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Parent–Child Conversations About Science: The Socialization of Gender Inequities?

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This study investigated the family as a context for the gender typing of science achievement. Adolescents ($N = 52$) from 2 age levels (mean ages = 11 and 13 years) participated with their mothers and fathers on separate occasions; families were from predominantly middle-income European American backgrounds. Questionnaires measured the parents' and the child's attitudes. Each parent also engaged his or her child in 4 structured teaching activities (including science and nonscience tasks). There were no child gender or grade-level differences in children's science-related grades, self-efficacy, or interest. However, parents were more likely to believe that science was less interesting and more difficult for daughters than sons. In addition, parents' beliefs significantly predicted children's interest and self-efficacy in science. When parents' teaching language was examined, fathers tended to use more cognitively demanding speech with sons than with daughters during one of the science tasks.

There are large differences in the number of women and men employed in the science and engineering labor force (Eccles, 1994; Eccles, Freedman-Doan, Frome, Jacobs, & Yoon, 2000; National Council for Research on Women [NCRW], 2002; National Science Foundation [NSF], 2000). In fact, women constitute fewer than one quarter of the scientists in the United States. This imbalance is mirrored in Europe (Dewandre, 2002). Some researchers have looked to gender differences in innate ability as a possible explanation for the inequity in science careers (e.g., Benbow & Lubinski, 1997). However, test reports indicate that the magnitude of gender differences in scientific ability is not large (Burkham, Lee, & Smerdon, 1997). Although boys outperform girls in standardized physical science tests in both 8th and 10th grades, this difference is associated with a small effect size ($d = .32$). Furthermore, no gender differences are reported in standardized test scores in life science ($d = -.02$). In addition, the magnitude of the gender difference in test scores in mathematics, which is considered a critical "filter" for entrance into many science courses, is negligible ($d = .15$; Hyde, Fennema, & Lamon, 1990). Given the large discrepancy between the number of women and men in science careers but the small gender difference in test performance, innate ability alone cannot account for gender differences in the science labor force. At a minimum, it would seem that the cultural context magnifies any possible preexisting gender differences in ability to create the large gender difference in science participation. For this reason, in the present study we examined parents' socialization beliefs and practices to understand possible causes of the apparent gender inequity in science participation.

The present study is distinct from prior studies of parental gender typing of children's learning and achievement in at least three ways. First, we looked at gender-related effects on parents' beliefs about their children's science interest and ability. In contrast, prior work on parents' gender-stereotyped attributions has emphasized the domains of mathematics, English, and sports (Eccles et al., 2000; Frome & Eccles, 1998; Parsons, Adler, & Kaczala, 1982). Science is a more masculine-stereotyped domain than mathematics (Eccles, Barber, Jozefowicz, Malenchuk, & Vida, 1999). Second, our study investigated parents' teaching language during science and nonscience activities. Prior research looking at parental gender typing in academic domains has generally examined either parents' and children's self-reports (e.g., Eccles et al., 2000) or parents' teaching-related behavior in a single teaching context (e.g., Crowley, Callanan, Tenenbaum, & Allen, 2001). In contrast, the present study examined several factors including parents' gender-typed beliefs about their children's science learning, parents' teaching language, children's science self-concept and achievement, and children's behavior with their parents. Furthermore, our study examined the activity setting as a possible factor. Different types of science activities were considered, ranging from the relatively more gender-neutral domain of biology to the more masculine-stereotyped domains of physics and computer technology (Greenfield, 1995a, 1995b). A relatively feminine-stereotyped domain—discussion of interpersonal dilemmas—was also included as a comparison condition.

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The conceptual model for the study reflects an eclectic mix of approaches (see Leaper, 2000). Ecological (Bronfenbrenner & Morris, 1998; Ogbu, 1981), ecocultural (Gallimore, Goldenberg, & Weisner, 1993), and sociocultural (Rogoff, 1990, 1995) models similarly emphasize the importance of the larger cultural practices, or macrosystem, in the study of child rearing. To a large extent, parenting practices follow from cultural practices. A community's institutions, role models, and opportunities guide parents' notions of what is needed for their children to succeed in society (Ogbu, 1981).

Gender may be one of the most pervasive factors within a society that affects a child's development (Bem, 1993). Regardless of income, ethnicity, or neighborhood, cultural practices tend to be organized differently for girls and boys. Through the process of enculturation, individuals typically internalize the gender ideology of their larger culture. This process of internalizing the cultural lens for viewing gender becomes the basis for people's gender schemas (Bem, 1993). Given that fewer women than men are employed in the science labor force (NCRW, 2002; NSF, 2000), parents might form a schema that mathematics and science are more appropriate cultural tasks for boys than for girls. For instance, even when girls received better grades than boys in mathematics, parents of daughters reported that they believed that their children had lower mathematics ability than did parents of sons (Frome & Eccles, 1998). Moreover, mothers of daughters believed that their children had to exert more effort to do well in mathematics than did mothers of sons. Similar biases may exist regarding parents' differential expectations for their sons and daughters in science (Goodnow, 1990; Kahle, 1988).

There is some indication that parents' gender-stereotyped attributions regarding their children's interest and competence may change with the child's age. According to the gender-intensification hypothesis (Crouter, Manke, & McHale, 1995; Hill & Lynch, 1983), during adolescence gender typing intensifies as pressures increase for girls and boys to fit into dating roles. As children enter adolescence, parents may believe that their daughters and sons either should have or do have gender-stereotyped interests. Supporting this prediction, gender differences in parents' estimation of children's ability in mathematics increase with the age of the child (Frome & Eccles, 1998). Perhaps mirroring parents, children's adherence to traditional gender roles increases as they negotiate the transition from elementary school to junior high school. Seventh and eighth graders indicate less interest and report lower grades in cross-gender material than do third through fifth graders (Katz & Ksansnak, 1994). Once girls reach puberty, they become less confident in their math abilities (Eccles, 1984) and begin to value math less (Eccles et al., 1999) than before. Moreover, the transition from elementary school to junior high school has been associated with lowered self-esteem in girls (Simmons & Blyth, 1987). Given the hypothesized link between parents' and children's attributions, the present study focused on parents of sixth and eighth graders in order to elucidate processes associated with children's transition to puberty.

Beliefs and expectations can guide parents' behavior and thereby may have an impact on their children's development (see Bugental & Johnston, 2000; McGillicuddy-DeLisi & Sigel, 1995; Miller, 1988). With regard to parents' gender-related schemas, there is some indication of an increasing correspondence between parents' and children's gender-related schemas as children get older (Tenenbaum & Leaper, 2002). Of particular relevance to the present investigation is the extent to which parents' gender-related beliefs about children's academic abilities may contribute to differences in children's motivation and success. The research literature indicates that parents' attitudes impact their children's mathematics achievement. For example, Frome and Eccles (1998) reported that mothers of daughters underestimated their daughters' mathematics abilities, whereas mothers of sons overestimated their sons' mathematics abilities. The mothers' beliefs, in turn, predicted the children's own beliefs about their abilities more strongly than did the children's grades. Mothers' achievement-related beliefs were more strongly related to children's achievement than were fathers' beliefs (Frome & Eccles, 1998; Parsons et al., 1982).

If parents' beliefs matter, they must be conveyed in social interactions with their children. In these ways, parents' internalization of cultural values is passed along to the next generation. Sociocultural (Rogoff, 1990), ecocultural (Gallimore et al., 1993), and ecological (Bronfenbrenner & Morris, 1998) models emphasize the role of everyday interactions for the transmission of culture. Social cognitive theory (Bandura, 1997; Bussey & Bandura, 1999) further details the processes by which parents contribute to the socialization of their children. In particular, social cognitive theory emphasizes the importance of observation, behavioral enactment, and motivation. For example, if parents show interest in science activities to their children, children learn about these activities and infer the benefits of engaging in science.

In addition to observation, children learn through practice. If parents tend to engage their sons in science-related activities more than they do their daughters, boys will be more likely than girls to develop familiarity and skill in these activities. The third relevant learning process is motivation. If parents give more encouragement for participating in science-related activities to their sons than to their daughters, boys may be more likely to develop more confidence and interest in science. In this regard, social cognitive theory underscores the impact of parents and other socializing agents in facilitating children's self-efficacy regarding particular competence domains. For example, parents may influence a child's interest and self-confidence in science learning by taking the child to a science museum, and they may further support the child's interest by explaining the exhibits (e.g., Crowley et al., 2001).

One of the most effective means for transmitting cultural practices is through language (Leaper, Anderson, & Sanders, 1998). Language allows parents to convey concepts and stimulate the child's thinking. This premise is emphasized in both sociocultural theory (Rogoff, 1990, 1995; Vygotsky, 1978; Wertsch, 1991) and social cognitive theory (Bandura, 1997; Bussey & Bandura, 1999). In the present study, three types of teaching discourse were examined: causal explanations, conceptual questions, and scientific vocabulary. All three of these speech forms are considered cognitively challenging.

As the term implies, a *causal explanation* provides a cause–effect description for an event. For example, in response to a query about why a plant died, a causal explanation might be "The plant died because it wasn't watered." Causal explanations have been linked to increased conceptual understanding, especially in the domain of science (Chi, de Leeuw, Chiu, & LaVancher, 1994; Dunbar, 1995). In addition, some have suggested that explanations may help children develop personal theories of how the world works (Crowley & Callanan, 1998).

The second type of cognitively demanding speech that was investigated is the *conceptual question*. This discourse strategy engages children in active thinking. For instance, when demonstrating how a raisin bobs in a bowl of water, a parent might ask, "What do you think made the raisin go up and down?" Sigel (1982) hypothesized that conceptual questions are stimulating because they lead the responder to reconstruct knowledge and thereby become engaged in representational thought (Sigel, 1982; Sigel, Stinson, & Flaugher, 1991; also see Tenenbaum & Leaper, 1997, 1998). The frequency of parental conceptual questions addressed to preschoolers has been shown to correlate with children's later advanced scholastic skills in domains such as reasoning and mathematics skills (Sigel et al., 1991).

Finally, the use of *scientific vocabulary* is a third form of teaching language that was considered. Parents' use of scientific vocabulary while demonstrating science tasks may increase children's understanding of science. Elementary school students' science vocabulary helps them understand scientific concepts and texts (Meyerson, Ford, Jones, & Ward, 1991).

The frequency with which parents use scientific talk should correlate with the frequency with which children use this talk. From a sociocultural perspective (Vygotsky, 1978; Wertsch, 1991), children learn in social interaction by internalizing parental speech; this speech guides children's future behavior. Children's use of scientific talk may guide their own scientific thinking and learning (e.g., Bivens & Berk, 1990). Furthermore, if parents use more cognitively demanding language with sons than with daughters during science activities, boys and girls will receive different opportunities to practice scientific problem solving.

There are different reasons why parents may use more teaching talk with boys than with girls while engaged in science activities. Although gender has been found to influence parents' speech style, these effects may depend on the activity setting in which parents and children are engaged (e.g., Leaper et al., 1998). Parents may verbally stimulate boys more than girls because of the masculine-stereotyped nature of science. Alternatively, it may be the task itself that leads parents to use more cognitively demanding language. The gender bias may occur when parents select the activity rather than when they are engaged in it. If so, parents may direct similar amounts of cognitively demanding speech to daughters and to sons when asked to participate in the same activities (see Leaper et al., 1998). Still another possibility is that parents may use more teaching-related speech with sons than with daughters regardless of the activity setting. Thus, it is necessary to compare parents' behavior in a variety of settings.

We included a nonscience and relatively feminine-stereotyped task in the present study to address the need for a comparison teaching task. One domain where girls have been observed to score higher than boys is in the area of interpersonal negotiation (Selman, Beardslee, Schultz, Krupa, & Podorefsky, 1986). Girls may do better than boys with interpersonal negotiation because their peer interactions are more likely to be dyadic, whereas boys' interactions tend to occur more often in groups (Benenson, Apostoleris, & Parnass, 1998; Leaper, 1994). Girls' dyadic friendships allow them to practice skills in resolving interpersonal dilemmas with others. Thus, solving interpersonal dilemmas is generally associated with the traditional socialization of girls. For this reason, during discussions about interpersonal conflicts, parents might use more cognitively demanding speech with daughters than with sons.

Besides contrasting science and nonscience activity settings, we investigated whether the particular domain within science may further influence how parents construct the situation. Different areas of science are relatively more masculine stereotyped than other areas. For example, biology is considered to be more gender neutral than other types of science (e.g., physics and technology), as evidenced by the relatively high female participation in the biological labor force (NCRW, 2002; NSF, 2000), by science museum exhibit preferences (Greenfield, 1995a), and by science fair participation (Adamson, Foster, Roark, & Reed, 1998; Greenfield, 1995b). Within the area of technology, girls report lower self-efficacy with computers than do boys (Nelson & Cooper, 1997). Given the potential importance of the teaching domain, we observed parent–child pairs interacting in biology, physics, computer, and interpersonal teaching tasks.

With regard to characteristics of the persons involved, the parent's gender is another factor that may influence the likelihood that parents interact differently with daughters and sons. Reviews of the literature indicate that fathers are generally more concerned than mothers with the gender typing of their children (Lytton & Romney, 1991; Siegal, 1987). Fathers act differently toward daughters and sons more consistently than do mothers. Also, fathers are more likely than mothers to encourage gender-typed behavior and to discourage cross-gender-typed behavior in their children. Therefore, fathers may be especially likely to use cognitively demanding language differently with sons and daughters.

Thus far in our introduction we have separately reviewed the potential influences of parents' beliefs and their behaviors in the socialization of girls' and boys' science learning and achievement. As noted earlier, the combined influences of parents' cognitions and behavior have received relatively little consideration in prior studies. Presumably, the factors are related. If parents' beliefs have an impact on children, then presumably the influence is mediated somehow through parents' behavior. There is some general indication that parents' beliefs can guide their child-rearing behaviors and children's subsequent development (see Bugental & Johnston, 2000; McGillicuddy-DeLisi & Sigel, 1995; Miller, 1988). For instance, parental beliefs may predict the teaching strategies that they employ with their children (McGillicuddy-DeLisi, 1982). If parents believe that science is more appropriate for boys than girls, it might explain why boys are exposed to more science-related activities than are girls (Eccles, 1994; Sjøberg & Imsen, 1988).

In addition to the parents' beliefs, the child's behavior is another potential influence on parents' behavior. Conversations are by nature reciprocal enterprises in which one partner's response depends on what the other person previously said. Considering child influences is particularly relevant when studying possible parental influences in the gender-typing process. Differences in how sons and daughters act toward their parents may be mistaken for gender differences in parents' treatment of their children (see Leaper, 2002). For example, if sons are more competent in science than daughters, they may elicit more cognitively demanding speech from their parents. Therefore, we carried out a set of analyses to test for the possible influences of the child's behavior or the parents' attitudes on any detected differences in parents' science talk with sons and daughters.

In summary, the present study investigated factors possibly related to parents' socialization of gender differences in science participation. A combination of self-report and observational measures was collected. The following hypotheses were tested:

Hypothesis 1a: Parents will rate daughters lower than sons in science interest and ability.

Hypothesis 1b: Parents' gender-stereotyped attributions will be more pronounced toward adolescents than toward younger children.

Hypothesis 2a: Parents' attributions of their children's science interest and ability will predict children's interest and self-efficacy in science.

Hypothesis 2b: The correlations between parents' ratings and children's self concepts (Hypothesis 2a) will be stronger for mothers than fathers.

Hypothesis 3: Parents' uses of cognitively demanding speech will be positively correlated with children's uses of the same speech strategies.

Hypothesis 4a: Parents will use more cognitively demanding speech forms with sons than with daughters during the science tasks.

Hypothesis 4b: The child gender effect on parents' use of cognitively demanding speech (Hypothesis 4a) will be more likely during either the physics or the technology tasks.

Hypothesis 4c: Parents will use more cognitively challenging speech forms with daughters than with sons during the interpersonal dilemma task.

Hypothesis 4d: Child gender effects on parents' use of cognitively demanding speech (Hypotheses 4a–4d) will be more likely for fathers than mothers.

Finally, we carried out exploratory analyses to test whether parents' attitudes and children's behavior were related to any observed differences in parents' treatment of daughters and sons.

Method

Participants

The sample consisted of 26 sixth-grade and 26 eighth-grade children and their mothers and fathers from the San Francisco and central coast areas of California. Families were recruited from public schools, summer camps, and after-school activities.

Children

There were 13 sixth-grade girls, 13 sixth-grade boys, 13 eighth-grade girls, and 13 eighth-grade boys. The mean age of the sixth-grade children was 11 years 8 months (*SD* = 7.8 months; range = 10 years 6 months to 13 years 3 months). The mean age of the eighth-grade children was 13 years 1 month (*SD* = 6.18 months; range = 11 years 8 months to 14 years 0 months). There was no significant age difference between girls and boys in either age group. There were no significant gender differences in birth order.

Mothers

The mean age of mothers was 43.23 years (*SD* = 4.60), and their ages ranged from 32 to 53 years. Eighty-three percent of mothers identified themselves as European American, 11% identified themselves as Latina (all of Mexican descent), and 4% identified themselves as being of Asian descent. The majority of the mothers were in the paid labor force (87%) and worked a mean of 32.31 hours (*SD* = 11.22) per week for pay. Of mothers reporting an occupation, 52% were classified as business managers and lesser professionals, and 14% were classified as administrative personnel and minor professionals on the Hollingshead Occupational Index. Mothers' educational background ranged from having completed some college to having graduate or professional school degrees. On average, mothers had a university degree.

Fathers

The mean age of fathers was 45.81 years (*SD* = 4.57), and their ages ranged from 34 to 55 years. Seventy-seven percent of fathers identified themselves as European American, 13% identified themselves as Latino (6 of Mexican and 1 of Caribbean descent), 6% identified themselves as being of Asian descent, and 4% identified themselves as African American. Ninety percent of fathers were in the paid labor force and worked a mean of 45.27 hours (*SD* = 8.01) per week for pay. According to the Hollingshead Index, 25% of fathers' occupations were classified primarily as higher executives and major professionals, 29% as business managers and lesser professionals, and 19% as administrative personnel and minor professionals. Fathers' educational background ranged from having completed the 11th grade of high school to completing graduate or professional school. On average, fathers had a university degree.

Parents

The average income of the families was $60,000–74,999, and incomes ranged from $20,000 to over $100,000. Five pairs of parents were divorced. In these cases, parents shared custody of their children. Significantly more fathers (n = 16) than mothers (n = 5) were employed in science- or technology-related careers, $\chi^2(1, N = 99) = 7.60$, $p < .01$. In addition, neither girls' (n = 6) nor boys' (n = 10) fathers were more likely to have science-related occupations, $\chi^2(1, N = 99) = 1.25$, *ns*. Finally, a Fisher's exact test indicated that neither girls' (n = 4) nor boys' (n = 1) mothers were more likely to have science-related occupations. (Careers in science or technology included allied health fields as well as any career that the National Science Foundation classifies as part of the science and technology labor force.) Finally, there was no significant difference between the occupational prestige of parents of girls and that of parents of boys.

Procedure

Two researchers visited families in their homes. Upon arrival, families were told that the researchers were interested in how "parents contribute to children's learning in everyday situations." Families were told that they would be asked to do four tasks and to complete a questionnaire. Parents also completed a consent form.

Mothers and fathers were visited separately, with the order of the parent visits counterbalanced. Half of the families in each group completed the questionnaires before doing the tasks, and the other half did the tasks before completing the questionnaires.

Teaching Tasks

Parent–child pairs were asked to do four activities, which were counterbalanced according to Latin square design. The science activities included biology, physics, and technology tasks. In addition, an interpersonal dilemma activity was included. There were two tasks for each science domain as well as for the interpersonal negotiation activity. Children completed one of the two tasks with each parent. Instructions were given to the participants before each task. The families were told to talk as much as they wanted and to act natural. After explaining the task, the researcher turned on the video recorder and left the families alone in a room in the family's house, typically the kitchen. Families were asked to spend 10 min on each task. However, some families completed the tasks before the allotted 10 min were used. After 10 min or after the participants called the researchers, the researchers returned to explain the next task. The tasks are described in the following sections.

Biology Tasks

Touch test. This task required a compass. The parent–child dyad was told that different parts in the arms from the fingertips to the elbows range in sensitivity. The goal was for the families to find which part of each person's arm was most sensitive. The researcher instructed the participants to test the sensitivity of their arms by touching with either one point or two along their partner's arm. Sensitive parts of the arm are those where a person can detect two points in close proximity with his or her eyes closed.

Taste test. This task required cotton swabs and separate cups filled with sugar water, lemon water, and salt water. The parent–child dyad was told that different parts of humans' tongues are able to detect certain flavors better than others. The goal was for the families to find out where on their tongues they could taste the three flavors the best. The researcher instructed the participants to dip the cotton swab into the different cups and then to touch their tongues in a variety of places.

Physics Tasks

Needle task. This task required a sewing needle, a bowl, water, soap, a napkin, and chopsticks. The researcher asked the dyad to float a needle on water. First, parents and children were instructed to place the needle on a napkin on top of the water, carefully poke the napkin, and leave the needle floating. Once the needle was floating, participants were told to add a drop of soap. The participants were told that the goal was for them to float the needle on water.

Bobbing raisins. This task required raisins, a seltzer tablet, a clear cup, and water. The researcher told the family that they were going to make raisins bob. Families were told to fill the cup halfway with water and then add two seltzer tablets and six raisins. The participants were told that the goal was for them to make the raisins bob.

Computer Technology Tasks

The Lost Mind of Dr. Brain. This task required a laptop, a mouse, and the game software. The researcher taught the parent how to play the computer game The Lost Mind of Dr. Brain (1995) while the child was in another room. The goal of the game is to use a series of commands to program the doctor to walk to his brain. The parent was instructed to teach her or his child how to play the game.

Thinkin' Things Sky Island Mysteries. This task required a laptop, a mouse, and the software for the game. The goal of Thinkin' Things Sky Island Mysteries (1998) is to use a series of commands to program the airplanes to follow a flight path. The procedure for the parent–child instruction was identical to that for the Dr. Brain game.

Interpersonal Reasoning Tasks

These tasks required a set of cards with printed dilemmas and questions. Parents and children read two different interpersonal dilemmas, which were adapted from Selman et al. (1986). Each set of two dilemmas involved one dilemma between peers. The first one read as follows:

> Tim was asked to go to the boardwalk by Joe, and Tim said he would go. Tim's friends don't like Joe, and say that they don't want Tim to go with Joe.

The second dilemma in each set involved conflict between a protagonist and an authority figure. It read as follows:

> Jane was asked by the teacher if she would mind helping Beth study for a test. Jane doesn't really like this girl at all, and she doesn't want to help.

The names of the protagonist in the dilemma matched the gender of the child participant. Parents and children were instructed to answer a series of questions after reading the dilemmas (e.g., "What is the problem here?" "What might [the protagonist] do to solve the problem?").

Counterbalancing of Tasks

To simplify counterbalancing, the needle task, the taste test, and the Sky Island Mysteries game (Set 1) were always presented together, and the bobbing raisins task, the touch test, and the Dr. Brain game (Set 2) were always presented together. Equal numbers of girls and boys were assigned to each set of tasks. Otherwise, the specific tasks within each set were counterbalanced across families, but the order of the tasks within each set was the same for each parent.

Questionnaire and Test Measures

Parents' ratings of their children's scientific interest and ability. A Science Attribution Questionnaire was used that was based on a similar questionnaire used by Eccles (1980) to study parents' evaluations of children's mathematics abilities. Parents were asked to evaluate their children's interest in science using the following sentence stem: "My child finds science . . . ." The answers ranged from *very boring* to *very interesting* on a 7-point scale.

Two measures were used to infer the parents' view of the child's *science ability:* difficulty and effort. For the difficulty question, parents were asked to complete the following sentence stem: "My child finds science . . . ." The answers ranged from *very easy* to *very hard* on a 7-point scale. For the effort question, parents responded to the following sentence stem: "To do well in science, my child has to try . . . ." The answers ranged from *a little* to *a lot* on a 7-point scale. The difficulty rating was missing for 1 father in the study.

Children's science self-efficacy. Children answered nine questions from Bandura's (1990) self-efficacy scale (e.g., "How well can you learn science?"; "How well can you learn social studies?"). Children were asked about general mathematics, algebra, science, biology, reading and writing skills, computers, a foreign language, social studies, and English class. Each item was rated on a 7-point scale (1 = *not well at all*, 7 = *very well*).

Children's academic interests and aspirations. Children answered questions about their interest in the school subjects in which they rated their self-efficacy (e.g., "How much do you like science?"; "How much do you like social studies?"). Thus, children were asked about nine school subjects. Each item was rated on a 7-point scale (1 = *not well at all*, 7 = *very well*). In addition, children were asked three questions about how many years of optional math, science, and computer classes they would take in the future (e.g., "How many years of optional math classes might you take in high school?")

Teachers' reports of children's grades. Children's teachers were asked to report children's grades and to complete questions about children's mathematics and science achievement (e.g., "How good is ______ at science?") using a 7-point Likert scale (adapted from Parsons et al., 1982). Thirty-three teachers (63% of children) returned the forms.

Coding

Segmentation. Verbatim transcripts were created from the videotapes. Before coding, the coders decided which utterances fit the coding scheme. The acceptable items were segmented into message units. A message unit is an individual speech act with a single thought unit that was bound by its intonation. Harriet R. Tenenbaum trained an undergraduate assistant for 8 hr per week for 4 weeks, for a total of 32 hr. After 1 month of training, two coders separately segmented 24 transcripts (3 sixth-grade daughter–mother and daughter–father transcripts, 3 eighth-grade daughter–mother and daughter–father transcripts, 3 sixth-grade son–mother and son–father transcripts, and 3 eighth-grade son–mother and son–father transcripts). Reliability was assessed by determining in how many instances coders agreed that a unit began and ended in the same place (e.g., with a particular word). The number of times that coders agreed that a unit began and ended on the same word was divided by the number of times that coders did not agree. The coders reached an agreement of 88%.

Speech codes. Videotapes were coded for the number of causal explanations, conceptual questions, and science vocabulary used by parents and children. A causal explanation explains a cause behind an event (e.g., "The needle fell because the soap reduced the surface tension" or "If you add a move, he [Dr. Brain] will move there"). A conceptual question is an abstract question about something that is beyond the immediate situation and that typically involves comparison or classification (e.g., "Why did Mother Nature make you sensitive to bitter on the tip?" or "Why did the needle sink?"). Scientific vocabulary refers to advanced vocabulary pertinent to the domain (e.g., "surface tension" or "carbon dioxide").

Examples of cognitively demanding speech from a parent–child conversation are presented in the following excerpt from a father–son conversation during the floating needle version of the physics task (coding classifications for utterances are italicized in brackets, and descriptions of the context appear within double parentheses):

Father: OK, Pokeman, drop the soap gently. ((needle drops))

Son: Oops. Maybe that's supposed to happen.

Father: All right, so you know why that happened, why it sank after you put the soap in? [*conceptual question*]

Son: Cuz I put it on it?

Father: You didn't put it on it. What happened is the soap changed the surface tension [*scientific vocabulary*] of the water, which caused the needle to be able to slip down under the water. [*explanation*]

Reliability. Harriet R. Tenenbaum trained an undergraduate assistant (who was not the same person who did the thought unit coding) for 8 hr per week for 12 weeks on the speech coding schemes for a total of 96 hr. To test for intercoder reliability, each coder independently coded 24 transcripts (23% of the data set). Reliability was evaluated with kappa coefficients. According to Fleiss (1981), kappa coefficients above .75 reflect excellent agreement. An overall kappa of .83 was obtained, with the following kappa coefficients for individual codes: conceptual questions, $\kappa = .69$; causal explanations, $\kappa = .96$; and science-specific vocabulary, $\kappa = .94$. For the domain coding, an overall kappa of .96 was obtained, with the following individual codes: biology, $\kappa = .96$; physics, $\kappa = .97$; technology, $\kappa = .99$; and interpersonal, $\kappa = .99$. After reliability was attained, coding was completed within approximately 3 weeks.

Results

Data Reduction

To reduce the number of statistical tests conducted, we combined parents' conceptual questions, causal explanations, and scientific vocabulary. This procedure provided a total amount of cognitively demanding units spoken in each task.

Preliminary Analyses

Four sets of preliminary analyses were carried out. First, the potential confounding influences of order effects were tested. Second, the potential confounding effect of either the mother or the father talking more than the other parent was tested. Third, possible gender differences in children's science grades, interest, and self-efficacy were examined. Finally, we examined parents' educational background and occupational prestige to decide whether they should be used as a covariate in the analyses.

Order Effects

No differences were found in parents' talk or in the questionnaire measures based on either (a) which parent went first, (b) whether parents completed the tasks or the questionnaire measures first, or (c) which set of tasks the parents completed.

Verbosity

No differences were found in the number of words spoken by parents based on either child gender, $F(1, 50) < 1$, parent gender, $F(1, 50) < 1$, or the interaction of these two factors, $F(1, 50) = 1.82$, *ns*. In addition, there was not a significant Child Gender × Parent Gender × Task interaction effect, $F(3, 48) < 1$.

Gender Differences in Children's Science Grades, Science Self-Efficacy, and Science Interest

There were no significant differences between girls' science grades ($M = 3.54$, $SD = 0.74$) and boys' science grades ($M = 3.55$, $SD = 0.72$) from the teachers who returned the forms, $F(1, 30) < 1$. In addition, there was no significant difference between girls' science self-efficacy ($M = 5.62$, $SD = 1.06$) and boys' science self-efficacy ($M = 5.77$, $SD = 0.99$), $F(1, 50) < 1$. Finally, no significant difference was found between girls' science interest ($M = 5.15$, $SD = 1.41$) and boys' science interest ($M = 5.76$, $SD = 1.27$), $F(1, 49) = 2.61$, *ns*.

Parents' Background Characteristics

To ascertain whether background characteristics, such as parents' educational prestige and educational attainment, should be employed as covariates, we calculated correlations between these characteristics and key parent variables. Key parent variables included parents' answers to the questionnaire items and their speech. Table 1 indicates that the only significant correlation was between fathers' educational attainment and use of cognitively demanding speech during the technology task. Fathers' educational attainment was used as a covariate in analyses involving cognitively demanding speech, as noted later.

Hypothesis Testing

Significant main effects and significant interaction effects pertinent to the hypotheses are described below. Eta-squared estimates of effect size are presented. Eta-squared is the measure of

Table 1
Intercorrelations Among Parental Education, Occupational Prestige, Cognitively Demanding Speech, and Attributions

Variable	1	2	3	4	5	6	7	8	9
1. Occupational prestige	—	−.20	.14	−.03	−.05	−.24	−.17	−.15	−.30
2. Education	−.62**	—	.04	−.08	.14	.19	−.07	−.06	−.05
3. Difficulty	.10	−.08	—	−.49**	.33	.35*	.05	.07	.34*
4. Interest	−.02	−.03	−.53**	—	−.19	−.05	−.18	−.23	−.06
5. Effort	−.03	−.03	.25	−.05	—	.04	−.01	−.16	.05
6. Biology	−.12	.15	−.11	−.04	−.01	—	−.03	.14	.44**
7. Physics	−.20	.07	−.21	.23	−.07	.43**	—	.20	.11
8. Technology	−.21	.32*	.01	.08	−.08	.02	.30*	—	.32**
9. Interpersonal	−.23	.15	.11	−.12	.11	.23	.21	.28*	—

Note. Data for mothers are above the diagonal, and data for fathers are below the diagonal. Correlations conducted between speech variables and occupational prestige were calculated for 41 mothers. Nine mothers were not employed outside the home. Because of missing data, correlations conducted between speech variables and educational background were calculated for 49 mothers. Three mothers had missing data. The other correlations were conducted for the 52 mothers in the sample. Correlations conducted between speech variables and occupational prestige were calculated for 49 fathers. Two fathers did not report their occupation, and 1 father was not employed outside the home. The other correlations were conducted for the 52 fathers in the sample.
* $p < .05$. ** $p < .01$.

the proportion of variance accounted for by a predictor. When it is .01 or above, it is considered a small (yet meaningful) effect size, when it is .09 or above, it is considered a medium effect size, and when it is .25 or above, it is considered a large effect size (Cohen, 1988).

Parents' Gender-Stereotyped Beliefs in Relation to Children's Gender, Age, and Self-Concepts

The first hypothesis was that parents of daughters would evaluate their child as lower in science interest and ability than would parents of sons. The second part of this hypothesis was that child age level would moderate this effect. To test this hypothesis, we conducted a three-way mixed-design analysis of variance with parent gender (mother or father), child gender (girl or boy), and child grade (sixth grade or eighth grade) as predictors. Parent gender was entered as a within-group factor, and child gender and child grade were between-groups factors. Parents' answers to the interest, difficulty, and effort questions were separately tested as dependent variables.

In support of the first part of the hypothesis, significant main effects for child gender occurred with parents' evaluations of interest and difficulty. Parents of sons ($M = 6.13$, $SD = 0.79$) were more likely to believe that their child was interested in science than were parents of daughters ($M = 5.04$, $SD = 1.39$), $F(1, 48) = 26.03$, $p < .01$, $\eta^2 = .21$. In addition, parents of daughters ($M = 3.75$, $SD = 1.44$) were more likely to believe that science was difficult for their child than were parents of sons ($M = 2.81$, $SD = 1.58$), $F(1, 48) = 9.74$, $p < .01$, $\eta^2 = .09$. However, parents of daughters and parents of sons did not differ significantly in their evaluations of the amount of effort needed for their children to do well in science, $F(1, 48) = 1.85$, *ns*.

There were no significant Child Gender × Child Grade interaction effects with any of the three measures. Therefore, the second part of the hypothesis, that gender-stereotyped attributions would be more likely among parents of older children than parents of younger children, was not confirmed.

Relations Between Parents' Beliefs and Children's Self-Concepts

The second hypothesis was that children's interest and self-efficacy would be correlated with parents' attributions. As can be seen in the correlation matrix in Table 2, general support was

Table 2
Correlations Among Parents' Attributions and Children's Science Self-Concept

Variable	1	2	3	4	5	6	7	8
1. Mothers' difficulty rating	—	−.49**	.33*	.27	−.31*	.16	−.33*	−.44**
2. Mothers' interest rating		—	−.19	−.30*	−.36**	−.17	.56**	.55**
3. Mothers' effort rating			—	.23	−.32*	−.03	.01	−.14
4. Fathers' difficulty rating				—	−.53**	.25	−.36*	−.24
5. Fathers' interest rating					—	−.05	.18	.23
6. Fathers' effort rating						—	−.15	−.12
7. Child's self-efficacy							—	.67**
8. Child's interest								—

Note. $N = 52$.
* $p < .05$ (two-tailed). ** $p < .01$ (two-tailed).

Table 3
Correlations Among Fathers' and Children's Cognitively Demanding Speech During Science Tasks

Variable	1	2	3	4	5	6	7	8
1. Fathers' cognitively demanding speech: biology	—	.43**	.02	.23	.21	.12	.04	−.12
2. Fathers' cognitively demanding speech: physics		—	.30*	.21	−.01	.55**	.08	−.21
3. Fathers' cognitively demanding speech: technology			—	.28*	.03	.27	.32*	.21
4. Fathers' cognitively demanding speech: interpersonal				—	.13	.12	−.01	.27
5. Children's cognitively demanding speech: biology					—	.13	.18	.37**
6. Children's cognitively demanding speech: physics						—	.35*	.04
7. Children's cognitively demanding speech: technology							—	.13
8. Children's cognitively demanding speech: interpersonal								—

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

found for this hypothesis. First, the more difficult that mothers believed that science was for their children, the lower the children's self-efficacy and interest. In addition, the more interested mothers believed that their children were in science, the higher the children's self-efficacy and interest. Thus, mothers' beliefs tended to be related to children's self-efficacy and interest. In contrast, only one relationship was significant between fathers' beliefs and children's self-efficacy. The more difficult that fathers believed that science was for their children, the lower the children's self-efficacy.

Hypothesis 2 included the expectation that the association between parents' beliefs and children's self-concept would be stronger with mothers than with fathers. In partial support of this prediction, the correlation between parents' ratings of their children's science interest and their children's science self-efficacy was significantly stronger for mothers than for fathers (see Table 2), $Z(1) = 2.23$, $p < .01$.

Relations Between Parents' and Children's Talk During Science Tasks

The third hypothesis predicted that parents' and children's uses of cognitively demanding speech during the science tasks would be positively related. The correlations for father–child and mother–child pairs are presented in Tables 3 and 4, respectively. As can be seen in Table 3, there were significant relations between fathers' cognitively demanding speech and children's cognitively demanding speech during the physics and technology tasks. Similarly, there were significant relations between mother's cognitively demanding speech and children's cognitively demanding speech during the biology and physics tasks, as can be seen in Table 4.

Child Gender Effects on Parents' Use of Cognitively Demanding Speech

The fourth hypothesis was that parents would use more cognitively demanding speech with sons than with daughters during the science tasks. The second part of this hypothesis proposed that the child gender effect would be more likely in the physics or the computer technology tasks than in the biology task. Conversely, the third part of the hypothesis proposed that parents would use more cognitively demanding speech with daughters than with sons during the interpersonal task. Finally, the fourth part of this hypothesis proposed that child gender effects on parents' speech would occur more for fathers than for mothers.

To test this hypothesis, we conducted a three-way mixed-design analysis of covariance with task (biology, physics, technology, or interpersonal) and parent gender (mother or father) as within-group factors and child gender (girl or boy) as a between-groups factor. Fathers' educational attainment served as a covariate given that during the technology task it was found to correlate with cognitively demanding speech, which was the dependent measure. A significant three-way Task × Child Gender × Parent Gender interaction effect emerged, $F(3, 47) = 4.44$, $p < .05$, $\eta^2 = .08$. Follow-up Tukey tests indicated that during the physics task, fathers of sons used more cognitively demanding talk than did fathers of daughters. No other interactions were significant. Table 5 displays the mean amount of cognitively demanding talk in each task.[1]

Exploring Possible Mediators of Child Gender Effects on Fathers' Speech

Regression analyses were conducted to identify the possible mediating influences of fathers' beliefs or children's behavior on fathers' differential use of cognitively demanding speech with daughters and sons. To test for a mediational model, according to Baron and Kenny (1986) the following regressions must be con-

[1] Because of the debate in the literature regarding whether proportions or frequencies are most appropriate for characterizing input to children (Hoff-Ginsberg, 1992; Pine, 1992), the analyses were repeated using the number of words spoken by the parents as a covariate. The results did not change.

Table 4
Correlations Among Mothers' and Children's Cognitively Demanding Speech During Science Tasks

Variable	1	2	3	4	5	6	7	8
1. Mothers' cognitively demanding speech: biology	—	−.03	.14	.44**	.45**	.14	.14	.57**
2. Mothers' cognitively demanding speech: physics		—	.20	.11	−.04	.45**	−.01	.04
3. Mothers' cognitively demanding speech: technology			—	.32*	.11	.14	.17	.24
4. Mothers' cognitively demanding speech: interpersonal				—	.07	.11	.00	.22
5. Children's cognitively demanding speech: biology					—	−.09	.16	.27
6. Children's cognitively demanding speech: physics						—	.42**	.10
7. Children's cognitively demanding speech: technology							—	.08
8. Children's cognitively demanding speech: interpersonal								—

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

ducted: First, the effect of the predictor variable on the mediator must be tested. Second, the effect of the predictor variable on the outcome variable must be tested. Third, the effect of both the predictor variable and the mediator on the outcome variable must be estimated. For evidence of a mediational model, all three equations must be significant, and the effect of the predictor variable must also be smaller in the third equation than in the second equation.

Fathers' beliefs and children's behavior were tested as potential mediators of child gender effects on fathers' behavior. When testing for the impact of fathers' attitudes, we selected their rating of the child's interest in science. As previously described, it was the measure associated with the largest amount of gender stereotyping. When testing for the influence of children's behavior as an intervening influence, we used the amount of the child's cognitively demanding speech.

The criteria for a mediational model were not met in either set of analyses. First, when fathers' attitudes were tested as a possible mediator, the first two regressions were statistically significant but the third one was not. Child gender predicted fathers' attitudes, $F(1, 50) = 16.71$, $p < .01$, $R^2 = .25$. Also, child gender predicted fathers' cognitively demanding speech, $F(1, 50) = 4.08$, $p < .01$, $R^2 = .08$. However, when child gender and fathers' attitudes were both entered into the regression, the model was not statistically significant, $F(2, 49) = 2.32$, *ns*. We can note that the child gender effect was smaller in the third test (R^2 change $= .03$) than in the second test, which is consistent with a mediational model.

When the child's behavior was tested as a possible mediator, the second and the third tests were statistically significant but the first one was not. Child gender predicted fathers' cognitively demanding speech, $F(1, 50) = 4.08$, $p < .05$, $R^2 = .08$. And the combination of the two factors was significantly associated with fathers' speech, $F(2, 49) = 13.43$, $p < .01$, $R^2 = .35$. However, child gender did not predict children's use of cognitively demanding speech, $F(1, 50) < 1$, *ns*.

Discussion

The results supported or partly supported each of the four hypotheses. In general, parents held gender-stereotyped expectations regarding their children's science interest and ability. They also tended to use teaching language in gender-typed ways. In contrast, there were no differences between girls and boys in their grades, interest, or self-efficacy in science. Thus, whereas there were no apparent differences between girls and boys in their science-related cognitions or behaviors, there was strong indication of differential treatment. The analyses indicated associations between parents' and children's science-related attitudes as well as between parents' and children's talk during the teaching tasks. The results are discussed in more depth in the following sections.

Gender and Age Differences in Parent Measures

Parents were hypothesized to hold gender-stereotypic attributions about their children's science achievement. This hypothesis was partially confirmed. Parents of daughters believed that their child was interested in science less than did parents of sons. In addition, parents of girls believed that science was difficult for their child more than did parents of boys. However, parents of daughters did not believe that their child had to try hard to do well in science more than did parents of sons. The present finding is similar to parents' gender-stereotypic attributions about children's mathematics achievement (Parsons et al., 1982).

Why might parents hold gender-stereotyped attributions about their children's abilities in the absence of differences in achievement? Parents' expectations may be guided by the prevalent view in the larger macrosystem that science is a more appropriate cultural task for men than for women (Goodnow, 1990). Thus, cultural patterns and ideologies may be more influential than children's actual performance in influencing some parents' beliefs about their own children. As Bem (1993) suggested, gender stereotypes are pervasive and influence many of our beliefs.

Table 5
Mean Number of Parents' and Children's Cognitively Demanding Speech Acts Across the Tasks

	Task			
Participants	Biology	Physics	Technology	Interpersonal
Mothers				
With girls	2.00 (2.23)	5.88 (8.18)	6.12 (3.70)	6.46 (5.44)
With boys	2.12 (3.54)	3.23 (3.56)	6.85 (3.79)	5.96 (4.76)
Fathers				
With girls	1.04 (1.77)	4.31 (4.22)	6.15 (4.31)	6.08 (4.72)
With boys	2.19 (3.18)	8.04 (8.42)	6.92 (3.21)	4.73 (3.48)
Daughters				
With mothers	0.69 (0.97)	2.15 (2.82)	2.65 (2.77)	7.08 (3.75)
With fathers	0.85 (1.67)	2.27 (2.92)	2.04 (1.82)	7.08 (4.94)
Sons				
With mothers	0.58 (1.07)	1.46 (1.90)	2.92 (4.23)	6.23 (4.76)
With fathers	0.50 (1.03)	2.92 (3.49)	2.50 (3.17)	4.69 (3.95)

Note. Standard deviations appear in parentheses.

Parents' gender-stereotypic attributions were also expected to be more pronounced for the older than for the younger age group. However, the age of the child did not moderate parents' gender-stereotyped attributions. Differences between children in the sixth and eighth grades may not have been sufficiently large to detect age-related changes in parents' gendered attributions. In addition, there was a considerable range of ages in the two grades. Alternatively, the cultural stereotypes about gender and science may influence parents' perceptions across a wide range of child ages.

Relation Between Parents' and Children's Attitudes

As predicted, parents' attributions about how difficult and interesting their children found science were related to children's self-efficacy and interest. Given that mothers' attributions are often more closely related to their children's mathematics self-concept than to their children's performance, Eccles et al. (2000) suggested that parents may influence the academic performance expectancies that their children develop. In fact, self-efficacy and interest have been found to predict science- and math-related career selection for college-aged students (Hackett & Betz, 1995). Furthermore, self-confidence has also been found to predict consideration of masculine-stereotyped careers (e.g., engineering, mathematics) for children in junior high school (Post-Kammer & Smith, 1986). Therefore, despite negligible differences in competence, fewer women than men may continue to select science courses.

Whereas both mothers' and fathers' attributions were related to their children's self-appraisals in science, mothers' attributions were more closely related than were fathers' attributions to children's self-efficacy and interest. Our finding is similar to past research on attributions for children's mathematics achievement (Parsons et al., 1982). In fact, mothers' attributions about mathematics may be a stronger predictor of children's mathematics self-concept than are children's previous or current grades in mathematics (Frome & Eccles, 1998).

What might account for the stronger and more consistent pattern of correlations in attitudes in mother–child pairs than in father–child pairs? One interpretation is that mothers are more aware than are fathers of their children's self-efficacy and that mothers base their attributions on children's actual self-efficacy. Another possibility is that mothers are more influential in the construction of children's self-efficacy than are fathers. In the present study, fewer than half of the mothers in the sample worked full time, and almost all of the fathers worked full time. Therefore, the mothers likely spent more time with their children than did the fathers. Consequently, mothers may have a more influential role in socializing children's self-efficacy as well as teaching them informally. However, as children enter into adolescence, they may increase their contact with same-gender parents (Crouter et al., 1995). During this period, sons' contact with their fathers may take on added importance. If so, sons may receive further encouragement to develop their interest and competence in science-related areas. Although fathers may be the parental figures who are traditionally most likely to encourage science achievement, this does not necessarily have to be the case. As more women enter science-related careers, mothers may be active in encouraging their daughters (and sons) in this domain.

Relations Between Parents' and Children's Uses of Cognitively Demanding Speech

As predicted, parents' and children's uses of cognitively demanding speech were positively related. In half of the tasks, children's cognitively demanding speech was correlated with parents' cognitively demanding speech. Sociocultural theories emphasize the view that children's development occurs through interactions with more advanced members of their community, such as their parents. Moreover, children learn simultaneously on personal, interpersonal, and community planes (Rogoff, 1995; Vygotsky, 1978). By listening to their parents use cognitively demanding speech during science tasks, children may have appropriated this type of talk. Such speech can help children develop scientific concepts and think about science at a deeper level.

Parents' Cognitively Demanding Speech With Daughters Versus With Sons

Parents' use of cognitively demanding speech was hypothesized to differ for girls and boys depending on the teaching task. First, parents of sons were expected to use more cognitively demanding speech than were parents of daughters during the science tasks—especially the physics or the computer tasks. Consistent with these hypotheses, fathers of sons used more cognitively demanding talk than did fathers of daughters during the physics task. In contrast to the hypotheses, fathers of daughters and fathers of sons used similar levels of cognitively demanding talk during the interpersonal task. Perhaps fathers interpreted this task as gender neutral.

It is noteworthy that, as predicted, fathers but not mothers were observed to act differently toward daughters and sons. Prior studies indicate that gender-differentiated treatment is more likely among fathers than mothers (see Siegal, 1987). Men tend to be more concerned than women with the adoption of gender-typed behavior (see Leaper, 2000).

Ecocultural theory suggests that families create routines, or activity settings, that make them part of their larger community (Gallimore et al., 1993). Participants co-construct activity settings on the basis of the personnel, task demands, and goals involved. Although the immediate physical environment determines an activity setting, people within a setting construct their interpretation of the activity (Farver, 1999). In the present study, fathers tended to act differently within particular tasks depending on the child's gender. In the physics task, fathers offered less teaching talk when they were interacting with daughters than when they were interacting with sons. The findings suggest possible biases in what fathers consider appropriate learning activities for sons and daughters. Fathers may view physics as something to encourage in their sons but not their daughters.

Despite the absence of any observed difference between girls' and boys' science grades among the observed children, fathers who encourage sons more than daughters may contribute to later gender differences in achievement. If the fathers continue to use more cognitively demanding speech with sons than with daughters, these boys might begin to outscore these girls on science tests. Boys might also begin to develop more advanced scientific theories than girls. Thus, fathers may unwittingly be contributing to a gender inequity in science achievement. As noted earlier, Eccles et al. (2000) identified similar family patterns as leading to gender differences in children's math achievement. The present study extends Eccles et al.'s research into the domain of science achievement and also considers some of the ways that parents may communicate their gender-typed expectations to their children.

Although expected gender-typed socialization practices were observed during the physics task, there were no corresponding gender effects on how either parent acted during the technology task. Technology is considered a masculine-stereotyped domain (Greenfield, 1995a), but both parents tended to provide equal amounts of cognitively demanding speech to daughters and sons in the computer task. Perhaps the way that we introduced the task mitigated variations in parents' behavior. Unlike the biology and physics tasks, the technology task was taught to the parent before the parent and the child played the computer game together. Thus, the parent was clearly the expert. Moreover, parents may have relied on the script used to teach them the task. An informal inspection of the transcripts suggests that there was little variability in parents' behavior during the technology tasks. Our interpretation suggests that when designing interventions to reduce differences in how fathers treat girls and boys, structured tasks may be one solution. Past research has indicated that structured tasks are often associated with less gender differentiation (Leaper et al., 1998).

Exploring Possible Mediators of Child Gender Effects on Parents' Speech

As discussed earlier, there were some forms of teaching language that fathers used more with sons than with daughters in certain science tasks. We carried out some exploratory analyses to see if either the father's beliefs about his child's science interest or the child's behavior acted as intervening processes linking the child's gender and the father's behavior. Neither set of analyses indicated a mediational model. First, although fathers tended to have gender-biased views of their daughters' and sons' interests in science, this did not appear to account for their gender-biased language behavior during the physics task. As noted in the Results section, the pattern of results was in the expected direction but did not fully meet the criteria for a mediational model.

In addition, whereas fathers' and children's amounts of cognitively demanding speech during the physics task were correlated, this correlation did not appear to explain fathers' greater use of this behavior with sons than with daughters. The lack of evidence for mediation must be viewed tentatively because of the limited sampling of the children's behavior. It is possible that girls and boys differed in other types of behavior that were not examined and that these differences affected fathers. For example, we did not analyze how well the children responded to the parents' teaching efforts and how parents in turn responded to the children's answers. In this regard, sequential methods of analysis can prove useful (e.g., Tenenbaum & Leaper, 1998).

Limitations

A few other limitations of the present study are worth noting. First, our sample size was relatively small. In particular, when our sample is broken down by child gender and age level, there may not be sufficient statistical power to detect age-related differences. Second, our study of age-related effects was based on the use of cross-sectional data. Without longitudinal data we do not know if parents' beliefs preceded or followed children's behavior. Specifically, it is difficult to ascertain if parents' attributions influenced children, if children's interests influenced parents' attributions, or if a combination of these influences was at work.

A third limitation follows from our use of a semistructured observational setting. As with any observational study carried out with the participants' awareness, it is unclear to what extent parents' and children's behaviors while being videotaped were representative of their normal lives. We may assume that most of the parents probably did not often teach science tasks to their children. More naturalistic studies may find larger differences in how parents treat girls and boys. For example, in informal science tasks in a museum, differences in fathers' treatment of girls and boys are much larger (Crowley et al., 2001). Thus, future research is recommended that considers both naturalistic and seminaturalistic science contexts when examining parents' cognitively demanding speech.

Finally, other types of parents' behavior may be linked more directly to children's science self-efficacy and interest. For example, planning a school schedule, designing a science fair project, or completing science homework are other types of activities in which parents may communicate their attitudes as well as create contexts for children's science learning. Examining different parent–child contexts would enable researchers to understand how parents help children make important decisions related to science selection and achievement.

Conclusions

Parents form their own beliefs about child development through their interaction with the culture, and in this way, the macrosystem shapes parents' beliefs (McGillicuddy-DeLisi & Sigel, 1995). Parents, in turn, contribute to the transmission of cultural values and emphases to their children through their social interactions in particular microsystems. The present study considered the possible relation between one pattern in the macrosystem—that is, the inequities in science achievement among women and men in the United States—and particular microsystems—specifically, parent–child interactions during teaching tasks.

In partial support of the role of macrosystem influences on parents, both fathers and mothers were found to hold gender-biased views of their children's interest and efficacy in science despite the lack of any evidence for actual gender differences in science achievement in the sample. Furthermore, there was support for the possible transmission of cultural patterns through particular microsystems. Fathers were found to differentiate between girls and boys during the physical science tasks.

When parents take the time to explain to their children, ask them conceptual questions, or use advanced vocabulary, they are treating their children in a manner that suggests that they believe that their children are capable of mastering a particular domain. Moreover, parents are providing their children with skills to become more competent in such domains (Crowley & Callanan, 1998). Parents who foster children's sense of mastery in particular domains produce self-efficacious individuals (Bandura, 1997; Harter, 1992). We have seen how some fathers may tend to promote this sense of mastery more in sons than in daughters.

Developing a sense of efficacy in science can influence the child's subsequent academic and career choices. Harter (1992) reported that children who perceive themselves competently in a specific domain are likely to want to engage in the domain and, as a consequence, to display more motivation. By participating in specific tasks, children learn about the domain and become more knowledgeable (Leaper, 2000). Our findings suggest that some fathers may be encouraging intellectual engagement in science-related activities in sons more than in daughters. When additionally confronted with other disincentives, such as similar gender biases among science teachers (Bianchini, Cavazos, & Helms, 2000), girls are likely to find it especially difficult to develop a sense of efficacy and interest in science. With increasing gender equity in the larger macrosystem, we may expect to see corresponding changes within particular microsystems such as the family and the schools. At the same time, as more parents and teachers themselves become sensitive to various gender biases, they will contribute to changes in the macrosystem.

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