sample (Sears, 1979). The gifted men and women were asked to rate how importance each of six goals were to them in making their life plans during early adulthood. Men rated only area (occupation) as having had higher importance than did the women; in contrast, the women rated four areas as having had higher importance than did the men (family, friends, richness of one's cultural life, and joy in living). These data suggest that the gifted women had desired a more varied or multi-faceted type of life than the men had desired at precisely the time in one's life when people make the major decisions about their life plans. One other pattern characterized the responses of these gifted men and women: Consistent with our hypothesis, the men rated family and occupation as of equal importance while the women rated family as more important than occupation.

<u>Summary.</u> There are clear differences in the interests, values, and preferences between gifted males and females. Furthermore, these differences reflect gender-stereotyped patterns. These results are consistent with the analysis linking values to gender differences in educational and vocational choices. Additional support for this hypothesis comes from a recent report by Benbow and Stanley (1982). Gifted girls in their study were less likely than gifted boys to take advanced mathematics in part because they liked language-related courses more than they liked mathematics courses. In addition, Benbow and Stanley (1984) found weak but consistent positive relations in their gifted samples between liking of biology, chemistry, and physics and subsequent plans to major in biology, chemistry, and physics respectively. In addition, students' interest did predict course taking in high school and college (Benbow and Minor, 1986).

Parents, Teachers, and Counselors

Gender differences in educational and vocational choices could also result from differential socialization experiences. Several studies have documented the importance of social support from parents, teachers and counselors in lives of women who make non-traditional educational and occupational choices (Barnett and Baruch, 1978; Casserly, 1980). Perhaps gifted girls make rather traditional educational and occupation choices because they are not adequately encouraged to consider alternative choices. How might parents, teachers, and counselors affect gifted children's vocational and educational choices?

1. Through their power as role models. Male and females adults do different things and these differences in behavior provide a model of appropriate occupations for males and females.

2. Through their power as interpreters of experience. Social agents can influence children's self concepts, personal values, and preferences through the interpretations of experience that they provide.

3. Through their power as counselors. Social agents can influence children's view of the educational and vocational world through explicit and implicit messages they provide as they "counsel" children. Social agents, especially parents and school personnel, give children information about the occupational world and the need to prepare themselves for that world. Often these messages are gender-role biased. To the extent that this is true, boys and girls will internalize different views of the occupational world, different ideas about their potential involvement in that world, and different ideas regarding the need to be able to support oneself.

4. Through their power as reinforcers. Social agents can influence choices by the pattern of reinforcements they provide for engaging in various behaviors. Peer interaction is an excellent example of how the power of reinforcement could limit women's participation in math, engineering and physical science. Students often discuss the educational and occupational options they are considering with their friends; these discussions inform the students both of the opinions of their peers and of the likely reactions their peers will have to various options. As is true for other social agents, these opinions and reactions are often gender-role biased (see, for example, Frieze and Hanusa, 1984; Kavrell and Petersen, 1984). Since peer acceptance is so important during the adolescent years (Kavrell and Petersen, 1984), the gender-role bias in adolescents' reactions to each other's plans may limit the educational and vocational options considered seriously by gifted females at a time when very important achievement-related decisions are being made. Fear of peer disapproval could also lead gifted girls to either drop out of or refuse to participate in special programs for the gifted.

5. Through their power as shapers of experience. Social agents can influence the educational and vocational decisions of gifted individuals more directly by actively structuring the options that are offered to gifted boys and girls. For example, entry into accelerated or special programs depends on being identified as gifted by school personnel. To the extent that the process of identification is gender-biased, gifted girls and boys may differ in the opportunities they are offered to develop their skills; findings relevant to this prediction are discussed below. Parents can also either limit or broaden their children's educational and vocational options by the economic, as well as psychological, support they provide for various

options. In the society at large, families with limited resources are more willing to invest these resources in their sons than in their daughters. If a similar preference characterizes families with gifted children, then gifted males should have more opportunities for special and advanced training than gifted females because their families are more willing to provide such opportunities. Such differences, if they exist, not only limit girls' options directly; they can also limit the development of gifted girls' preferences because they restrict the range of experiences gifted girls are exposed to.

Now lets look at the research related to these types of influence. I'll begin with noting that very little relevant information is available and what is available is quite limited in its scope and reliability. For example, some of the work claiming to show that gender differences among the gifted do <u>not</u> result from differences in boys and girls social experiences is based on a few self-report questionnaire items asking things like "Do you encourage your child to do well in math?" This type of question does not provide an adequate assessment of social experience.

Parents

In both the Terman and the Johns Hopkins studies, the parents of gifted boys and girls believed in their children's general intellectual talents. The child's gender, however, had more effect on the parents' estimates of their child's specific skills. For example, parents in Terman's study rated sons higher than daughters on math and mechanical ingenuity; they also rated daughters higher than sons on drama, music and general dexterity. Since this patterns of gender differences also characterized the children's performance on standardized skill tests, we can not determine the direction of causality for these data; the parents' estimates may have been a reflection of the differences they were observing in their children or the parents may have helped to create the behavioral differences through differential socialization practices (Terman, 1926). In our own study of gifted elementary school children (see Eccles & Harold, 1992), parents of gifted girls had most confidence in their child's ability in reading and instrumental music; in contrast, parents of gifted sons had most confidence in their child's math and sport ability. In addition, these parents provided gifted girls with more opportunity to develop their reading and instrumental skills while they provided their gifted sons with more opportunity to develop their interest and skill in sports. Interestingly, there were no gender differences on the aptitude measures we gave these children at the start of the study. Together these results suggest the parents of these gifted children were creating rather than reflecting gender differences in their children's aptitude.

Studies with more typical populations also suggest that the parents are creating gender differences in skill level, interest patterns, and self-perceptions through differential socialization

(Eccles, 1992; Huston, 1983; Parsons, Adler, & Kaczala, 1982). For example, in a longitudinal study of gender role socialization duirng the elementary school years, we have shown that parents have gender-role biased perceptions of their children's competencies: they believe boys are better than girls in sports and math while girls are better than boys in language arts and instrumental music. The parents in this study also believe that boys are more interested than girls in sports, math, and science, while girls are more interested than boys in reading and instrumental music. These perceptions exist despite very little actual gender difference in the children's aptitudes and interests (Eccles, 1992). Proponents of a self-fulling prophecy view of the socialization of gender differences would argue that these differences in parents' perceptions set in motion a set of events that ultimately create the very differences that the parents originally believed to exist. But few studies have looked at the link between the experiences provided by parents and parents' beliefs. In our recent work, we have investigated how this process of differential provision of experiences is linked to general and specific beliefs, particularly with regard to gender-role socialization. The evidence suggests that parents' general gender-role beliefs influence their perceptions of individual children's competencies and interests: for example, parents who endorse the cultural stereotype that boys are naturally better at math (or sports) than girls, have lower estimates of their daughters' math (and athletic) ability than one would predict given the girls' actual level of competnece as measures by our aptitude indicators and by teacher ratings. In turn, these perceptions affect the kinds of experiences parents provide for their children: these parents provide boys with more opportunities to do math-related (and athletic) activities than they provide for girls.

This sequence is illustrated in Figure 2. This figure illustrates the theoretical model my colleagues and I have been using to study the socialization of gender differences in interests and competencies. Essentially, we are hypothesizing that parents' gender-role stereotypes, in interaction with their child's sex, affect the following mediators: (1) parents' causal attributions for the children's performance, (2) parents' emotional reaction to their children's performance in various activities, (3) the importance parents attach to their child acquiring various skills, (4) the advice parents provide their child regarding involvement in various skills, and (5) the activities and toys parents provide for their children. In turn, we predict that these subtle and explicit mediators influence the development of the following child outcomes across the various gender-role stereotyped activity domains: (1) children's confidence in their ability, (2) children's interest in mastering various skills, (3) children's affective reaction to participating in various activities; and, as a consequence of these self- and task-perceptions, (4) the amount of time, and type of effort, the children end up devoting to mastering, and demonstrating, various skills (see Eccles, Jacobs, & Harold, 1991). Our initial results confirm these predictions (Eccles, 1992; Eccles, Jacobs, & Harold, 1991).

Gender-role bias in parental beliefs is evident on other measures as well. Parents in the Johns Hopkins' studies were asked their occupational aspirations for their children. These parents had rather limited occupational aspirations for their daughters; the majority of the parents of girls (between 89 and 94 percent in one study) expected their daughters to follow the traditional female-occupational pattern of working for a while and then taking time out to raise their children (Brody and Fox, 1980; Fox, 1982). The parents were also more likely to expect their sons to enter math-related or scientific fields (Brody and Fox, 1980) and to provide their sons with math-and science-related toys, kits, and books (Astin, 1974). Finally, parents of daughters reported noting giftedness in their child at a later age than parents of sons (Fox, 1982) and were often quite surprised when informed that their daughter might be gifted (Fox, personal communication). Thus, although parents have a generally positive attitude toward their daughters' intellectual talents, they do not appear to be encouraging their daughters to develop these talents in occupational pursuits to the same extent that parents of boys do. And in many cases, they appear to underestimate their daughters' talents.

Finally, there is clear evidence that mothers and fathers model different involvement in various academic subjects. Benbow and her colleagues have found that fathers are more likely to help their children in math and science than are mothers. This difference in parental behavior could influence the boys' and girls' interest in the science.

Teachers and Counselors

The data on teachers are quite mixed. On the one hand, Terman (1926, 1930) found teachers to be quite positive toward both gifted boys and girls. The teachers rated gifted girls more positively than gifted boys in terms of their performance and competence on most subjects and on deportment. In addition, boys were more often reported as being weak in at least one subject than girls. On the other hand, both Terman (1926) and Fox (1982) found that teachers were less likely to identify girls as gifted and to recommend them for accelerated educational progress. Furthermore, to the extent that teachers held negative stereotypes of gifted children, their stereotypes of gifted girls were more negative than their stereotypes of gifted boys (Solano, 1977). Finally to the extent that teachers treat boys and girls differently in the classroom, these differences are most marked among the brightest students in the class (Brophy and Good, 1974; Parsons, Kaczala, and Meece, 1982).

Both Fox (1976) and Luchins and Luchins (1980) present an even more negative picture of teachers. Fox (1976) found evidence of active resistance on the part of some teachers to continued accelerated math training for the girls who had participated in the Johns Hopkins Summer Accelerated Math Program. Furthermore, the presence or absence of teacher and counselor support for continued participation in accelerated math training was the major factor distinguishing between the girls who continued and the girls who chose to drop back into a more traditional math program. Similarly, in their study of female mathematicians, Luchins and Luchins (1980) found that 80 percent of the females, as compared to only 9 percent of the males, had encountered active discouragement from continuing their math training; this discrepancy was especially pronounced during the college years. Similar results characterize studies of more typical populations. When bias exists math and physical science teachers provide boys with a more positive learning experience than girls (see Eccles, 1989).

Evidence regarding the role of counselors is sparser but equally troublesome. In general, counselors have not been found to be especially encouraging of non-traditional educational and occupational choices for either boys or girls (see Eccles and Hoffman, 1984). A similar pattern characterizes the few available studies on the role of the counselor for gifted students. For example, counselors have been found to actively discourage gifted girls from continuing their accelerated math training program (Fox, 1976). Likewise, more than a quarter of the gifted adults interviewed by Post-Kammer and Perrone (1983) reported that their high school counseling had been poor or inadequate. Similarly, Benbow and Stanley (1982) found that less than 12% of gifted students they identified in their talent search were participating in any special programs; thus, the majority of gifted children are not receiving any special opportunities designed to facilitate the development of their extraordinary intellectual talent. And girls are less likely than boys to be among the few who do receive these special opportunities: For example, only 6% of the girls compared to 11% of the boys in the Benbow and Stanley (1982) sample were in special programs.

These results are especially disturbing given the growing body of evidence that teachers and counselors can be an important source of encouragement for gifted girls. Several studies have demonstrated the positive effect of supportive teachers and well-designed classroom intervention programs on gifted and talented girls educational and vocational plans (e.g. Brody and Fox, 1980; Callahan, 1979; Casserly, 1980, Fox, 1976; Fox, Benbow, and Perkins, 1983; Gordon and Addison, 1985; Tomlinson-Keasey and Smith-Winberry, 1982, 1983; Tobin and Fox, 1980). For example, Tomlinson-Keasey and Smith-Winberry (1983) found that a strong positive association between gifted girls' interest in high level careers and their involvement in high intensity special programs for the gifted.

Pat Casserly (1980)'s work provides another clear example of this. She identified the 20 school districts in the United States that had the best record of enrollment by talented females in their advanced placement courses (AP courses)in math and science; she interviewed students, teachers, and counselors at these schools regarding the factors that they believed accounted for the high participation rates of the female students in these courses. Several themes emerged rather consistently across the districts: early placement in a curricular track that leads automatically to the AP (advanced placement) courses; high proportions of females in the classes from the beginning of the tracking sequence; active efforts to allow female friends to stay together in these courses; active support by the teachers of the females' interests, confidence, and, perhaps most importantly, participation in class activities; active recruitment of younger females into the courses by the AP teachers and by female students already enrolled in the AP courses; active career counseling by AP teachers within their classes; and creative, non-competitive instruction in the AP classes.

Casserly's study clearly suggests that supportive teachers can play an important role in encouraging gifted and talented females to develop their math and science skills and to consider seriously careers in math and science. Casserly's study also indicates that early acceleration may be important. Several studies suggest that adolescent gifted girls are less attracted to special programs, particularly in math and science, than adolescent gifted boys (Fox, 1976; Fox, Benbow, and Perkins, 1983; Tobin and Fox, 1980). In contrast, accelerated programs begun in elementary school have as many, if not more, female participants as male participants. Furthermore, both girls and boys enrolled in such programs retain their accelerated status throughout high school and graduate at an earlier age than their non-accelerated peers without any apparent deleterious effects on their intellectual and social development (c.f. Callahan, 1979).

Finally, Casserly's study points to the importance of instructional strategies themselves. The AP teachers in her study were especially likely to include career counseling in their courses, to use non-competitive teaching strategies, to include applied concerns drawn from fields such as engineering, design, medicine, and architecture, to stress the creative components of math and science rather than facts and endless word problem sets, and to be actively committed to nonsexist education. Observational studies of science teachers suggest that a similar set of characteristics differentiates teachers who produce high levels of interest in science among their female students from teachers who do not (Kahle, 1983).

Further support of the importance of these characteristics is provided by Fox (1976). Concerned with the low participation rates of gifted girls in the special program being offered at the Johns Hopkins University for gifted children, these researchers designed a special math class to attract females. This class incorporated many of the "girl friendly" principles uncovered by Casserly and Kahle: It was taught using cooperative learning strategies and included career guidance. In addition, it was taught by females and all the students were females. The class was successful in increasing the participation rates of those gifted female students who successfully completed the program. Unfortunately, longitudinal follow-ups of these students indicate that the long range impact of this experience was minimal, suggesting that one shot interventions are not very effective in producing lasting change and that "girl friendly" practices need to be a continuing part of gifted girls educational experiences (Brody and Fox, 1980).

In summary, these studies suggest that certain instructional styles may be turning girls off to math and physical science - strategies such as competitive learning strategies, heavy focus on the mechanical applications of math and physical science rather than more people-oriented applicatons (such as designing more liveable communities or preventing pollution). To the extent that girls and boys come to school with different value systems (see earlier discussion), courses should have different appeal to girls and boys if the courses incorporate particular value systems into the material used for instruction (e.g., if the teachers use competitive rather cooperative learning strategies or if the teacher relies heavily on thing-oriented examples rather than people-oriented examples, or if the teacher does not make sure that the students are exposed to female as well as male role models and that female students get to participate just as fully as male students in class discussions and class activities). Furthermore, these studies indicate that math and physical science do not have to be taught in these ways; more girl friendly instructional approaches can be used. And when they are, girls are more likely to continue taking courses in these fields and to consider working in these fields when they become adults.

Conclusions

As is true in the population-at-large, gifted males and females differ in their educational and occupational patterns in a rather gender stereotyped fashion. This article explores the reasons why this might be true and outlines a research agenda to study these hypotheses. Gender-role beliefs and schema seem especially important influences in that these schema can affect both expectations for success in a wide range of activities and the subjective value individuals attach to participation in various educational, occupational, and family-related pursuits. The beliefs and behaviors of parents, teachers, counselors, and peers are also critical. These socializers appear to lack confidence in girls' ability or motivation to succeed at math, engineering and physical science and they do little to foster girls' interest in these fields Given the omnipresence of gender-role prescriptions regarding appropriate occupational choices for women, there is little basis for girls to develop non-traditional goals if their parents, teachers, and counselors do not encourage them to consider these options. And there is even less basis if these socializers actively discourage such consideration.

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