

Achievement in Math and Science: Do Mothers' Beliefs Matter 12 Years Later?

Martha M. Bleeker and Janis E. Jacobs
The Pennsylvania State University

Past research has indicated an association between parents' beliefs and adolescent children's self-perceptions of ability and has shown the importance of accounting for parents' gender-stereotyped beliefs when examining boys' and girls' self-perceptions of math–science ability. The current study extends these findings by examining the longitudinal relations between mothers' earlier gender stereotypes and perceptions and adolescents' later math–science achievement beliefs and career choices. As predicted, mothers' earlier perceptions of their adolescents' abilities were related to adolescents' math–science self-efficacy 2 years after high school, with adolescents' self-perceptions of math ability during 10th grade mediating the relation with mothers' perceptions. Moreover, mothers' earlier predictions of their children's abilities to succeed in math careers were significantly related to later career choices.

Despite efforts to increase the participation of women in high-status fields involving mathematics and science, women continue to be less likely than men to pursue a college education in such fields (e.g., National Science Foundation [NSF], 2000). In the past decade, however, women have indicated greater interest in careers in some areas of math and science, such as the life sciences and business management, even though their participation in computer science, physics, and engineering remains low. For example, women earned 45% of the doctorates granted in life sciences in 1999 and nearly 50% of the business degrees granted in 1999–2000 (National Center for Education Statistics, 2001a), but earned only 23.4% and 14.9% of doctorates granted in the physical sciences and engineering, respectively (Sanderson, Dugoni, Hoffer, & Myers, 2000). Furthermore, among all individuals who hold bachelor's degrees in science and engineering, women are less likely than men to be employed in such fields. The most recent report from the NSF (2000) indicates that women constitute only 23% of the science and engineering labor force. This underrepresentation of women is especially evident in the physical sciences,

where women comprise only 9% of employed engineers and 10% of employed physicists (NSF, 2000).

Gender differences in attitudes about various domains within math and science appear to develop in early adolescence. In one study, for example, high school girls rated their degree of interest in biology and physical science as well as their future career preferences. Girls were more likely to indicate interests in biology than physical science and were more likely to predict having future careers in health science than in the physical sciences (Jacobs, Finken, Griffin, & Wright, 1998). Additionally, recent research indicates that female high school students feel less confident than male students about their abilities and likelihood of success in physical science and engineering professions, but feel more confident in health-related professions that rely heavily on training in the biological sciences and in business and managerial positions that rely on applied math skills (Bae & Smith, 1996; Eccles, Barber, & Jozefowicz, 1998). Thus, when examining gender differences in math–science achievement and career choices, one needs to consider the specific type of science or math field.

Multiple causes for the gender gap in mathematics and science educational and career attainment have been explored in recent decades, including biologically based ability differences and individual characteristics such as self-efficacy (e.g., Bandura, Barbaranelli, Vittorio-Capra, & Pastorelli, 2001; Benbow & Stanley, 1980). Although these explanations have each received some support, recent studies (Braswell et al., 2001; Hall, Davis, Bolen, & Chia, 1999; Hyde, 1997) reveal that previously reported differences between boys' and girls' abilities in math and science have decreased substantially in recent years. For example, several recent studies show no gender differences in middle school students' math and science abilities (National Center for Education Statistics, 2001b) or high school students' science achievement examinations, math tests scores, and grades (Catsambis, 1999; Hassan & Khalifa, 1999). Thus, in recent years, declining gender differences in performance on math and science indicators during adolescence have been juxtaposed against continuing (and in some cases, increasing) gender differences in employment in math and science fields.

Martha M. Bleeker, Department of Human Development and Family Studies, The Pennsylvania State University; Janis E. Jacobs, Department of Human Development and Family Studies and Department of Psychology, The Pennsylvania State University.

This research was funded by grants from the National Institute of Mental Health, the National Science Foundation (NSF), and the National Institute of Child Health and Human Development to Jacquelynn Eccles and by grants from NSF, the Spencer Foundation, and the W. T. Grant Foundation to Jacquelynn Eccles and Bonnie Barber. We thank the following people for their contributions: Jacquelynn Eccles, Bonnie Barber, Allan Wigfield, Carol Midgley, David Reuman, Douglas MacIver, Harriet Feldauer, Rena Harold, Constance Flanagan, Andrew Fuligni, Lisa Colarossi, Kathy Houser, Debbie Jozefowicz, Pam Frome, Mina Vida, Laurie Meschke, and Amy Arbretton. We also thank D. Wayne Osgood for his statistical consultation on this project.

Correspondence concerning this article should be addressed to Martha M. Bleeker, Department of Human Development and Family Studies, The Pennsylvania State University, S-113 Henderson Building, University Park, PA 16802. E-mail: mmb216@psu.edu

The narrowing gender gap in performance has led researchers to focus on socialization and attitudinal, rather than biological, explanations for gender differences in college majors and career choices. One of the most consistent findings in this work has been the important role played by parents as socializers of their children's academic achievement, including gender differences in ability perceptions, course selection, and college major. Although strong relationships between parents' attitudes and their children's beliefs and achievement have been found (e.g., Jacobs, 1991; Jacobs & Eccles, 1992), prior research has not been able to assess the long-term effects of parental beliefs on achievement outcomes, such as older adolescents' math-science self-efficacy and young adults' career and educational choices. The current investigation is a longitudinal follow-up to a previous study that found strong relations between mothers' gender stereotypes, perceptions of their children's abilities, and their children's self-perceptions of ability 1 year later. The present study follows the same sample of participants to determine the longitudinal effects of parents' earlier perceptions on the beliefs and choices of their adolescent children as they enter young adulthood.

Relations Between Self-Beliefs and Achievement

One area within achievement research that has received substantial attention is the development of self-perceptions of ability in math and science. Self-perception of ability, sometimes referred to as *self-concept of ability*, is defined as "the assessment of one's own competency to perform specific tasks or to carry out role-appropriate behaviors" (Eccles et al., 1983, p. 82). Most evidence suggests that although the gap between boys' and girls' ability levels in math and science has decreased substantially since the early 1980s, with girls outperforming boys in some cases, girls still report lower self-efficacy and self-perceptions in math and science, often greatly underestimating their abilities (Heller & Ziegler, 1996; Jacobs, 1991; Jacobs & Eccles, 1992; Juang & Silbereisen, 2002; Pajares, 1996). For example, Meece and Jones (1996) found no gender differences in fifth- and sixth-grade students' science grades or standardized test scores, but girls reported less confidence than boys in their ability to perform well on science tasks in the classroom.

Several other studies provide evidence suggesting that an individual's self-perception of ability is related to career choice more than an individual's actual ability (e.g., Eccles & Wigfield, 1995; Farmer, Wardrop, & Rotella, 1999; Meece, Wigfield, & Eccles, 1990). For instance, the girls and boys in Catsambis's (1999) study had similar mathematics test scores and grades in the eighth grade. However, female students had less confidence in their math abilities than did male students and were significantly less likely than male students to indicate mathematics when describing their career aspirations when in the 10th grade. Similarly, within a group of 1,990 high school seniors who scored above the 90th percentile on the Mathematics portion of the Scholastic Aptitude Test, girls were only two thirds as likely as boys to indicate plans for pursuing a career in science or engineering (Matyas & Dix, 1992).

The Significance of Parents' Beliefs

In attempts to explain the finding that gender differences in self-perceptions are larger than actual differences in achievement, some researchers (e.g., Eccles, Wigfield, & Schiefele, 1998; Ja-

cobs, 1991; Jacobs & Eccles, 1992, 2000) have theorized that parents' gender-typed beliefs and perceptions may impact their children's career aspirations and ultimate choices. The Eccles et al. (1983) model of parent socialization includes parents' general beliefs about the world such as gender stereotypes in addition to parents' specific beliefs about their children. According to this model, the messages parents provide to their children include information regarding the values they attach to various activities, such as math and science, and are often based on parents' perceptions of their children's ability. Such messages are expected to relate to children's motivation to pursue particular activities, such as enrollment in advanced math and science courses. Over time, children construct their own self-perceptions and interests, based on their parents' messages, integrate these beliefs into their self-systems, and ultimately, use such beliefs in future task choices, such as choosing a college major (Jacobs & Eccles, 2000). The Eccles et al. (1983) model has been tested and supported by research examining the relations between parents and their children, from childhood to early adolescence (e.g., Eccles et al., 1998; Jacobs, 1991; Jacobs & Eccles, 2000).

Jacobs explored the relation between gender stereotypes and parent-child ability perceptions in two studies (Jacobs, 1991; Jacobs & Eccles, 1992). In the first study, Jacobs (1991) reported that parents who held traditional gender stereotypes favoring boys in mathematics expressed less confidence in their children's math abilities if they had daughters and more confidence if they had sons, regardless of their children's actual abilities and performance levels. Furthermore, Jacobs's analyses revealed that parents' gender-typed beliefs were indirectly related to children's self-perceptions, so that boys had consistently higher mathematics ability beliefs and future expectancies than did girls, despite the fact that girls had higher grades in mathematics than boys at all grade levels. Research examining gender-differentiated views about science suggests that parents are likely to hold gender-stereotyped beliefs about science as well (Crowley, Callanan, Tenenbaum, & Allen, 2001; Jones, 1991; Levin, Sabar, & Libman, 1991; Tenenbaum & Leaper, 2003).

In a second study, Jacobs and Eccles (1992) reported that mothers' perceptions of their children mediated the relation between past performance and children's self-perceptions of ability. The test of mediation was theoretically driven; the Eccles (Parsons) et al. (1983) model predicts that children's self-perceptions of competence are associated with their parents' beliefs and interpretations of children's previous achievement outcomes. The results of this study indicate that mothers' perceptions of their children mediated the interaction of child's gender and mothers' gender stereotype on children's self-perceptions. This hypothesis was supported by the fact that the path between the interaction term (Child's Gender \times Mothers' Gender Stereotype) and the children's perceptions became nonsignificant when mothers' perceptions of the child were entered into the model, whereas the relation between the interaction term and mother's perceptions was significant. Thus, when mothers held stereotypic beliefs and had children of the gender not favored by the stereotype (girls, in the case of mathematics), they held less favorable perceptions of their children's abilities to succeed in such domains, even after controlling for actual ability.

Although the evidence for the relations among parents' gender-typed beliefs, parents' perceptions of their own children, and children's self-perceptions presented in these studies (Jacobs,

1991; Jacobs & Eccles, 1992) is compelling, the longitudinal perspective of the role of parents' perceptions was limited because the studies spanned only 2 years. Thus, even though parents' beliefs were related to children's beliefs in the short run, the long-term importance of such beliefs on adolescent outcomes can best be evaluated at a later point in time, when adolescents are making important choices about careers and college majors. These long-term relations between parental perceptions and adolescent outcomes have not previously been evaluated because of the lack of data spanning the entire period from early adolescence to early adulthood.

Importance of High School Years

Numerous studies have shown significant relations between attitudes during the high school years and decisions to pursue careers in math and science. In fact, women and men in science careers, as compared with those in nonscience careers, took more high school elective science courses and aspired to higher prestige careers as adolescents (Farmer et al., 1999); however, female students generally take fewer science classes in high school than their male counterparts (NSF, 1997). Even among college students who are interested and capable of achieving in math and science, girls tend to have taken fewer advanced mathematics courses in high school than their male peers (e.g., Farmer, Wardrop, Anderson, & Risinger, 1995). Moreover, recent studies (Seymour & Hewitt, 1997) have revealed that female adolescents' low self-confidence in math-related subjects is strongly related to the selection of a nonscience major. Likewise, women's declining confidence during the early years of college has been related to a switch from math and science to other fields (Sax, 1995).

Because adolescents are influenced by their parents' perceptions and beliefs during high school (e.g., Bregman & Killen, 1999), students whose parents do not encourage them to take such classes will not encounter the experiences in math and science that help them develop needed levels of self-efficacy to pursue math and science careers. In fact, students identify parents as the strongest influence on career and course decisions (Bender, 1994; Lunneborg, 1982; Young, 1985), particularly when choosing careers in science or engineering (Dick & Rallis, 1991).

Current Study

Although the relations between parents' perceptions and their children's self-beliefs have been well documented (e.g., Heller & Ziegler, 1996; Jacobs, 1991; Jacobs & Eccles, 1992), no longitudinal studies have been conducted to assess the long-term significance of parental beliefs as individuals become young adults and begin their own careers. Additionally, even though research certainly indicates an important relationship among parents' gender stereotypes, parents' perceptions of their adolescents' behaviors, and adolescents' self-perceptions, no studies have attempted to track the relations between parents' earlier beliefs and their children's self-perceptions as they reach late adolescence and begin to make important educational choices. Moreover, no studies have documented the relations between parents' gender stereotypes and perceptions of their offspring during early adolescence and the actual career and educational choices made by their children in young adulthood. Thus, the current longitudinal study will extend Jacobs's (1991) and Jacobs and Eccles's (1992) original findings

and examine the relations between parents' gender beliefs and perceptions of their adolescents' abilities and the career plans and educational choices of both male and female adolescents 12 years later.

On the basis of the earlier findings, we predicted that mothers' gender stereotypes and perceptions of their children's abilities during early adolescence would be related to adolescents' math-science career self-efficacy and career choice. To examine this pattern, we tested three hypotheses. First, we expected mothers' perceptions of their adolescents' likelihood of success in careers that require math ability to be related to adolescents' math-science self-efficacy 2 years after high school. Next, we predicted that adolescents' self-perceptions of math ability during 10th grade would mediate the relation between mothers' perceptions and adolescents' math-science career self-efficacy. Finally, we expected mothers' earlier gender stereotypes and perceptions of their children's abilities to succeed in math-oriented careers to be related to the careers their young adult children selected after graduating from college or high school (if the individual was not college bound). In addition, on the basis of the literature reviewed earlier, we expected to find gender differences in individuals' career choices. Specifically, we predicted that men would be more likely to choose careers in physical sciences and women would be more likely to report careers in the life sciences-business and that these differences would be related to mothers' gender stereotypes and perceptions of their children's abilities.

Method

Participants

This study is a longitudinal follow-up to the one conducted by Jacobs and Eccles (1992), with participants from the Michigan Study of Adolescent Life Transitions. During the first wave of data collection in the fall of 1983, children were members of 143 sixth-grade math classrooms located in 12 school districts in primarily White middle- and working-class suburbs outside of a large city in Michigan. All sixth-grade teachers were asked to participate, and approximately 80% agreed. Within each classroom, all students and their parents were asked to participate, and 80% of the students ($n = 2,471$) and 62% of the mothers ($n = 1,380$) participated by completing questionnaires. This investigation includes only participants who remained in the eighth wave of the study during 1996 at age 24–25 years and whose mothers had also participated when they were in the sixth grade. The total number of participants who met these criteria was 1,007. Of this total, however, only a subsample of 354 mothers and their children answered all of the items used in the current study. Thus, sample size varies, depending on the number of items used (such changes in sample size are clearly marked in the *Results* section). It is important to note that the subsample of 354 who answered all questions did not have significantly different values for mothers' gender stereotype, mothers' perceptions of children's success in a math-oriented career, or adolescents' science and math career self-efficacy, compared with the total sample of 1,007 participants.

Procedure

Data regarding parents' and students' beliefs about math and science were collected from parents during the second and third waves of data collection (sixth and seventh grades, during 1984) and from adolescents during 10th grade (1988), 2 years after high school (1992), and at age 24–25 years (1996; see Table 1 for description of waves). Data regarding students' math-science abilities were collected from the participants' sixth-grade teachers in 1984, during the second wave of data collection. During

Table 1
Year and Grade Level of Child for Each Wave of Study

Wave	Year	Grade or age	Respondent
2	1984 (spring)	6th grade	Parent–teacher
3	1984 (fall)	7th grade	Parent
5	1988	10th grade	Student
7	1992	2 years posthigh school	Student
8	1996	Age 24–25 years	Student

the spring and fall semesters of 1984, mothers responded to questionnaires containing items about their children's abilities and future expectancies for success in math and responded to items about their gender-stereotypic beliefs in math. The questionnaires were mailed to the homes of mothers who agreed to participate, and each mother completed the questionnaire and returned it in a prepaid envelope. When adolescent participants were still in school (i.e., 1988), trained field staff administered questionnaires to students in two 30-min sessions during mathematics classes. Students answered questions at their own pace without time limits. During later waves of data collection (1992, 1996), questionnaires were mailed to the homes of adolescents who had previously participated, and each adolescent completed the questionnaire and returned it in a prepaid envelope.

Measures

Adolescent and parent questionnaires. The questionnaires contained a variety of items regarding parents' and adolescents' beliefs and attitudes about mathematics and science. The items that were used in this study are a subset of the total items asked in the larger study. These items have been used in previous studies (e.g., Jacobs, 1991; Jacobs & Eccles, 1992), and

good psychometric properties of these measures have been reported elsewhere (e.g., Eccles et al., 1983; Eccles-Parsons, Adler, & Kaczala, 1982; Jacobs, 1991; Jacobs & Eccles, 1992). All scores obtained with the scales exhibited good internal consistency (ranging from .60 to .88), as tested by Cronbach's alpha coefficient.

Adolescent measures. The first adolescent scale consisted of three items and measured adolescents' self-perceptions of math ability during the 10th grade (e.g., "How good at math are you?"). The reliability of this scale was .86, indicating that the items in the scale appear to be focusing on the same construct. The second scale, administered 2 years after completion of high school, consisted of four items and measured adolescents' science and math career self-efficacy (e.g., "How well do you think you would do in a science- or math-related field?"). The Cronbach's alpha for the responses on this scale was .83. All scale items were designed with 7-point Likert response formats (see Table 2).

During young adulthood, participants aged 24–25 years also answered a single-item question about their current career or occupation. Participants reported their main occupation and were given instructions to be as specific as possible. Occupations were first coded using the three-digit 1980 census codes. A listing of codes pertinent to the data in this study was taken from an index of approximately 23,000 occupational titles, assigned to occupations by the U.S. Census Bureau. Then, on the basis of a review of previous literature (i.e., Farmer et al., 1999; Jacobs et al., 1998; Seymour & Hewitt, 1997) examining math–science career achievement, we categorized occupations as life science–business careers (coded as 0), physical science–computing careers (coded as 1), or nonscience careers (coded as 2). Graduate students were included in the category in which they were studying. Some examples of careers that were coded as life science–business careers are health assessor, business supervisor, and health technologist. Examples of physical science–computing careers are mathematician, computer scientist, and engineer. Some examples of nonscience–

Table 2
Cronbach's Alpha for Adolescent Scales

Scale and item	Response rating scale anchors	α
Adolescent's Self-Perception of Math Ability		.86
How good at math are you?	1 = <i>not at all good</i> , 7 = <i>very good</i>	
If you were to rank all the students in your math class from the worst to the best in math, where would you put yourself?	1 = <i>at the bottom</i> , 7 = <i>at the top</i>	
Compared to most of your other school subjects, how good are you at math?	1 = <i>much worse</i> , 7 = <i>much better</i>	
Adolescent's Science and Math Career Self-Efficacy		.83
How well do you think you would do in a science- or math-related field?	1 = <i>not do well at all</i> , 7 = <i>would do very well</i>	
How well do you think you would do in a job as a physical scientist (scientist with a PhD)?	1 = <i>not do well at all</i> , 7 = <i>would do very well</i>	
How good would you be in a career that required using advanced math?	1 = <i>not at all good</i> , 7 = <i>very good</i>	
How good would you be in a career that required you to do math?	1 = <i>not at all good</i> , 7 = <i>very good</i>	
Adolescent's Occupation or Career		(single item)
For those working for pay . . . Currently, what is your main occupation?		

Table 3
Cronbach's Alpha for Parent and Teacher Scales

Scale and item	Response rating scale anchors	α
Mother's Gender Stereotype		.60
In general, how would you compare females and males in math?	1 = <i>females better</i> , 5 = <i>males better</i>	
In general, who do you believe finds math more useful in their adult lives?	1 = <i>females</i> , 5 = <i>males</i>	
In general, to whom do you believe math is more important?	1 = <i>females</i> , 5 = <i>males</i>	
Mother's Prediction of Child's Success in Math Career		(single item)
How successful do you think your child would be in a career requiring math ability?	1 = <i>not at all</i> , 7 = <i>very successful</i>	
Teacher's Rating of Child's Math Ability		.88
How much natural mathematical talent does this student have?	1 = <i>very little math talent</i> , 7 = <i>a lot of math talent</i>	
Compared to other students in this class, how well is this student performing in math?	1 = <i>bottom of class</i> , 7 = <i>one of the best in the class</i>	

nonmath careers are lawyer, retail worker, and jobs associated with food preparation (see the Appendix for complete lists).

Parent measures. The first parent scale assessed respondents' general beliefs about boys' and girls' relative mathematical abilities and is labeled *mothers' gender stereotype*. This scale has been used in previous studies and has been shown to have good psychometric properties (see Jacobs, 1991; Jacobs & Eccles, 1992). The gender stereotype scale, which was administered to mothers when their children were in sixth grade, consisted of three items, each answered using a 5-point Likert response scale, with higher numbers indicating stereotypes in favor of males (e.g., "In general, how would you compare females and males in math?"). The Cronbach's alpha for responses on this scale was .60. Finally, a single item asked parents how successful their child would be in a career requiring math ability, and it was answered using a 7-point Likert response scale, when children were in seventh grade (see Table 3).

Teacher ratings. Teachers' ratings were used as measures of children's mathematics performance and ability. Teachers' ratings were collected during students' sixth-grade year of school (spring 1984). A scale consisting of two items (rated on a 7-point Likert scale) was used to assess teachers' perceptions of each student's ability in math (e.g., "How much natural mathematical talent does this student have?"). The correlation of the items in this scale was .88 (see Table 3).

Results

Before testing the model, we conducted a set of preliminary *t* tests on the original sample of participants (i.e., including individuals who did not participate in later waves), comparing boys' and girls' responses on relevant independent and dependent variables. The entire sample was included in these descriptive analyses. We used the Bonferroni correction method¹ for multiple comparisons to adjust the alpha level for significance. Teachers of sixth-grade

girls rated their abilities significantly higher than boys, $t(500) = 2.88, p < .01$. Despite this objective indicator, mothers of seventh-grade boys reported significantly higher expectations of success in math-oriented careers than mothers of girls, $t(500) = 2.66, p < .01$, and 10th-grade boys reported significantly higher perceptions of math ability than girls, $t(500) = 2.93, p < .01$. Mothers of boys reported more gender stereotypical views favoring boys in mathematics than mothers of girls, $t(500) = 2.45, p < .01$. Finally, 19–20-year-old male adolescents reported higher self-efficacy for math–science careers than female adolescents, $t(500) = 10.18, p < .001$. All of these significance levels meet the requirement for statistical significance under the Bonferroni correction ($\alpha < .01$). Means and standard deviations for all variables are presented in Table 4.

Because sample sizes were large for each of these measures, effect sizes are also reported in Table 4, as measures of the strength of the correlations between dependent variables and child's gender. Cohen's *d* statistic² was used to compute effect sizes and can be interpreted as the amount of variance in the dependent variable

¹ The Bonferroni adjustment is used to keep the experiment-wise error rate to a specified level (in this case, $\alpha = .05$). This adjustment is made by dividing the alpha level by the number of comparisons made. In the current set of analyses, five comparisons were made; to keep the overall experiment-wise error rate to 5%, each of the analyses was evaluated against .05 divided by 5. That is, for any one comparison to be considered significant, the obtained *p* value would have to be less than .01, rather than .05. This adjustment decreases the chance of making a Type I error.

² Cohen's *d* statistic is defined as the difference between the means, $M_1 - M_2$, divided by the standard deviation (Cohen, 1988).

Table 4
Means, Standard Deviations, and *t* Tests of Parent, Teacher, and Adolescent Variables

Variable and grade	Girls		Boys		<i>t</i>	<i>d</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
Teacher's rating of child's math ability (6th grade)	4.20	1.18	4.05	1.21	2.88**	.12
Mother's gender stereotype (6th grade)	3.13	0.39	3.19	0.39	2.45**	.15
Mother's prediction of child's success in math career (7th grade)	5.17	1.40	5.40	1.39	2.66**	.17
Adolescent's perception of math ability (10th grade)	4.55	1.37	4.76	1.31	2.93**	.16
Adolescent's math-science career self-efficacy (age 19-20 years)	3.49	1.49	4.33	1.51	10.18***	.54

Note. *n* = 502. For each *t* test, *df* = 500.

** *p* < .01. *** *p* < .001.

explained by the grouping factor (child's gender; Cohen, 1988). Although all of the *t* tests described above indicate significance (*p* < .01), child's gender accounts for only a small proportion of the variance in mother's prediction of child's success in a math career (*d* = .17), teacher's rating of child's math ability (*d* = .12), adolescent's perception of math ability (*d* = .16), and mother's gender stereotype (*d* = .15). Child's gender accounts for a medium proportion of variance (*d* = .54) in adolescent's math-science career self-efficacy (Cohen, 1988). Consistent with recent research (Meece & Jones, 1996), these analyses indicate that although most gender differences in math ability are very small, consistent differences exist between boys' and girls' levels of self-efficacy. We investigate additional predictors of such gender differences (e.g., mothers' perceptions) in the subsequent analyses.

Relations Between Mothers' Beliefs and Adolescents' Career Self-Efficacy

The analyses used in the current study were based on analyses reported by Jacobs (1991) and Jacobs and Eccles (1992), who examined the significance of mothers' gender stereotypes by regressing the mothers' perceptions on a set of predictor variables, including gender of child, mothers' stereotypic beliefs during children's sixth-grade year, the interaction of mothers' stereotypic beliefs and child gender, and teachers' ratings of children's math ability during sixth grade. The interaction term was the variable of major interest in Jacobs's (1991) and Jacobs and Eccles's (1992) analyses because mothers' gender-stereotypic beliefs were expected to moderate the relation between child gender and mothers' ability perceptions once children's abilities had been controlled.

This first analysis in the present study used the same strategy used by Jacobs in previous studies (Jacobs, 1991; Jacobs & Eccles, 1992) to regress adolescents' math-science career self-efficacy after high school on the interaction of child gender and mothers' gender stereotypes, as well as mothers' predictions of children's success in math-oriented careers. The interaction term was constructed by first standardizing the stereotype variable and then multiplying the gender and stereotype variables together. All other variables (dependent and independent) were standardized before being entered into the regression equation. Variables used to form the interaction may not be interpreted simply as main effects, but when coded properly, they may be meaningfully interpreted in light of the interaction (see Judd & McClelland, 1989). In each analysis, gender of child was coded as daughters = -0.50 and

sons = 0.50, so that the coefficient for gender corresponds to the gender difference in standard deviation units at the mean level of stereotyping. Because of the same coding strategy, the coefficient for stereotype may be interpreted as the effect of stereotyping, averaging across sons and daughters. Most important for present purposes, the coefficient for the interaction term corresponds to variation in the gender difference across levels of stereotyping. A positive coefficient indicates that as stereotypes grow stronger, the gender difference increases in the direction of higher scores for boys. The magnitude of the coefficient reflects the amount of change in the gender difference per standard deviation of stereotyping (Kerlinger & Pedhazur, 1973, pp. 252-253).

A regression equation was computed, using gender of child, mothers' stereotypic beliefs during children's sixth-grade year, the interaction of mothers' stereotypic beliefs and child gender, teachers' ratings of children's math abilities during sixth grade, and mothers' predictions of children's success in math-oriented careers as predictors. All variables were entered at once, allowing us to measure the unique contribution of each variable. Teachers' ratings from the sixth grade were used to control for adolescents' math abilities. The goodness of fit for this model is measured by the *R*² value (see Table 5); the *R*² value of .18 is typical for this

Table 5
Regression of Adolescent's Math-Science Career Self-Efficacy on Mother's and Adolescent's (Age 19-20 Years) Perceptions of Math Ability

Predictor variable	Self-efficacy (<i>b</i> ^a)
Adolescent's gender (girls = -.50, boys = .50)	.36***
Mother's gender stereotype (6th grade)	.00
Adolescent's Gender × Mother's Gender Stereotype	.00
Teacher's rating of child's math ability (6th grade)	.21***
Mother's prediction of child's success in math career (7th grade)	.20***
<i>N</i>	354
<i>R</i> ²	.18
Adjusted <i>R</i> ²	.17

^a The reported path coefficients are *b* weights, rather than the more familiar beta weights (Kerlinger & Pedhazur, 1973, p. 25). However, because of the standardization procedures, *b* weights can be interpreted as beta weights for all variables except for gender and the interaction term. The appropriate interpretation of all the variables is described in the text.
*** *p* < .001.

kind of research. It should be noted that although the original sample was 1,007, not every adolescent–mother dyad completed every item used in the current and subsequent regression analyses. Thus, these regression analyses were conducted using a subsample of adolescent–mother dyads that participated fully at each wave of data collection ($n = 354$).

In Table 5, the significant positive term for child gender indicates that men reported higher levels of math–science career self-efficacy than women at age 19–20 years. Although the interaction of mothers' stereotypic beliefs and child gender were not significantly associated with adolescents' math–science career self-efficacy, mothers' predictions of children's success in math careers was significantly related to career self-efficacy (see Table 5). Mothers who reported more positive predictions of their children's success in math careers when their children were in the seventh grade were more likely to have children who reported higher math–science career self-efficacy in late adolescence.

The second hypothesis was related to the role of adolescents' self-perceptions as a mediator between mothers' perceptions and adolescents' later career self-efficacy. The first step used to establish mediation is to show a significant relation between the independent variable and the mediator (Baron & Kenny, 1986). In this case, the relation between the independent variable (mothers' predictions of children's success in math careers) and the mediator (adolescents' perceptions of math ability in the 10th grade) was investigated by computing a regression using gender of child, mothers' stereotypic beliefs during children's sixth-grade year, the interaction of mothers' stereotypic beliefs and child gender, teachers' ratings of children's math abilities during sixth grade, and mothers' predictions of children's success in math careers as independent variables and adolescents' perceptions of math ability in the 10th grade as the dependent variable. Once again, all variables were entered at once, allowing us to measure the unique contribution of each variable. As expected, the significant coefficient for mothers' predictions indicates that mothers' who reported more positive predictions of their children's successes in math-oriented careers were more likely to have children who reported higher self-perceptions of math ability in 10th grade (see Table 6, column 1).

The next step in establishing mediation is to show that the independent variable (mothers' predictions of children's success in math careers) is related to the dependent variable (adolescents' math–science career self-efficacy; Baron & Kenny, 1986). A regression equation was computed, with all variables entered simultaneously, using gender of child, mothers' stereotypic beliefs during children's sixth-grade year, the interaction of mothers' stereotypic beliefs and child gender, teachers' ratings of children's math abilities during sixth grade, and mothers' predictions of children's success in math careers as independent variables and adolescents' math–science self-efficacy as the dependent variable. As expected, mothers who reported more positive predictions of their children's successes in math careers were more likely to have adolescents who reported higher math–science career self-efficacy (see Table 6, column 2).

The final step in establishing mediation is to show that the mediator variable (adolescents' self-perceptions of math ability at 10th grade) is related to the dependent variable (adolescents' math–science career self-efficacy; Baron & Kenny, 1986). Thus, the mediator variable was added to the equation as an independent variable, and results indicated a significant, positive relation between the mediator and the variable measuring adolescents' career self-efficacy (see Table 6, column 3). Importantly, when the mediator was added to the model, the b weight for the independent variable (mothers' predictions of children's success in math careers) decreased from .20 to .15, and the estimated path coefficient (Clogg & Petkova, 1995) was significant ($z = 1.73$; $p < .05$), suggesting that adolescents' self-perceptions in high school partially mediate the relation between mothers' earlier perceptions and the later career self-efficacy of older adolescents (see Figure 1). It is clear, however, that the variables in the original equation continue to be directly related to later math–science career efficacy; their effects are not completely explained by the presence of the mediator.

Career Choices During Late Adolescence

Finally, we hypothesized that a mother's perception of her child during middle school ultimately affects the career her young adult

Table 6
Regressions of Adolescents' Self-Perceptions on Mothers' and Adolescents' Perceptions of Math Ability: Establishing Mediation

Predictor variable	Adolescents' self-perception of math ability in 10th grade (b)	Adolescents' math–science career self-efficacy for age 19–20 years (b)	To test for mediation, adolescents' math–science career self-efficacy for age 19–20 years (b)
Adolescent's gender (girls = $-.50$, boys = $.50$)	.00	.36***	.34***
Mother's gender stereotype (6th grade)	.00	.00	.00
Adolescent's Gender \times Mother's Gender Stereotype	.00	.00	.00
Teacher's rating of child's math ability (6th grade)	.30***	.21***	.11*
Mother's prediction of child's success in math career (7th grade)	.14***	.20***	.15**
Adolescent's self-perception of math ability (10th grade)			.33***
R^2	.13	.18	.29
Adjusted R^2	.12	.17	.28

Note. $N = 354$. The reported path coefficients are b weights, rather than the more familiar beta weights (Kerlinger & Pedhazur, 1973, p. 25). However, because of the standardization procedures, b weights can be interpreted as beta weights for all variables except for gender and the interaction term. The appropriate interpretation of all the variables is described in the text.

* $p < .05$. ** $p < .01$. *** $p < .001$.

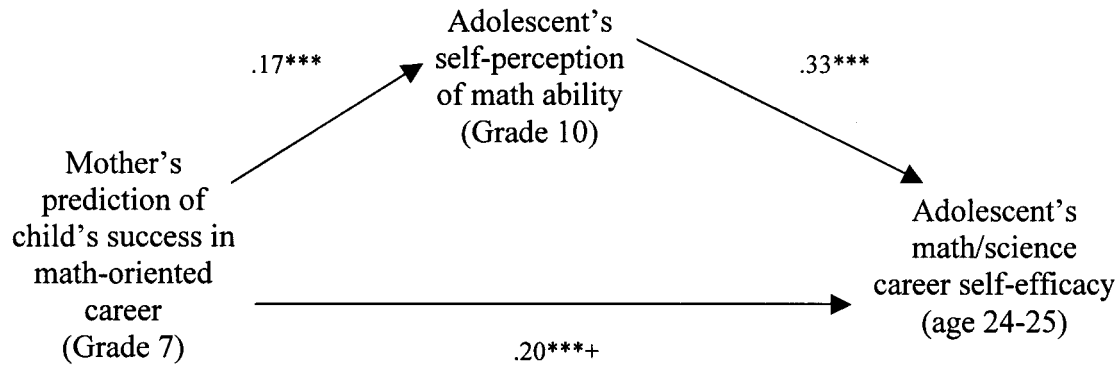


Figure 1. Child's self-perception mediates the relation between mother's prediction of child's success in a math-oriented career and child's later career self-efficacy. + The b weight drops to .15 ($p < .01$) when the mediating variable is added into the model. *** $p < .001$.

child chooses after graduating from college or high school (if the individual is not college bound). Multinomial logistic regression analyses were chosen to test this hypothesis because career choice is a categorical variable with three values (life science–business, physical science–computing, nonscience); thus, the goal of the analyses is to estimate the probability that a case will be classified into one as opposed to the other two categories of the dependent variable (see Menard, 1995). Multinomial logistic regression is a variation of binomial logistic regression, useful when the observed outcome is categorical in nature, with more than two values. It produces a formula that estimates the probability of the occurrence as a function of the independent variables. The multinomial logistic regression analyses were conducted twice—once for all participants (i.e., college- and noncollege-bound participants) and once for college-bound participants alone. Although the results for these two sets of analyses were nearly identical, they are both presented (see Table 7). Analyses were not computed for noncollege-bound participants alone, because the sample size for noncollege-bound students in science careers was too low ($n = 31$).

A regression equation was computed, using gender of child, mothers' stereotypic beliefs during children's sixth-grade year, the interaction of mothers' stereotypic beliefs and child gender, teachers' ratings of children's math abilities during sixth grade, mothers' predictions of children's success in math careers, and the interaction of mothers' predictions of children's success and child's gender as predictors, and career choice (life science–business [$n = 51$], physical science–computing [$n = 45$], nonscience [$n = 258$]) as the dependent variable. All variables were entered at once, allowing us to measure the unique contribution of each variable. The values of the career variable were coded so that the reference category was nonscience careers, allowing us to examine the relationship of each independent variable to the contrast between (a) life science–business career versus nonscience career and (b) physical science–computing career versus nonscience career. The third possible comparison (life science–business career versus physical science–computing career) is redundant with the first two comparisons, but we will consider it separately later to aid in the interpretation of results.

As can be seen in Table 7, adolescents' gender was significantly related to a higher likelihood of entering a life science–business career versus a nonscience career, in both the total sample and

college subsample. Male adolescents in the total sample were 67% ($e^{-1.11}$) less likely to choose a life science–business job than a nonscience job.³ None of the other independent variables were significantly related to adolescents' career choice. These analyses suggest that mothers' predictions of children's success in math careers and mothers' gender stereotypes during middle school were not significantly related to whether their adolescents chose to pursue careers in life science–business over nonscience careers.

In contrast, adolescents' gender, mothers' predictions of children's success in math careers, and the interaction of adolescents' gender and mothers' predictions of children's success in math careers were significantly related to entering a physical science–computing career versus a nonscience career, regardless of college attendance (see Table 7). Female adolescents in the total sample were almost four times ($e^{1.34}$) less likely to choose a physical science job than a nonscience job. Likewise, with each one unit increase on mothers' prediction of success in a math-oriented career during middle school, adolescents were nearly two times ($e^{0.67} = 1.95$) as likely to be working in a physical science–computing career as opposed to a nonscience career at age 24–25 years, regardless of college attendance. The significant negative interaction term for both models indicates that female adolescents whose mothers reported low predictions of children's success in math careers were 66% ($e^{-1.09}$) more likely to choose careers in nonscience than in physical science–computing; however, mothers' perceptions had only a minimal effect on male adolescents' chances of choosing a nonscience career, as opposed to a career in physical science–computing (see Figure 2). The goodness of fit for these models is measured by the pseudo R^2 value (see Table 7) and is roughly comparable with a regular R^2 in linear regression. The pseudo R^2 value of .10 is typical for this type of research.

Finally, the values of the career variable were recoded so that the reference category became physical science–computing career ($-1 =$ nonscience career, $0 =$ life science–business career, $1 =$ physical science–computing career). Although this additional

³ The symbol e is the constant associated with the natural logarithm; raising e to a power is also known as the exponential function. In these analyses, raising e to the power of the b coefficient (e^b) for each variable gives us the odds of choosing a nonscience career over a life science career, for example, with respect to each predictor variable.

Table 7
*Logistic Regression of Science or Nonscience Career on Parent and Adolescent Beliefs:
 Full Sample*

Predictor variable	Life science–business vs. nonscience career		Physical science–computing vs. nonscience career	
	B	Exp(B)	B	Exp(B)
Adolescent's gender (girls = $-.50$, boys = $.50$)	-1.11^{**} (-0.98)	0.33 (0.38)	1.34^{***} (1.33) ***	3.82 (3.78)
Mother's gender stereotype (6th grade)	0.00 (0.02)	1.00 (1.02)	0.15 (0.12)	1.16 (1.12)
Adolescent's Gender \times Mother's Gender Stereotype	0.16 (0.07)	1.17 (1.07)	-0.28 (-0.26)	0.76 (0.77)
Teacher's rating of child's math ability (6th grade)	0.13 (0.07)	1.14 (1.08)	0.11 (0.00)	1.11 (0.99)
Mother's prediction of child's success in math career (7th grade)	0.14 (0.22)	1.15 (1.25)	0.67^{**} (0.70) **	1.95 (2.01)
Adolescent's Gender \times Mother's Prediction	0.28 (0.11)	1.32 (1.11)	-1.09 (-1.11)	0.34 (0.33)

Note. Results for college students are in parentheses. $N = 345$ (299). Pseudo $R^2 = .10$ (.10). Percentage correctly classified was 78.1% (75.4%). Exp(B) = estimated odds ratio.
 $^{**} p < .01$. $^{***} p < .001$.

analysis is somewhat redundant, this coding scheme allowed us to examine the additional relationship of each independent variable to the contrast between life science–business career and physical science–computing career. Multinomial logistic regression analyses, identical to the analyses explained above, were computed after recoding the career variable. As can be seen in Table 8, adolescents' gender and the interaction of adolescents' gender and mothers' prediction of success in a math career were significantly related to entering a life science–business career versus a physical science–computing career in the model using the total sample. Male adolescents were 91% ($e^{-2.45}$) less likely to choose a job in the life sciences than in physical science–computing. Moreover, the significant negative interaction term for the model including all participants indicates that female adolescents whose mothers re-

ported low predictions of children's success in math careers were nearly four times ($e^{1.37}$) as likely to choose careers in nonscience than in physical science–computing; however, mothers' perceptions had only a minimal relation with male adolescents' chances of choosing a nonscience career, as opposed to a career in physical science–computing (see Figure 3). The relationship between the interaction term and career choice was not statistically significant in the college student model.

In summary, these analyses suggest that after controlling for mother's gender stereotypes and teachers' ratings, mothers' predictions of their children's success in a math-oriented career during the seventh grade were positively related to their daughters' pursuits of careers in physical science–computing over careers in life science–business or nonscience domains. This effect was not

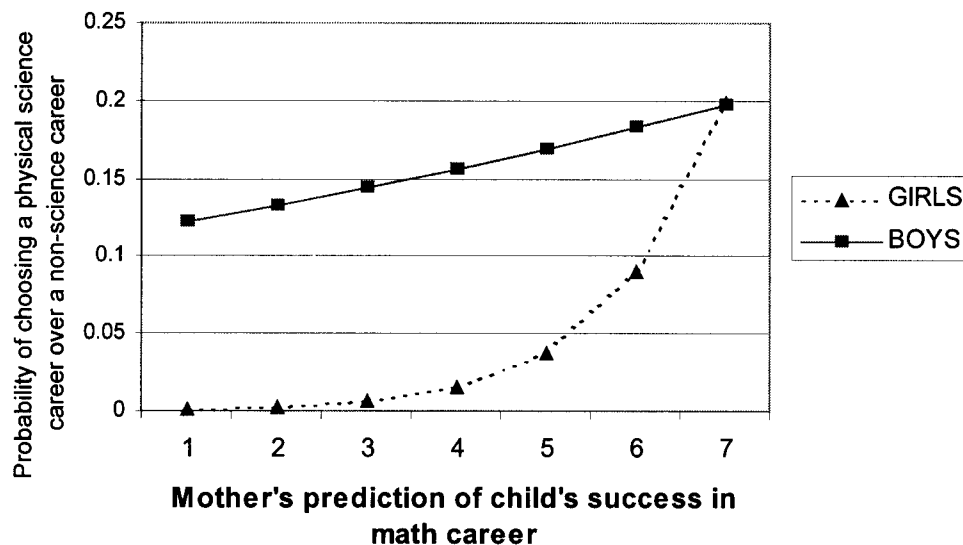


Figure 2. Relation between mothers' perceptions (sixth grade) and young adults' career choices (age 24–25 years): Probability of physical science over nonscience.

Table 8
Logistic Regression of Life Science–Business Versus Physical Science–Computing Career on Parent and Adolescent Beliefs

Predictor variable	All participants		College students only	
	B	Exp(B)	B	Exp(B)
Adolescent's gender (girls = $-.50$, boys = $.50$)	-2.45^{***}	0.09	-2.31^{***}	0.09
Mother's gender stereotype (6th grade)	-0.15	0.86	-0.09	0.91
Adolescent's Gender \times Mother's Gender Stereotype	0.43	1.54	0.33	1.39
Teacher's rating of child's math ability (6th grade)	0.02	1.02	0.08	1.09
Mother's prediction of child's success in math career (7th grade)	-0.53	0.59	-0.48	0.62
Adolescent's Gender \times Mother's Prediction	1.37^*	3.93	1.21	3.37
<i>N</i>	354		299	
Pseudo R^2	.10		.10	
Percentage correctly classified	78.1%		75.4%	

Note. The values of the career variable have been recoded so that the reference category is physical science–computing career (-1 = nonscience career, 0 = life science–business career, 1 = physical science–computing career). This coding scheme allows the additional relationship of each independent variable to the contrast between life science–business career and physical science–computing career to be examined. Exp(B) = estimated odds ratio.

* $p < .05$. *** $p < .001$.

found for sons, however. Sons were more likely to choose careers in physical science–computing than in life science–business, regardless of mothers' predictions of success.

Discussion

Unlike previous studies, the current findings illustrate the long-term significance of mothers' earlier beliefs on adolescents' later self-perceptions and career choices. In earlier studies using the same sample, Jacobs (1991; Jacobs & Eccles, 1992) uncovered an important association between parents' world beliefs (e.g., stereotypes) and their expectations for their own children. Although the authors suggested that parents' gender stereotypes and early perceptions might have long-term implications for their children's achievement choices, this suggestion had not been previously

tested. After 12 years, the children have become young adults, and we are finally able to answer that question by showing that mothers' perceptions of their children's abilities are both directly and indirectly related to the self-perceptions and later career choices of their offspring.

We expected mothers' beliefs about their middle school children to be related to their adolescents' self-perceptions following high school. Indeed, mothers who reported higher perceptions of their adolescents' success in math-oriented careers had adolescent children who reported higher math–science career self-efficacy. Although the interaction of child gender and mother's gender stereotype was not related to adolescents' math–science career self-efficacy longitudinally, we know from past research (Jacobs, 1991; Jacobs & Eccles, 1992) that the same mothers' prior gender

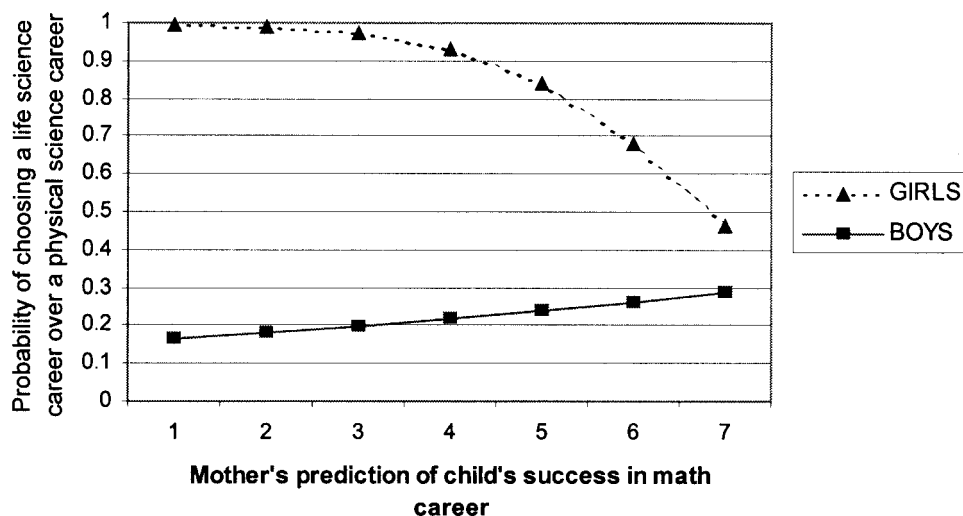


Figure 3. Relation between mothers' perceptions (sixth grade) and young adults' career choices (age 24–25 years): Probability of life science over physical science.

stereotypes were directly related to their perceptions of their children's ability and only indirectly related to their children's self-perceptions of ability in math 1 year later. This suggests that early perceptions of one's child may be shaped by general stereotypic beliefs that, in turn, are related to children's later self-beliefs and performance. This interpretation is supported by the finding that boys had higher math ability beliefs than did girls, despite the fact that girls had higher teacher ratings than boys, and suggests that adolescents form their self-perceptions on the basis of more than just their own performance. Gender-differentiated messages from parents and other sources may account, in part, for their nondata-based beliefs.

In addition, adolescents' self-perceptions of math ability during the 10th grade mediated the relation between mothers' perceptions and adolescents' math-science career self-efficacy. This finding supports our hypothesis and suggests the existence of a longitudinal pattern; mothers' perceptions of their children's abilities during the seventh grade were indirectly related to their older adolescents' feelings of math-science career self-efficacy, through a direct relation with their adolescents' self-perceptions during high school. Thus, mothers who reported high perceptions of their children's abilities to succeed in math careers during middle school were significantly more likely to have adolescents who reported high self-perceptions of math ability during the 10th grade and high math-science career self-efficacy 2 years after high school. By illustrating the long-term significance of parents' perceptions, this finding extends Eccles's and colleagues' (e.g., Eccles-Parsons et al., 1982; Jacobs, 1991; Jacobs & Eccles, 1992) findings that parents' perceptions of their children's abilities and their expectations for their children's future successes are related to children's developing perceptions of self-competence.

The most important findings from this study are the enduring links between mothers' early expectations for their children and the children's later career decisions. As expected, the interaction of an adolescent's gender and a mother's prediction of her child's ability to succeed in a math career was a direct indicator of whether a young adult chose a career in physical science-computing, as opposed to a nonscience or life science-business career. In fact, regardless of whether they attended college, female adolescents whose mothers reported low perceptions of their abilities to succeed in math careers were 66% less likely to choose careers in physical science-computing than in nonscience. In addition, college-bound female adolescents whose mothers reported these low perceptions were almost four times more likely to choose careers in life science-business than in physical science-computing. Interestingly, mothers' perceptions had only a minimal relation with male adolescents' chances of choosing nonscience and life science-business careers, as opposed to careers in physical science-computing. It is clear that mothers' perceptions are differentially related to career choice, depending on the gender of the child.

The pattern of results found in this study confirms Jacobs's (1991; Jacobs & Eccles, 1992) earlier findings about the relations between mothers' expectations and adolescents' self-perceptions and provides evidence for the importance of mothers' early perceptions on the long-term achievement beliefs and career choices of their children. Although researchers have believed that parents' perceptions matter for the socialization of achievement attitudes and choices of their children, such long-term relations between parents' expectations and their children's actual achievement out-

comes have never before been documented. Even though mothers' stereotypic beliefs about math and science were not significantly related to their children's self-perceptions in high school, after high school, or to their actual career decisions, their perceptions of their children's abilities to succeed in math-oriented careers were directly related to adolescents' actual educational and career choices. The current findings indicate that gender differences in attitudes are present in early adolescence and continue throughout middle school and high school. Despite the fact that girls have higher teacher ratings than boys, girls report lower self-perceptions of math ability, are less likely to indicate plans to pursue math and science careers than boys, and are ultimately less likely to choose careers in physical science-computing, if their mothers reported low perceptions of their abilities.

Although female participants in the current study were more likely than their male counterparts to report careers in math-science overall, there were notable gender differences within math and science careers. For instance, the women who reported careers in math-science were more likely to choose careers in life science and business, as opposed to more stereotypically male careers in physical science and computing. These findings support Sanderson et al.'s (2000) suggestion that women have become more likely to indicate interest in certain areas of science, such as life science or biology, even though their participation in computer science, physics, and engineering remains low. In fact, in the current study, only 5.0% of female participants chose careers in physical science-computing, whereas 14.4% of women chose careers in life science-business. Similarly, 12.4% of male participants chose careers in physical science-computing, whereas only 4.3% of men reported careers in life science-business. These findings correspond to national statistics indicating that women comprise only 9% of employed engineers and 10% of employed physicists in the United States (NSF, 2000). Thus, even for science-bound girls, areas within science are clearly gender typed.

Although the current findings add an important longitudinal piece to the achievement literature, certain limitations of the study must be mentioned. First, the original sample of adolescents and their mothers is not a random sample; instead, the sample is composed of the 80% of adolescents and 62% of mothers who were interested in participating during the child's sixth-grade year of school. In addition, because of the longitudinal nature of the study, attrition occurred as adolescents moved away from home and began careers of their own or chose not to answer certain items over time, resulting in fewer participants during the last few waves of data collection than in beginning stages. Also, the study was limited to a predominately White, middle-class sample; therefore, the findings and the model may not be generalized to other populations. It is possible that other groups of parents may hold stronger or weaker gender stereotypes and that such beliefs may hold different associations with their children's beliefs and behaviors. Finally, because of our focus on the importance of attitudes for achievement and career choice, we used self-report instruments. It is possible that less subjective measures, such as achievement tests, would have yielded different relations with career choice.

Although the research presented here highlights the importance of mothers' beliefs, this study was designed to focus only on the long-term relations between stereotypes, perceptions, and later adolescent beliefs and career choices, rather than on the contextual processes of how parents communicate their views. A closer

examination of the ways in which parents convey their beliefs to their children (e.g., toy purchases, activities, encouragement) and how these vary by gender and across grade levels is needed in the future. In addition, the reliability of the gender stereotype scale is relatively low; the measure could be improved in future research by adding more items. Finally, numerous factors beyond parental beliefs and values are likely to be related to young adults' educational and career choices, including teachers, peers, and other social forces.

Conclusion

Past research shows that parents' perceptions are indirectly related to adolescents' self-perceptions, but previous studies have not attempted to track the relations between parents' beliefs and adolescent self-perceptions from early adolescence to late high school. Moreover, no studies have been able to document the long-term relations between parental beliefs and gender stereotypes on career and educational choices in young adulthood. Findings from the current study provide information to fill both of these gaps in the literature. Clearly, mothers' beliefs about their adolescents' abilities in math and science are shaped by gender stereotypes and are related to the development of their adolescent children's self-perceptions of math ability. Furthermore, mothers' early beliefs are related to older adolescents' feelings of math-science career self-efficacy and ultimately to whether young adults pursue careers in certain areas of math and science.

This study provides some insight into potential reasons for the continuing gender gap in science careers (Higher Education Research Institute, 1996), particularly in the physical sciences (NSF, 2000), despite the decrease in gender differences in math and science academic achievement. According to our findings, gender-differentiated parent perceptions, as well as adolescents' self-perceptions, play a large role in career decisions. This is not to suggest that numerous other factors are not important. For example, contextual factors such as school environment, peers, and teachers' beliefs may be related to adolescents' development of self-efficacy, values, and beliefs about the domains of math and science (Burkham, Lee, & Smerdon, 1997; Eccles, 1987). Teachers who entice their students with exciting science experiments and encourage both boys and girls to participate in challenging activities may increase adolescents' desires to learn about various areas of science, regardless of the messages they receive at home (Burkham et al., 1997). Likewise, it is possible that girls who have peers who are high achieving and interested in math are more likely to remain in challenging math courses throughout high school compared with girls whose peers are mainly interested in more gender-stereotypic activities such as socializing (Eccles, 1987).

Furthermore, factors such as parents' educational attainment and socioeconomic status are likely to be related to adolescents' experiences and achievement in math and science. In fact, several studies (e.g., Flanagan, 1990; Furstenberg, 1993) suggest that it is more difficult to succeed academically, especially in challenging domains such as math and science, when one lives in a high-risk neighborhood or if one is financially stressed. Moreover, Eccles et al. (1983) has suggested that parents' values about math and science play a role in shaping their children's values, which in turn are related to children's later achievement choices. Future longitudinal research in this area should attempt to measure and include

these types of variables; however, the findings from this study clearly indicate the importance of continuing to include parental beliefs in our studies if we are to understand adolescents' later educational and career choices.

References

- Bae, Y., & Smith, T. M. (1996). *Issues in focus: Women in mathematics and science*. Washington, DC: National Center for Educational Statistics.
- Bandura, A., Barbaranelli, C., Vittorio-Capra, G. V., & Pastorelli, C. (2001). Self-efficacy beliefs as shapers of children's aspirations and career trajectories. *Child Development, 72*, 187-206.
- Baron, R. M., & Kenny, D. A. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology, 51*, 1173-1182.
- Benbow, C. P., & Stanley, J. C. (1980, December 12). Sex differences in mathematical ability: Fact or artifact? *Science, 210*, 1262-1264.
- Bender, S. (1994). *Female student career aspirations in science* (SSTA Research Centre Rep. No. 94-04, SSTA Research in Brief). Regina, Saskatchewan, Canada: Saskatchewan School Trustees Association.
- Braswell, J. S., Lutkus, A. D., Grigg, W. S., Santapau, S. L., Tay-Lim, B., & Johnson, M. (2001). *The nation's report card: Mathematics 2000* (National Center for Education Statistics Rep. No. 2001-517). Jessup, MD: Education Publication Center.
- Bregman, G., & Killen, M. (1999). Adolescents' and young adults' reasoning about career choice and the role of parental influence. *Journal of Research on Adolescence, 9*, 253-275.
- Burkham, D. T., Lee, V. E., & Smerdon, B. A. (1997). Gender and science learning early in high school: Subject matter and laboratory experiences. *American Educational Research Journal, 34*, 297-331.
- Catsambis, S. (1999). The path to math: Gender and racial-ethnic differences in mathematics participation from middle school to high school. In L. A. Peplau & S. C. DeBro (Eds.), *Gender, culture, ethnicity: Current research about women and men* (pp. 102-120). Mountainview, CA: Mayfield.
- Clogg, C. C., & Petkova, E. (1995). Reply to Allison: More on comparing regression coefficients. *American Journal of Sociology, 100*, 1305-1312.
- Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Erlbaum.
- Crowley, K., Callanan, M. A., Tenenbaum, H. R., & Allen, E. (2001). Parents explain more often to boys than to girls during shared scientific thinking. *Psychological Science, 12*, 258-261.
- Dick, T., & Rallis, S. (1991). Factors and influences on high school students' career choices. *Journal for Research in Mathematics Education, 22*, 281-292.
- Eccles, J. S. (1987). Gender roles and women's achievement-related decisions. *Psychology of Women Quarterly, 11*, 135-172.
- Eccles, J. S., Barber, B., & Jozefowicz, D. (1998). Linking gender to educational, occupational, and recreational choices: Applying the Eccles et al. model of achievement-related choices. In W. B. Swann, Jr., J. H. Langlois, & L. A. Gibert (Eds.), *Sexism and stereotypes in modern society: The gender science of Janet Spence* (pp. 153-192). Washington, DC: American Psychological Association.
- Eccles, J. S., & Wigfield, A. (1995). In the mind of the actor: The structure of adolescents' achievement tasks values and expectancy-related beliefs. *Personality and Social Psychology Bulletin, 21*, 215-225.
- Eccles, J., Wigfield, A., & Schiefele, U. (1998). Motivation to succeed. In W. Damon (Ed.) & N. Eisenberg (Vol. Ed.), *Handbook of child psychology: Vol. 3. Social, emotional, and personality development* (5th ed., pp. 1017-1095). New York: Wiley.
- Eccles (Parsons), J., Adler, T. F., Futterman, R., Goff, S. B., Kaczala, C. M., Meece, J. L., & Midgley, C. (1983). Expectancies, values, and

- academic behaviors. In J. T. Spence (Ed.), *Achievement and achievement motivation* (pp. 75–146). San Francisco: Freeman.
- Eccles-Parsons, J., Adler, T. F., & Kaczala, C. M. (1982). Socialization of achievement attitudes and beliefs: Parental influences. *Child Development, 53*, 322–339.
- Farmer, H. S., Wardrop, J. L., Anderson, M. Z., & Risinger, R. (1995). Women's career choices: Focus on science, math, and technology careers. *Journal of Counseling Psychology, 42*, 155–170.
- Farmer, H. S., Wardrop, J. L., & Rotella, S. C. (1999). Antecedent factors differentiating women and men in science/nonscience careers. *Psychology of Women Quarterly, 23*, 763–780.
- Flanagan, C. A. (1990). Families and schools in hard times. In V. C. McLoyd and C. A. Flanagan (Eds.), *New directions for child development* (Vol. 46, pp. 7–26). San Francisco: Jossey-Bass.
- Furstenberg, F. (1993). How families manage risk and opportunities in dangerous neighborhoods. In W. J. Wilson (Ed.), *Sociology and the public agenda* (pp. 231–258). Newbury Park, CA: Sage.
- Hall, C. W., Davis, N. B., Bolen, L. M., & Chia, R. (1999). Gender and racial differences in mathematical performance. *Journal of Social Psychology, 139*, 677–689.
- Hassan, M. M., & Khalifa, A. (1999). Sex differences in science achievement across ten academic years among high school students in the United Arab Emirates. *Psychological Reports, 84*, 747–757.
- Heller, K. A., & Ziegler, A. (1996). Gender differences in mathematics and the sciences: Can attributional retraining improve the performance of gifted females? *Gifted Child Quarterly, 40*, 200–210.
- Higher Education Research Institute. (1996). *The American freshman: National norms for Fall, 1996*. Los Angeles: University of California, Graduate School of Education and Information Studies.
- Hyde, J. S. (1997). Gender differences in math performance: Not big, not biological. In M. R. Walsh (Ed.), *Women, men, and gender: Ongoing debates* (pp. 271–287). New Haven, CT: Yale University Press.
- Jacobs, J. E. (1991). Influence of gender stereotypes on parent and child mathematics attitudes. *Journal of Educational Psychology, 83*, 518–527.
- Jacobs, J. E., & Eccles, J. S. (1992). The impact of mothers' gender-role stereotypic beliefs on mothers' and children's ability perceptions. *Journal of Personality and Social Psychology, 63*, 932–944.
- Jacobs, J. E., & Eccles, J. S. (2000). Parents, task values, and real-life achievement-related choices. In C. Sansone & J. M. Harackiewicz (Eds.), *Intrinsic and extrinsic motivation: The search for optimal motivation and performance* (pp. 405–439). San Diego, CA: Academic Press.
- Jacobs, J. E., Finken, L. L., Griffin, N. L., & Wright, J. D. (1998). The career plans of science-talented rural adolescent girls. *American Educational Research Journal, 35*, 681–704.
- Jones, G. (1991). Gender differences in science competitions. *Science Education, 75*, 159–167.
- Juang, L. P., & Silbereisen, R. K. (2002). The relationship between adolescent academic capability beliefs, parenting, and school grades. *Journal of Adolescence, 25*, 3–18.
- Judd, C. M., & McClelland, G. H. (1989). *Data analysis: A model comparison approach*. San Diego, CA: Harcourt Brace Jovanovich.
- Kerlinger, F. N., & Pedhazur, E. J. (1973). *Multiple regression in behavioral research*. New York: Holt, Rinehart & Winston.
- Levin, T., Sabar, N., & Libman, Z. (1991). Achievements and attitudinal patterns of boys and girls in science. *Journal of Research in Science Teaching, 28*, 315–328.
- Lunneborg, P. W. (1982). Role model influences of nontraditional professional women. *Journal of Vocational Behavior, 20*, 276–281.
- Matyas, M. L., & Dix, L. S. (1992). *Science and engineering programs: On target for women?* Washington, DC: National Academy Press.
- Meece, J. L., & Jones, M. G. (1996). Gender differences in motivation and strategy use in science: Are girls rote learners? *Journal of Research in Science and Teaching, 33*, 407–431.
- Meece, J. L., Wigfield, A., & Eccles, J. S. (1990). Predictors of math anxiety and its influence on young adolescents' course enrollment intentions and performance in mathematics. *Journal of Educational Psychology, 82*, 60–70.
- Menard, S. (1995). *Applied logistic regression analysis*. Thousand Oaks, CA: Sage.
- National Center for Education Statistics. (2001a). *Digest of educational statistics: Postsecondary education*. Retrieved May 29, 2002, from <http://nces.ed.gov/>
- National Center for Education Statistics. (2001b). *Results of the National Education Longitudinal Study of 1988 eighth graders*. Retrieved May 29, 2002, from <http://nces.ed.gov/>
- National Science Foundation. (1997). *Women and science: Celebrating achievements, charting challenges*. Arlington, VA: Author.
- National Science Foundation. (2000). *Women, minorities, and persons with disabilities in science and engineering* (NSF Rep. No. 00-327). Arlington, VA: Author.
- Pajares, F. (1996). Self-efficacy beliefs and mathematical problem-solving of gifted students. *Contemporary Educational Psychology, 21*, 325–344.
- Sanderson, A. R., Dugoni, B. L., Hoffer, T. B., & Myers, S. L. (2000). *Doctorate recipients from United States universities: Summary report 1999*. Chicago: National Opinion Research Center.
- Sax, L. J. (1995). Gender and major-field differences in the development of mathematical self-concept during college. *Journal of Women and Minorities in Science and Engineering, 1*, 291–307.
- Seymour, E., & Hewitt, N. M. (1997). *Talking about leaving: Why undergraduates leave the sciences*. Boulder, CO: Westview Press.
- Tenenbaum, H. R., & Leaper, C. (2003). Parent-child conversations about science: The socialization of gender inequities? *Developmental Psychology, 39*, 34–47.
- Young, P. M. (1985). *The influence of parents on the educational and occupational decision making of their children: Reducing sex role stereotyping in vocational education*. Laramie: University of Wyoming, Laramie College of Education. (ERIC Document Reproduction Service No. ED 277 813)

Received June 23, 2002

Revision received June 15, 2003

Accepted August 12, 2003 ■