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Parents explain more often to boys than to girls during shared scientific
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Abstract

Young children's everyday scientific thinking often occurs in the context of parent-child interactions. In a study of naturally occurring family conversation, parents were three times more likely to explain science to boys than to girls while using interactive science exhibits in a museum. This difference in explanation occurred despite the fact that parents were equally likely to talk to their male and female children about how to use the exhibits and about the evidence generated by the exhibits. The findings suggest that parents engaged in informal science activities with their children may be unintentionally contributing to a gender gap in children's scientific literacy well before children encounter formal science instruction in grade school.

Prior to their first science instruction in school, many children are exposed to science through informal educational contexts such as museums, television shows, Web pages, and books (Gelman, Massey, & McManus, 1991; Korpan, Bisanz, Bisanz, Boehme, & Lynch, 1997). Children often participate in these activities in the company of their parents, yet little is known about how families learn in informal science settings. In particular, little is known about whether boys and girls experience informal science in the same ways.

Girls in the United States continue to lag behind boys on many measures of science achievement (O'Sullivan, Reese, & Mazzeo, 1997). One reason often cited to account for gender gaps in science achievement is differential teacher-student discourse in classrooms. Teachers have been described as more likely to encourage boys than girls to ask questions, make integrative comments, and explain (American Association of University Women, 1995; Jones & Wheatley, 1990; Kelly, 1988). Although interventions in response to such findings have often been targeted at teacher bias, the effect may be driven at least in part by differences in volunteer rates between boys and girls (Altermatt, Jovanovic, & Perry, 1998). Regardless of why the difference occurs, the logic of the claim with respect to science education is that the reflective thinking involved in answering questions and constructing explanations leads boys to develop deeper conceptual knowledge about science and greater interest in science.

Could a similar gender difference characterize parent-child conversations during informal science learning? No prior study has examined this question directly, although findings from two literatures are relevant. One set of findings comes from developmental psychology. In studies of the development of children's gender roles, families are often observed during play. The most consistent finding in this literature is that if parents use different interaction styles with boys and girls, the difference is usually linked to the parents' perception of whether the play activity is gender-appropriate for boys or for girls (Leaper & Gleason, 1996; Lytton & Romney, 1991; McGillicuddy-de Lisi, 1988); this is particularly true in the case of fathers (Siegal, 1987). To the extent that parents see science as a stereotypically male activity, these findings suggest that parents may show differences in how they interact with boys and girls while engaged in informal science activities.

A second set of relevant findings comes from the literature on museum learning. Historically, studies of learning in museums have focused on nonverbal behaviors such as the length of time visitors stay engaged with an exhibit (Dierking & Falk, 1994). The few studies of museum activity that have focused on parent-child conversation provide suggestive but inconclusive evidence that parents may be more likely to talk to boys than girls while using exhibits (e.g., Cone & Kendall, 1978; Diamond, 1994).

The current study focused on whether parents explain more often to boys than to girls while using interactive science exhibits in a museum. Explanations include talk about causal relations, analogies, and scientific principles. Our focus on explanations was motivated by prior studies showing that when children, undergraduates, or professional scientists focus on building explanations during scientific thinking, they develop more coherent theories, are better at interpreting evidence, and are better at transferring knowledge to solve new problems (e.g., Chi, de Leeuw, Chiu, & LaVancher, 1994; Dunbar, 1995; Okada & Simon, 1997). Furthermore, by the time children enter school, they have already constructed naive scientific theories to account for biological, psychological, physical, and geological events and entities (Wellman & Gelman, 1998). Children's developing explana-

tions for the causal and relational structure of their everyday environments are thought to be core mechanisms in creating and organizing these theories (Callanan & Oakes, 1992; Carey, 1985). Thus, to the extent that parents help children build explanations about science during informal science activities, they may facilitate children's scientific problem-solving skills, as well as aid them in constructing and revising naive theories about science.

Method

Participants

After the data-reduction procedure described in the next section, the final sample included 298 interactions, each from a different family: 65 involving fathers with 1 or more boys, 34 involving fathers with 1 or more girls, 78 involving mothers with boys, 54 involving mothers with girls, 42 involving mothers and fathers with boys, and 25 involving mothers and fathers with girls. Of the 185 families including boys, the youngest boy was 1 to 3 years old in 88 families, 4 to 5 years old in 66 families, and 6 to 8 years old in 31 families. Of the 113 families with girls, the youngest girl was 1 to 3 years old in 43 families, 4 to 5 years old in 41 families, and 6 to 8 years old in 29 families.

Data Collection and Reduction

Video cameras and wireless microphones were set up at 18 interactive science exhibits in a California children's museum. Exhibits demonstrated content from biology, physics, psychology, geography, or engineering and could be successfully manipulated by a single child (i.e., no exhibit necessarily required parent or staff participation). Data were collected on 26 days spaced over a 30-month period, including weekends and weekdays, in the summer and during the school year.

Researchers greeted families entering the museum, explained that they were videotaping as part of a research project, and asked parents for written consent to participate (more than 90% agreed). Children in consenting families wore stickers coded to identify their ages. This was the only contact the research team had with the families. If, in the natural course of their visit, children wearing stickers chose to engage an exhibit under study, the engagement was videotaped.

Videotapes were segmented into nonoverlapping interactions beginning when the first child from a family—the *target child*—engaged an exhibit and ending when he or she disengaged. The next target child was the first child from a new family who engaged the exhibit after all members of the previous target child's family had disengaged. Thus, each interaction was a unique slice of time capturing the complete engagement of a particular target child at an exhibit. Because our focus was on parent-child interaction, children appearing on the videotape were not designated as targets if they visited exhibits without their parents. There was no difference between the percentage of boys (27.3%) versus girls (26.9%) who visited exhibits without parents.

This procedure initially yielded 351 independent family interactions. Because we were interested in preschool and young elementary school children, we excluded 13 families with

no children younger than 9 years old. Because we were interested in parent-child interactions, we excluded one interaction in which a museum staff member talked to the family while they were engaged with an exhibit. Finally, because interactions including only boys or girls provide the most direct test of potential gender differences, we excluded 39 families in which boys and girls engaged an exhibit together. Thus, the final sample included 298 families.

Coding of Conversation and Action

Conversations were coded for whether parents explained an exhibit, gave directions, or talked about evidence:

- A conversation was coded for *explanation* if a parent talked about causal connections within the exhibit interface (e.g., “When you turn that fast, it makes more electricity” at an exhibit including a hand-cranked generator), about relations between observed phenomena and more general principles (e.g., “You see all those colors because the bubble reflects different kinds of light” at an exhibit where visitors can pull a sheet of bubbles up in front of a black background), or about analogies to related phenomena (e.g., “This is just like that one time when our plants died because we forgot to water them” during a time-lapse video of withering bean sprouts).
- A conversation was coded for *giving directions* if parents gave directions on exhibit use that did not establish any causal, analogical, or principled connections (e.g., “Put your hands on those sensors” at an exhibit that measures a visitor’s heartbeat).
- A conversation was coded for *talking about evidence* if parents spoke about evidence that could be observed at the exhibit, that is, if they made reference to visual, auditory, or tactile information that did not establish any causal, analogical, or principled connections (e.g., “There’s the crankshaft!” at an exhibit where a telepresence robot roves underneath a stationary fire truck).

Actions were coded for who initiated engagement with the exhibit and whether the target child directly manipulated the exhibit:

- Whether the child, parent, or both initiated engagement was defined by who appeared first at the exhibit on the videotape. Researchers turned on the videotape as the target child approached an exhibit, so initiation was often recorded. When the tape recording began with both parents and children already at an exhibit, we did not code initiation.
- The target child was determined to have directly manipulated an exhibit if he or she successfully completed at least one of the core exhibit manipulations. Core manipulations were actions that effected change in ways consistent with the educational goals of the exhibit. Simply touching an exhibit was not sufficient.

Coding was conducted by multiple raters. Reliability was assessed by having 20% of the interactions coded by more than one rater. Agreements exceeded 86%.

Results

Analysis of nonverbal measures of children's activity suggested that, regardless of gender, children took an active role in choosing and using the interactive science exhibits. First, boys and girls were not significantly different in whether they initiated engagement: Engagement was child initiated in 78% of interactions including boys, compared with 74% of interactions including girls. Second, the vast majority of both boys (96%) and girls (99%) were actively involved in manipulating the exhibits. Third, the mean length of time children remained engaged with an exhibit also showed no significant difference between boys ($M = 107$ s, $SD = 117$ s) and girls ($M = 88$ s, $SD = 93$ s), $t(288) = 1.43$, *n.s.* When 13 outliers greater than 2 standard deviations above the mean were excluded, mean engagement times for boys ($M = 86$ s, $SD = 68$ s) and girls ($M = 83$ s, $SD = 69$ s) were virtually identical.

In contrast, boys were three times more likely than girls to hear explanations from their parents. Parents used at least one explanation in 29% of interactions with boys compared with 9% of interactions with girls, $\chi^2(1, N = 298) = 16.50$, $p < .0001$. This difference was almost completely accounted for by boys hearing many more explanations of causal connections (22% of interactions) than girls (4%). All children were unlikely to hear explanations including general principles (3% for boys, 5% for girls) or analogies (6% for boys, 3% for girls). (Subtotals exceed totals because some parents used more than one kind of explanation.)

Figure 1 shows the percentage of interactions that included explanations, first by the parents' gender and then by the age of the child. As shown in Figure 1a, differences in the frequency of explanations to boys versus girls were most extreme in father-child interactions, $\chi^2(1, N = 99) = 10.34$, $p < .01$, but were also present in mother-child interactions, $\chi^2(1, N = 132) = 5.58$, $p < .05$. When both parents were present, the difference was in the same direction but did not reach significance.¹

As shown in Figure 1b, differences in the frequency of explanation were relatively stable across all ages of children in the study. Of the 298 interactions, 51 included a target child and one or more siblings who were in different age groups. In these cases, the age of the youngest child was used to assign an age to each interaction. Parents explained more often to boys than girls, regardless of whether children were 1 to 3 years old, $\chi^2(1, N = 131) = 7.27$, $p < .01$; 4 to 5 years old, $\chi^2(1, N = 107) = 4.63$, $p < .05$; or 6 to 8 years old, $\chi^2(1, N = 60) = 4.90$, $p < .05$. Assigning age based on the oldest child rather than the youngest child produced similar findings, all χ^2 s > 4.10 , all $ps < .05$.

The gender difference observed in parents' explanation did not characterize other kinds of talk by parents. Parents were equally likely to talk about how to manipulate exhibits when interacting with boys (66%) and girls (60%), $\chi^2(1, N = 298) = 1.01$, *n.s.*, and were equally likely to talk about the visual, auditory, or tactile information available from exhibits when interacting with boys (66%) and girls (57%), $\chi^2(1, N = 298) = 2.59$, *n.s.* No differences emerged when data were broken down by gender of parents, age of youngest child, or age of oldest child, all χ^2 s < 3.5 , all $ps > .05$.

¹Explanations were coded in 25% of interactions with both parents: Mothers explained in 13% of those interactions, fathers in 5%, and both mothers and fathers in 7%.

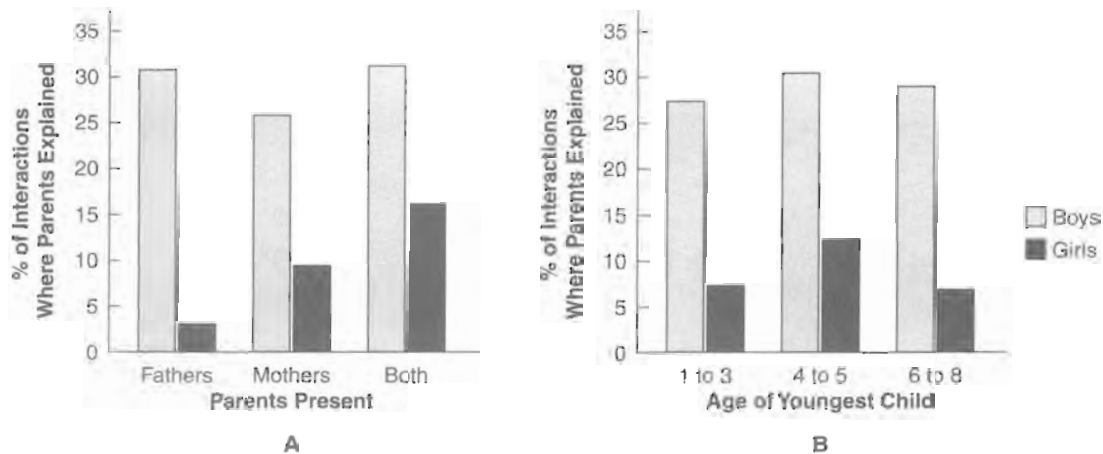


FIGURE 1 Percentage of parent-child interactions in which parents explained interactive science exhibits in a museum. Explanations were coded when parents talked about causal relations within exhibits, scientific principles illustrated by exhibits, or analogical connections between exhibits and real-world devices or events. Percentage of interactions with explanations is shown as a function of whether children were with fathers, mothers, or both (a) and as a function of the age of the youngest child involved in the interaction (b). Results are shown separately for boys and girls.

Why did parents explain more often to boys than girls? It is possible that, much like teachers in the classroom (Altermatt et al., 1998), parents in the museum explained more often to boys because boys asked more questions. If this were true, we would expect parents' explanations to have often been preceded by children's questions. However, we found that children who heard explanations rarely asked questions of any kind. In the 10 s prior to the first explanation offered by a parent, only 8% of boys and 6% of girls asked any kind of question. In the 60 s prior to the first explanation, only 13% of boys and 13% of girls asked any kind of question.

Discussion

This study demonstrated that parents were more likely to explain to boys than to girls during informal science activity. Parents brought their daughters to a museum, engaged interactive science exhibits with them, talked about what to do with exhibits, and talked about what to perceive from exhibits; however, the crucial step of providing an explanatory context for the experience was primarily reserved for boys. The findings are especially noteworthy because we observed differences in the rate of parents' explanation to children as young as 1 to 3 years old, suggesting that parents may be involved in creating gender bias in science learning years before children's first classroom science instruction.

Compared with explanation as defined in philosophy or pedagogy (Leinhardt & Schwarz, 1997), explanation as we defined it was simple, incomplete, and mundane—no

more than a few words uttered by a parent at an appropriate moment during the ongoing activity. Such “explanatoids” are offered when relevant evidence is the focus of joint parent-child attention and thus may serve the function of providing children an on-line structure for parsing, storing, and making inferences about evidence as it is encountered (Crowley & Galco, 2001). Although we located this study in a museum, the essential properties of the activity characterize many of the everyday activities in which early scientific and technical thinking are first constructed—building with blocks, mixing watercolors, or figuring out how a new computer game works, for example. The hypothesis that explanation from parents shapes what children learn from such activities is consistent with earlier laboratory work showing that simple adult explanations lead to deeper children’s learning and that, without adult assistance, children are unlikely to construct explanations on their own (Crowley & Siegler, 1999; Göncü & Rogoff, 1998; Krascum & Andrews, 1998; Siegler, 1995).

Parents who involve children in informal science activities not only provide an opportunity for children to learn factual scientific information, but also provide opportunities for children to engage in scientific reasoning, to develop an interest in learning more about science, and to develop a sense that practicing the habits of scientific literacy is an important priority. Until the design of informal science contexts recognizes and addresses gender differences in parents’ explanation, the full potential of informal science learning to interest and involve girls in science will remain unrealized.

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