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Gender Biases in Early Number Exposure to Preschool-Aged Children

Alicia Chang¹, Catherine M. Sandhofer²,
and Christia S. Brown³

Abstract

Despite dramatically narrowing gender gaps, women remain underrepresented in mathematics and math-related fields. Parents can shape expectations and interests, which may predict later differences in achievement and occupational choices. This study examines children's early mathematical environments by observing the amount that mothers talk to their sons and daughters (mean age 22 months) about cardinal number, a basic precursor to mathematics. In analyses of naturalistic mother–child interactions from the Child Language Data Exchange System (CHILDES) database, boys received significantly more number-specific language input than girls. Greater amounts of early number-related talk may promote familiarity and liking for mathematical concepts, which may influence later preferences and career choices. Additionally, the stereotype of male dominance in math may be so pervasive that culturally prescribed gender roles may be unintentionally reinforced to very young children.

Keywords

early childhood, gender, language input, mathematics, number, parent–child interaction

Early vocabulary and concept acquisition have been consistently associated with the specific words parents most frequently use in speech while interacting with their young children (e.g., Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991). This effect of input frequency has also been documented in specific categories, such as number.

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For instance, parental numeric speech to children at age 2 years 6 months has been shown to relate directly to the amount of number words children produce at both age 2 years 6 months and age 3 years 2 months (Suriyakham, Levine, & Huttenlocher, 2006). A recent study indicates that there are large cross-language differences in the amount parents talk to children about number in the United States and China (Chang, Sandhofer, Adelchanow, & Rottman, 2010). In this article, we further examine American parents' language input when talking to children about number concepts, and ask whether culturally prescribed gender roles might affect the frequency with which parents talk to boys versus girls about number as early as 2 years of age.

Mathematics and math-related fields are indisputably male dominated in the United States. For example, in American universities, math and engineering department faculties are overwhelmingly male, with women comprising only 17% of tenure-track faculty in mathematics and just 11% in engineering (National Science Foundation, 2008). Despite the gender differences in the pursuit of math-related careers, there are no differences in standardized math performance from elementary school through college (Hall, Davis, Bolen, & Chia, 1999; Hyde, Lindberg, Linn, Ellis, & Williams, 2008; Matthews, Ponitz, & Morrison, 2009; cf. Benbow & Stanley, 1983). There are gender differences, however, in perceived competence, expectations, and interest in math, which have been shown to predict later achievement and occupational choices (Bandura, Barbaranelli, Vittorio Caprara, & Pastorelli, 2001; Dweck, 2007; Eccles, 2007; Häussler & Hoffmann, 2002).

Although the majority of studies find no widespread differences in standardized math performance, there are a few reports of early emerging gender differences in math competence. For example, in kindergarten, boys have a greater ability to learn math concepts and have higher math competence than girls (Byrnes & Wasik, 2009). Boys also appear to be more fluent in math and better at retrieving math concepts from memory than girls by second grade (Carr, Steiner, Kyser, & Biddlecomb, 2008).

However, even when differences in mathematical competence are controlled for, boys have higher *perceived* competence in math than girls (Eccles, Barber, Jozefowicz, Malenchuk, & Vida, 1999; Eccles & Wigfield, 2002; Evans, Schweingruber, & Stevenson, 2002). By the spring of kindergarten, for example, boys have a greater willingness to learn math concepts (Byrnes & Wasik, 2009), and by at least third grade, boys rate their own competence higher than girls do, even in the absence of differences in math achievement (Herbert & Stipek, 2005). Based on the expectancy-value model of achievement (Bandura et al., 2001), which suggests that individuals are most motivated to pursue domains in which they expect to succeed, it is not surprising that girls (who do not expect to succeed in math because of their low perceived competence) show declining interest in math across their school careers (Fredricks & Eccles, 2002; Guimond & Roussel, 2001; Wigfield, Eccles, Mac Iver, Reuman, & Midgley, 1991).

Early attempts to explain these gender disparities as innate gender differences in mathematical predisposition have generally failed to find support (for a review, see Spelke, 2005). For example, gender gaps in math performance have been shown on

cross-national achievement tests; yet in countries that have more gender equality (e.g., Norway and Sweden), these gaps disappear (Guiso, Monte, Sapienza, & Zingales, 2008), and the largest gender differences in math performance occur in countries (e.g., Turkey and Korea), where this stereotype is most strongly endorsed (Nosek et al., 2009). These findings suggest that gender disparities in mathematical predisposition arise from extrinsic factors, and, in particular that culture-specific social influences affect differences in math competence, expectations, and interests.

There is strong evidence that social influences are involved in math-related gender differences. There is a widely held stereotype that boys have stronger innate math abilities than girls, a stereotype more strongly endorsed by boys than girls (Hyde, Fennema, & Lamon, 1990). By high school, most adolescents expect boys to be better than girls at math (Tenenbaum & Leaper, 2003). Gender stereotypes about math have important implications because they are shown to affect children's performance in math. The effect of gender stereotypes on math performance is apparent from a young age, with girls as young as 7 years old underperforming on math tasks when their gender identity, and thus gender stereotype, is made salient (Huguet & Regner, 2009; Neuville & Croizet, 2007). This suggests that children are knowledgeable about, and influenced by, gendered math stereotypes from a young age.

Furthermore, there is evidence that parents and teachers socialize children differently regarding mathematics. Boys receive more attention and encouragement in math from parents and teachers (Eccles, Freedman-Doan, Frome, Jacobs, & Yoon, 2000; Watt, 2004). In addition, Bleeker and Jacobs (2004) found that mothers of sons assumed that their children would be more successful in math-related careers than did mothers of daughters. Compared with children's actual performance based on their math grades, Frome and Eccles (1998) found that mothers overestimated boys' abilities and underestimated girls'. Mothers also tend to encourage math activities for boys more than girls, and this in turn predicts boys' greater participation in math activities (Simpkins, Davis-Kean, & Eccles, 2005). Parents' perceptions of their child's competence, which was rated as higher for boys than girls despite actual achievement, predict children's own ratings of their competence (Herbert & Stipek, 2005). Even very young children are given gender-specific toys that may promote greater spatial abilities among boys (see Tracy, 1987, for a review).

Despite evidence that there are gender differences in attitudes about math at the start of school at age 5 years (Byrnes & Wasik, 2009), and despite evidence for gender socialization regarding math, we know very little about *early* socialization experiences prior to entering school. Therefore, the present research examines whether there are gender differences in math socialization among very young children. As boys show greater confidence and willingness to learn math concepts at the start of school than girls, it seems likely that their early experiences with their parents (i.e., their primary socializer prior to school) are both gendered and influential. Thus, we consider the ways parents talk to their daughters and sons about early math concepts, specifically the amount that parents talk to boys versus girls about number. We predicted, in line

with gender stereotypes, that boys would have greater exposure to number words and concepts than girls.

Method

To determine whether young boys and girls received different amounts of exposure to number language in natural learning settings, we analyzed 32 American English transcripts of naturalistic interactions between children (16 boys, 16 girls) and their primary caregivers (all mothers).

Transcript Selection

American English transcripts from the Child Language Data Exchange System (CHILDES) database (MacWhinney & Snow, 1990) of mother–child dyads were first identified as naturalistic (either home observations or laboratory free-play settings without experimenter intervention) and selected based on the age of the target child.¹ The transcripts were originally recorded for purposes outside the current study (e.g., phonetic development) and none of the original studies had a focus on numerical language input. Children under 5 years of age (i.e., preschool age) were selected because they were highly unlikely to have already entered formal schooling or to have substantial numerical or mathematical knowledge. Mothers were not deliberately chosen, though recordings were made of children and their primary caregivers; all of whom were selected happened to be mothers. The majority of mothers were Caucasian, middle to upper-middle class, with college to postgraduate education.

Children were matched across gender groups by age and length of transcript (mean age = 21.84 months, $SD = 2.57$, range 20–27 months). Length was determined by summing total utterances (lines) containing speech within each transcript. All interactions took place either at home or in free-play laboratory settings and did not directly involve outside observers or participants. Contexts included free-play activities with toys or picture books, mealtimes, and social exchanges, although we selected transcripts that contained minimal book reading. Each of the transcripts included in the present study consisted of separate parent–child pairings (i.e., no one parent–child dyad appeared in more than one transcript in our sample), although some CHILDES corpora contain multiple recordings of the same dyad(s). The mean age of male children ($N = 16$) was 21.63 months ($SD = 2.92$). The mean age of female children ($N = 16$) was 22.06 months ($SD = 2.24$). For male children, 12 of the transcripts were recorded during free-play sessions in the laboratory, and one was recorded in the child’s home (for three sessions, the location was not stated). For female children, 10 of the transcripts were recorded during free-play sessions in the laboratory, and 3 were recorded in the child’s home (for 3 sessions, the location was not stated). On average, utterance lengths of transcripts depicting mother–son interactions contained 345.32 lines ($SD = 421.27$); lengths of mother–daughter transcripts averaged 473.44 lines ($SD = 398.28$). Lengths of transcripts did not differ significantly based on gender of child.

Analysis

Transcripts were analyzed for (a) overall maternal number-specific speech and (b) cardinal number speech by native English speakers. Overall, maternal number-specific speech included all instance of number terms (including cardinal number, numerals, age, time, and requests to count). Examples of the range of types of utterances that were coded as overall number-specific speech were

“One, two, three, four, five.” (counting)

“He’s gonna be 90!” (age)

“He can see, because he has two eyes here.” (cardinal number)

“How many feet do you have?” (request to count)

We also separately examined the utterances in which parents used cardinal numbers in their speech to children. Cardinal numbers represent the number of items in a set, based on the quantity. These types of utterances were of particular interest because an understanding of the cardinal meaning of number terms involves understanding quantity as a property of a set and is closely related to an understanding of whole number (see Chang et al., 2010 for a discussion). Examples of the types cardinal utterances we found in speech to children were,

“Five raisins.”

“You only have one Garfield.”

“Look at that, two beds!”

The transcripts were coded by two native English speakers as part of a larger project on parent–child conversations about number concepts. Initial training involved cross-coding of the same transcript and discussing line by line to ensure agreement. The training transcripts were not included in the analysis. The coders were not aware of any hypotheses or that gender differences were of interest. In all, 20% of the transcripts were cross-coded to determine reliability. Cohen’s kappa coefficients were calculated and indicated very high levels of interrater agreement for both overall maternal number utterances ($\kappa = .97$) and cardinal number utterances ($\kappa = .92$). The percentage of maternal numeric speech was calculated by dividing utterances containing number-specific instances by the total number of lines (utterances, as defined by the CHILDES manual) of maternal speech within each transcript. In cases of disagreement, consensus was reached through discussion.

Results and Discussion

Figure 1 illustrates the gender differences in overall number and cardinal number speech occurrences as percentages of total maternal speech in the American English sample. An independent-samples *t* test revealed statistically significant differences in

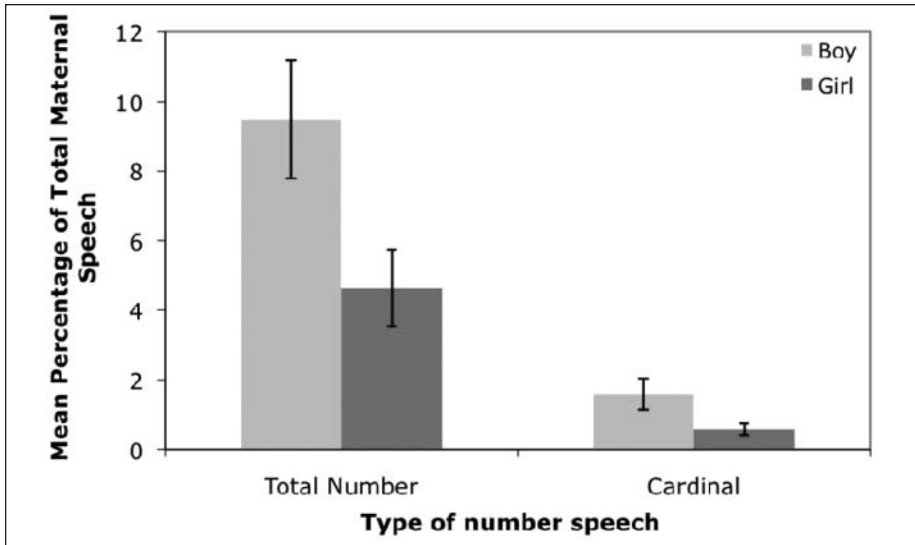


Figure 1. The mean percentage of overall maternal number and cardinal number speech directed to boys and girls

the percentages of overall numeric speech used when interacting with boys compared with girls, $t(30) = 2.40, p < .05, d = .88$. That is, mothers used number terms with boys an average of 9.49% of utterances ($SD = 6.78\%$) compared with 4.64% of utterances with girls ($SD = 4.43\%$).

More specifically, we examined the frequency of maternal cardinal number speech (i.e., explicit quantifications) between genders. Because cardinality indicates quantity as a property of a set, more exposure to this type of number speech may direct greater attention to the relationship between number terms and set sizes. Mothers were significantly more likely to use cardinal numbers to quantify sets (e.g., “four crayons”) with boys, $t(30) = 2.11, p < .05, d = .77$. On average, 1.59% of speech to boys ($SD = 1.80\%$), but only 0.58% of speech to girls ($SD = 0.64\%$), contained cardinal numbers.

Our results suggest that even at ages as young as 22 months, American parents draw boys’ attention to numerical concepts far more often than girls’. Indeed, parents speak to boys about number concepts twice as often as they do to girls. Large effect sizes in our samples were also found, which augment our findings that amount of maternal number speech is robustly affected by gender of child. These data comport with previous research on American parents’ interactions with children during science learning, which indicated that parents are more likely to give detailed explanations and instruction to boys than girls (Crowley, Callanan, Tenenbaum, & Allen, 2001; Eccles et al., 2000).

This study suggests that gender-stereotypical views remain a strong influence on how parents perceive children’s math interests and abilities, and they communicate with boys and girls in-line with such views. Although these stereotypical differences

in language input are likely inadvertent, and would be denied by most parents, previous work has shown it can still affect children's interests and self-perceptions of competence (Guimond & Roussel, 2001; Tenenbaum & Leaper, 2003). In the present sample, heavier parental emphasis on numerical concepts to young boys may guide boys' attention and interest to quantification and manipulation of sets, whereas comparatively less conversation about numbers with girls may reduce their awareness of quantities and mathematical concepts in everyday life, which may decrease their later interests in related domains.

It is highly encouraging that gender gaps in performance and course choice have narrowed in recent decades (National Science Foundation, 2008). These changes underscore the impact of social factors leading to greater gender equality in a relatively short period of time. Despite this closing gap, boys and girls still hold different interests and self-perceptions of competence. Considering these existing gender differences in math, it is important for research to examine whether there are indeed different social influences for boys and girls regarding math. Future work should examine gender differences in language input in greater detail. One limitation of the current study involves the use of the CHILDES database. Because the CHILDES transcripts were recorded for a variety of purposes across the different corpora, we did not have control over children's activities. It is possible that frequency of number talk could have been affected by specific activities or scenarios chosen by the children or parents. Greater gender differentiation in parental speech to children has been found in more open-ended than closed-ended contexts (Lytton & Romney 1991; Leaper, Sanders, & Anderson 1998). Because the majority of the transcripts were collected in open-ended contexts (e.g., free play) rather than closed-ended contexts (e.g., structured laboratory settings), further research is needed to determine whether parent number speech to children might vary based on specific tasks or activities.

The current study makes a vital contribution to the extant literature by documenting robust early gender differences in math-related input from parents. Although previous research has demonstrated a relationship between children's attitudes about mathematics and gender socialization in the classroom, parental language input may also shape children's attitudes about mathematics through less overt means, prior to formal schooling, and as early as 22 months of age.

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Note

- 1 Transcripts were selected from the *English-USA CHILDES Corpora*. We list the corpora-provided demographic description, description of activities, and specific corpus citations for each of the 11 transcripts.

Bates: Children were White, and from middle- to upper-class backgrounds. Free-play sessions in the laboratory included toys, books, and snacktimes (Bates, Bretherton, & Snyder, 1998; Carlson-Luden, 1979).

Bernstein-Ratner: Children of college-educated mothers and white-collar husbands participated in free-play sessions in the laboratory with toys (e.g., blocks, stuffed animals, puppets, books) (Bernstein-Ratner, 1982).

Bloom 1973: Child of the investigator (PhD) participated in free-play sessions in the laboratory with toys and snack time.

Brown: Middle-class child of Black, "well-educated" minister and elementary school teacher. Participated in free play at the child's home (Brown, 1973).

Cornell: Samples of families originally used for graduate student projects. No other specific demographic information available.

Demetras Working: Children whose parents worked during the day were recorded in free-play sessions with toys. No other specific demographic information available (Demetras, 1989a; 1989b).

Gleason: White, middle-class children from Boston recruited from nursery schools participated in free-play sessions in the laboratory, including a toy car, picture book, and playing "store" (Gleason, 1980).

Higginson: Natural home observations of children of undergraduate and graduate students (Higginson, 1985).

Sachs: Longitudinal study of investigator's (PhD) daughter recorded at the child's home (Sachs, 1983).

Suppes: Longitudinal study of a single child. No other specific demographic information available (Suppes, 1974).

Valian: English sample of cross-linguistic comparison of child language acquisition. White, range of working class to upper-middle class (PhD) parents (Valian, 1991).

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