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*Mathematics achievement and the science of mathematics education: evidence from different nations*

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# SUM THING TO TALK ABOUT: CAREGIVER-PRESCHOOLER MATH TALK IN LOW-INCOME FAMILIES FROM THE UNITED STATES

## *Algo matemático de que hablar: conversaciones de matemáticas entre cuidadores y preescolares en familias de bajos ingresos en los Estados Unidos*

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**INTRODUCTION**. The early home environment is critical for laying a strong numerical foundation for young children's development. Participation in math-related informal learning activities in the home is associated with caregiver and child talk about math; however, it is unclear which activities promote different types of math talk. **METHOD**. We observed whether the math talk that 33 families from low-income backgrounds from the United States engaged in varied across three math-related activities – book reading, puzzle solving, and board game play. Math talk was coded into five categories: counting, numeral identification, cardinality, ordinal relations, and arithmetic. **RESULTS**. There was substantial variability in the amount of caregiver and child math talk. The amount and types of math talk caregivers and children engaged in varied by activity. Of the three activities, the board game elicited the most math talk. The most frequent type of talk during an activity corresponded to the specific numerical content embedded in each activity. **DISCUSSION**. Findings suggest that caregivers are responding to the play context when engaging in math-related informal learning activities. Understanding factors that influence math talk could inform the type of activities used in future home-based interventions aimed at reducing the gap in early mathematical understanding between children from lower- and higher-income backgrounds in the United States.

**Keywords:** *Mathematics, Parent influence, Achievement gap, Play, Low-income.*

## Introduction

At the start of kindergarten, there is wide variation in children's mathematical understanding. On average, children from low socioeconomic status (SES) backgrounds are over-represented among those with low mathematical understanding (Jordan & Levine, 2009; Starkey, Klein & Wakeley, 2004). The mathematical achievement gap between young children from higher and lower socioeconomic status (SES) groups is partially attributable to differences in their experience with informal learning activities. McGivney (1999) characterizes informal learning experiences as activities that take place outside of dedicated learning environments, such as school. Participation in these activities is typically driven by the interests of the individuals and may not be recognized as fostering learning. Examples of math-related informal learning activities include board games, card games, number and shape books, cooking, shopping, and number songs (LeFevre *et al.*, 2009; Vandermaas-Peeler, Boomgarden, Finn & Pittard, 2012). In families from diverse backgrounds, parental reports of the frequency of engaging in informal math activities in the home have been linked to children's early math knowledge (e.g., Niklas & Schneider, 2014; Skwarchuk, Sowinski & LeFevre, 2014). On average, children from lower SES backgrounds compared to children from higher SES backgrounds less frequently participate in math-related informal learning activities as reported by both children and parents (Ramani & Siegler, 2008; Vandermaas-Peeler, Nelson, Bumpass & Sassine, 2009).

Informal number activities can facilitate mathematics development by providing children with opportunities to learn and practice math concepts that are embedded in games or real world contexts (LeFevre *et al.*, 2009). Although the evidence between experiences with math-related informal learning activities and math understanding in early childhood has been mixed (see Elliott & Bachman, 2017 for review), several studies have shown the positive impact of informal number activities. For example, Blevins-Knabe and Musun-Miller (1996) found that greater participation in math-related activities in the home prior to kindergarten predicted higher scores on a standardized math test. Ramani and Siegler (2008) found that the number of board games preschool children from low-income backgrounds reported having played outside of school was correlated with their counting, numeral identification, and numerical magnitude knowledge. Similarly, LeFevre *et al.* (2009) found that the frequency of reported participation in math-related informal learning activities was positively associated with kindergarteners' mathematical knowledge measured by a standardized test, even after controlling for child vocabulary, working memory, and frequency of participation in literacy-related activities. The present study adds to this previous literature by observing how interactions among caregiver-child dyads from low-income backgrounds varied across three common math-related activities – book reading, puzzle solving, and board game play. A better understanding of how different numeracy activities influence interactions will aid in the development of home and center-based programs and interventions. This is especially important for families from low-income backgrounds, whose children are, on average, at a greater risk for poor mathematical achievement (Jordan & Levine, 2009).

### Math Talk during Informal Learning Activities

According to Vygotsky (1978), children learn within their zone of proximal development (ZPD), which is "the distance between [a child's] actual developmental level... and the level of potential development... under adult guidance" (p. 86). He argued that learning takes place within the ZPD, because more advanced partners provide guidance, which allows children to extend the limits of their current understanding and gain knowledge.

Caregiver-child participation in informal learning activities may be associated with children's mathematical understanding because they provide a rich and flexible context in which caregivers can engage their children within their ZPD (Rogoff, Ellis & Gardner, 1984; Saxe, Guberman & Gearhart, 1987). For example, mothers adapted the instructions they gave their children during a classification task based on their child's age (Rogoff, Ellis & Gardner, 1984). Similarly, mothers changed their instructions based on their children's ability levels during counting tasks (Saxe, Guberman & Gearhart, 1987).

These studies are indicative of one mechanism by which caregivers may engage their children within their ZPD, which is through "math talk". Math-related informal learning activities provide opportunities for math talk, which consists of discourse about number or numeracy-related concepts, such as counting, arithmetic, numeral identification, cardinality, and magnitude comparison (Levine, Suriyakham, Rowe, Huttenlocher & Gunderson, 2010). Parents can guide their children, ask questions, and provide information related to these mathematical concepts while engaging in every day informal activities. The frequency and quality of exposure to math talk that children receive prior to the start of formal schooling is critical for later mathematical understanding (Gunderson & Levine, 2011; Klibanoff, Levine, Huttenlocher, Vasilyeva & Hedges, 2006; Levine *et al.*, 2010).

However, in the early home environment, there is variation in the amount of math talk heard by children, and greater exposure to math-related input is related to better numerical understanding in children. Levine and colleagues (2010) observed children from a range of SES backgrounds for 90 min every 4 months between the ages of 14- and 30-months-old. They found that the amount of number words heard by the children in the home varied from 4 to 257 number words over the 7.5 hrs of observed interactions, and that this variation in the amount of number words was predictive of cardinality understanding at 46 months, even after controlling for SES. A follow-up study with the same families revealed that the type of math talk that parents engaged in was important. Specifically, parent number talk involving counting or labeling the cardinal value of visible objects and talk about large sets of objects were the most predictive of children's later number knowledge (Gunderson & Levine, 2011). Thus, these studies on parent number talk suggest that the quantity and quality of math-related input children receive varies widely, and this variation is related to children's later mathematical understanding.

However, it is critical to identify factors that contribute to variations in math-related talk between caregivers and children. One likely contributor is the differences in the mathematical content embedded in the activities and the numerical knowledge necessary to complete them. For example, parent-preschooler dyads from both lower- and higher-income backgrounds were more likely to engage in number talk during play with pretend food and money than while reading a book about characters going grocery shopping (Vandermaas-Peeler *et al.*, 2009). Although the book was math-related, it was possible for parent-child dyads to read it without engaging in talk about money or numbers. In contrast, pretending to buy and sell groceries elicited talk about the money and numbers because children needed to use their numerical knowledge in order to complete the pretend transactions. The authors concluded that the specific nature of the materials are important to consider when attempting to encourage math talk. Relatedly, other activities require talk about numbers to engage in them, such as board games, which often involve counting spaces and identifying numerals on the spinner during game play (Ramani, Siegler & Hitti, 2012). Indeed, parents provide answers, instruct, model, and re-represent mathematical information while playing board games with their preschoolers (Bjorklund, Hubertz & Reubens, 2004). Thus, math-related informal learning activities likely create differential opportunities to engage in math talk due to variations in the numerical content embedded in them.

Few studies, however, have examined the frequency and types of math talk across different math-related informal learning contexts. One such study compared the frequency of different types of math talk between middle-income parents and their four-year-olds across four activities: block play, book reading, math workbook completion, and paper crafts (Anderson, 1997). Block play elicited the most varied mathematical talk, including spatial talk, grouping, naming numbers, counting, and recognizing numerals. Book reading elicited talk about counting, comparing sizes, and naming numbers. Workbooks elicited talk about recognizing equal set sizes, naming numerals, and recognizing numerals. Paper crafts elicited talk about naming shapes, counting, and comparing sizes. Thus, the different activities elicited different types of math talk; however, parents were aware of the mathematical nature of the study, which may have affected the frequency of their math talk.

## The Current Study

In the current study we examined how math talk in low-income families varied across three math-related informal learning activities - book reading, puzzle solving, and board game play. We specifically selected these activities because previous research has found they elicit different types of math-related talk (Anderson, 1997; Anderson, Anderson & Shapiro, 2005; Bjorklund *et al.*, 2004; Levine, Ratliff, Huttenlocher & Cannon, 2012). However, no study has explicitly compared math talk in these three activities in low-income families. Data for the current study were drawn from a previous study that examined the relations between caregiver-child math talk in families from low-income backgrounds during informal learning activities, participation in number-related activities in the home, and children's numerical knowledge (Ramani, Rowe, Eason & Leech, 2015). Caregivers and their children participated in a dyadic interaction with a standard set of three activities chosen to elicit talk about math. In addition, unlike previous studies, families were unaware of the mathematical focus of the study. Caregivers' math talk during the interaction varied widely and talk about advanced number concepts for preschoolers, such as cardinality and ordinal relations, predicted children's more advanced number skills.

The present study extends these previous findings in a critical way by specifically examining whether the quantity and type of caregivers' and children's math talk varied during each the three activities from the dyadic interaction. The first activity was a storybook that featured items to count from 1-10 and included the corresponding Arabic numeral on each page. The second activity was a wooden puzzle with 10 numbered pieces of various colors. The third activity was a simple board game with 10 numbered spaces, two game pieces, and a numbered spinner. Understanding the differences between the activities will provide insight into what kinds of math-related activities are effective at eliciting different types of mathematical discourse. This research will allow for making evidence-based recommendations to caregivers with limited time or resources for purchasing activities. Furthermore, these findings could inform recommendations for activities that elicit math talk in particular areas that are appropriate for a child's developmental level.

The primary aim of this study was to examine whether the quantity and type of caregiver and child math talk differed across book reading, puzzle solving, and board game play. We predicted that the quantity and type of caregiver and child math talk would vary by activity and that the number board game would elicit the most math talk. We made this prediction even though there were many similarities between the activities. For example, all of the materials displayed the Arabic numerals 1-10, emphasized the standard order count sequence, highlighted the ordinal relations between numbers and mapped written numerals onto corresponding quantities of physical objects or pictures. Further, all of the activities provided opportunities for talk about various numerical areas, including counting, cardinality, identifying numerals and their order, arithmetic concepts, and comparing quantities. However, the activities varied in the degree and manner in which mathematical content was embedded them and the amount of child numerical knowledge required to complete them. For example, caregivers could read the entire book without drawing the child's attention to the numerical content on each page because it was not necessary to complete the activity. The puzzle required knowledge of the number sequence to most efficiently complete it though it was possible that caregivers could rely on their own numerical knowledge rather than their children's knowledge. In contrast, the board game required the use of children's numerical knowledge for completion of the activity because numeracy is embedded in the activity. Specifically, caregivers and children had to identify the numeral on a spinner to determine how many spaces to move, count the spaces on the game board in order to advance their tokens, and discuss cardinality when determining if they had moved the correct number of spaces. Importantly, given the dyadic nature of the activity, we predicted it would elicit greater caregiver math talk to support children's active use of numerical knowledge than the other two activities. Thus, all three activities had similar *potential* to elicit math talk, but they varied in the amount of math talk *required* to complete them.

We also predicted that the three activities would primarily elicit different types of math talk. Specifically, we predicted that the book would elicit talk about counting and cardinality because of the focus of quantity in the story. We also predicted that the puzzle would elicit talk about numeral identification and ordinal relations because of the numbers on the pieces and the importance of using the number sequence for assembling the puzzle. Finally, we predicted the board game would elicit the most varied amount of math talk because of the necessity to identify numerals, count, and understand cardinality in order to play the game.

The secondary aim of the study was to examine how caregiver math talk during each activity related to child math talk. We predicted that the quantity of caregiver math talk would be related to the quantity and types of child math talk given the dyadic interactions, consistent with previous research (Rogoff *et al.*, 1984; Saxe *et al.*, 1987).

## Method

### Participants

Participants were 33 preschoolers (*M* = 4 years, 4 months; range = 3 years, 2 months to 5 years, 7 months; 60% female) and their primary caregivers (26 mothers, 5 fathers, and 2 grandmothers). Children were recruited from one Head Start center with three classrooms in the mid-Atlantic region of the United States. Head Start is a federally funded early childhood educational program in the United States for families living at or below the poverty line. On a demographic survey, the majority of the caregivers reported having a household income of less than $25,000 (56% of the household incomes were less than $25,000; 25% household incomes were between $26,000 and $35,000, and 19% of the household incomes were $36,000 or greater). There was a range of caregiver education: 6% completed some high school, 27% had completed a high school diploma/GED, 42% completed some college/

vocational training, 21% completed a 2-year college degree, and 9% completed a 4-year college degree or postgrad/professional degree. Children in the sample were 70% African American or Black, 24% Caucasian/White, and 6% mixed-race, with 21% identifying as Hispanic or Latino. Caregivers were 70% African American or Black and 30% Caucasian/White, with 15% identifying as Hispanic or Latino.

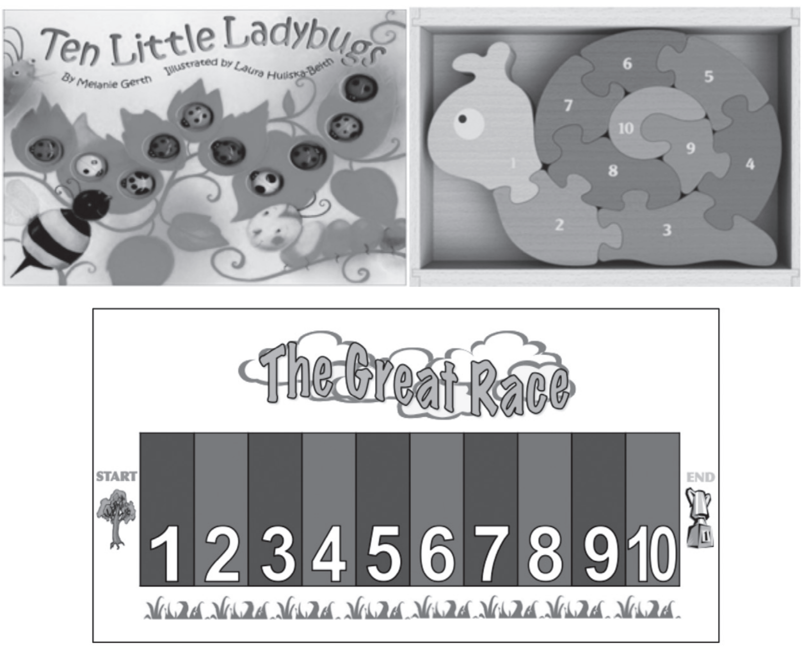
## Procedure

The study consisted of one 15-min caregiver-child interaction and a 20-min follow-up to assess children's numerical knowledge one to two weeks following the initial observation. Data were collected as part of a larger study on language and math development. Visits were conducted at the Head Start center either in an unoccupied classroom or in a room nearby the children's classroom. Dyads participated in the Three Bags Task (Vandell, 1979). During the interaction, dyads were seated on a blanket and were given three bags numbered from 1 to 3 each containing a different item (Figure 1). Caregivers were instructed to interact with their children as they typically would at home. They were also told they could play with each activity as long as they wanted, but they had to open the bags in numerical order. After giving the instructions, the experimenter either left the room or sat quietly out of sight of the families completing paperwork. Each interaction was video-recorded for later transcription and coding.

## Three Bags Task

- **Book.** The first bag contained the commercially available book *Ten Little Ladybugs* by Melanie Gerth. In this book,

**Figure 1. The three informal learning activities used in the Three Bags Task. The first bag contained the book. The second bag contained pieces of the wooden snail puzzle, and the third bag contained *The Great Race* board game**



each of the ten ladybugs disappears one at time. The accompanying text on each page emphasizes that every time a ladybug disappears, there is one less ladybug than before. Rhymes are integrated into the text to help children guess the next number in the sequence (e.g. "Ten little ladybugs, sitting on a vine. Along came a butterfly– then there were… (on the next page) nine". On each page, the text describes the number of ladybugs left, the pictures include the corresponding number of ladybugs, and the associated Arabic numeral is presented in the corner.

- **Puzzle.** The second bag contained a commercially available ten-piece wooden jigsaw puzzle that forms the shape of a snail when complete and a picture of the completed puzzle. Each puzzle piece was a different color and was labeled with a number from 1 to 10. The puzzle is designed so that it was most easily assembled in the order the pieces are numbered.
- **Board game.** The third bag contained the board game *The Great Race* (Siegler & Ramani, 2008), two animal characters tokens, a spinner with the numbers 1 and 2, and simple instructions on how to play on the top of the box. The board had 10 horizontally arranged rectangles of equal size numbered 1-10 from left to right on the board. "Start" was written to the left of the rectangles and "End" to the right. The instructions said that caregivers and children should take turns spinning the spinner to advance the number of places on the board indicated by the spinner and that the character to reach 10 first would win the game.

**Measures of Caregiver and Child Talk**

All caregiver and child speech during the interactions was transcribed verbatim at the level of the utterance by reliable transcribers from the videos using the CHAT conventions of the Child Language Data Exchange System (CHILDES, MacWhinney, 2000). A second reliable transcriber verified each transcript.

Every utterance was coded into specific categories of talk by two trained coders. Math talk was coded into five non-exclusive, non-hierarchical categories: counting, numeral identification, cardinality, ordinal relations, and arithmetic (definitions and examples are provided in Table 1). Percent agreement was used to establish reliability because the codes were not mutually

**Table 1. Definitions of caregiver and child math talk**

| Code | Definition | Caregiver examples | Child examples |
|---|---|---|---|
| Counting | Counts or asks child to count | "Can you count the butterflies?" | "One, two, three…" (counting spaces on game board) |
| Number Identification | Identifies numerals or asks child to identify numerals | "What number is on this page?" | "That's a four (response to caregiver question)" |
| Cardinality | Refers to or labels number of elements in a set | "How many spaces should you move?" | "There are five ladybugs" |
| Ordinal relations | Describes order of numbers or asks about order of numbers | "What comes after three?" | "Four comes next" |
| Arithmetic | Adds or subtracts two numbers or asks child about addition or subtraction | "The butterfly took one" | "Three (response to caregiver question, "What is four take away one?") |

exclusive. Both coders independently coded 20% of the transcripts with at least 80% percent agreement for both caregiver and child math codes. Discrepancies were resolved after discussion.

Because the time spent and total amount of talk during each activity could vary, percentages of caregiver and child math talk were created by dividing the number of math talk utterances by the total number of utterances during each activity and multiplying by 100. The data for math talk percentages were not normally distributed. Therefore, math talk variables were transformed using the arcsine transformation for all analyses, which is especially appropriate for data in the form of percentages (Sokal & Rohlf, 1995) to ensure normality and linear relations between measures. For the book reading activity, math talk that was part of the text of the book was not counted toward the math talk total during that activity. Further, the non-transformed math talk means are also reported in the results section to ease interpretability.

## Results

### Descriptive Statistics

There was substantial variability in caregivers' and children's math-related utterances. Caregivers produced on average 65 math-related utterances (*SD* = 31) with a range from 19 to 151 utterances. Caregivers' percentage of math-related utterances averaged 19% (*SD* = 6%) and ranged from only 8% to 34%. Children produced on average 37 math-related utterances (*SD* = 22) with a range from 7 to 88 utterances. The percentage of math talk utterances for children on average was 17% (*SD* = 9%), with a range from 5% to 44%.

Child age was not significantly related to the proportion of caregivers' or children's math-related talk, nor was child age significantly related to any of the types of math talk between caregivers and their children.

On average, dyads spent approximately 3 min reading the book (*SD* = 1.15), 5.5 min doing the puzzle (*SD* = 2.80), and approximately 4 min playing the board game (*SD* = 1.50). These differences in time spent on activity were significant overall, $F(2, 64) = 10.78$, $p < .01$, $\eta_p^2 = .25$. Significantly less time was spent on the book than the puzzle, $p < .001$ and the board game, $p < .001$. There was no significant difference in the amount of time dyads spent on the puzzle and the board game.

### Caregiver Math Talk Across the Three Activities

Analyses of caregiver math talk were conducted in the following order. First, we conducted repeated measures analyses of variance (ANOVAs) to compare the proportion of overall math talk for caregivers and children across the activities. Next, we compared types of caregivers' and children's math talk across the three activities using repeated measures multivariate analyses of variance (MANOVAs). In cases where the data violated the assumption of sphericity, the Greenhouse–Geisser correction to the degrees of freedom was used. All post hoc tests were conducted using Bonferroni's *t* statistic.

- **Overall caregiver math talk.** A repeated measures ANOVA comparing the proportion of caregiver math talk to total talk across the activities revealed a main effect of activity, $F(2, 64) = 17.68$, $p < .001$, $\eta_p^2 = .36$. Post hoc comparisons demonstrated that the proportion of math talk used by caregivers while playing the board game (*M* = 27%; *SD* = 12%) was higher than during the book (*M* = 13%; *SD* = 10%) and the puzzle (*M* = 13.5%; *SD* = 7%), $p < .001$. There was no difference in the percentage of math talk between the book and the puzzle.
- **Types of caregiver math talk.** To examine how the types of math talk that caregivers engaged in varied by activity, we

conducted a repeated measures MANOVA with the four types of math talk that occurred (counting, cardinal values, numeral identification, and ordinal relations). Arithmetic talk was not included in the analyses because it only occurred during the book and board game with very low frequency. Main effects emerged for activity, $F(8, 25) = 16.16$, $p < .001$, $\eta_p^2 = .84$. Univariate analyses revealed effects of activity for each type of talk.

– ***Counting.*** Counting-related talk varied by activity, $F(2, 64) = 22.49$, $p < .001$, $\eta_p^2 = .41$. Caregiver counting-related talk occurred more during board game play ($M = 3.55\%$; $SD = 2.70\%$) and book reading ($M = 2.7\%$; $SD = 3.02\%$) than during the puzzle ($M = 0.63\%$; $SD = 0.98\%$, $p < .01$ and $p < .001$, respectively). There was no difference in counting-related talk during the board game and the book.
– ***Cardinal values.*** There was a main effect of activity for cardinal values, $F(1.701, 54.43) = 36.34$, $p < .001$, $\eta_p^2 = .53$. Caregivers engaged in more cardinality-related talk during board game play ($M = 11.71\%$; $SD = 6.38\%$) than book reading ($M = 5.58\%$; $SD = 6.59\%$) and puzzle play ($M = 0.55\%$; $SD = 1.09\%$, $p < .001$ for both comparisons). They also engaged in more cardinality talk during book reading than during the puzzle, $p < .001$.
– ***Numeral identification.*** Talk related to numeral identification varied by activity, $F(2, 64) = 26.35$, $p < .001$, $\eta_p^2 = .45$. Caregivers engaged in a greater percentage of numeral identification talk during the board game ($M = 11.69\%$; $SD = 5.68\%$) and puzzle ($M = 9.77\%$; $SD = 5.96\%$) than during book reading ($M = 3.53\%$; $SD = 3.94\%$, $p < .001$ for both comparisons). There was no difference in numeral identification talk during the board game and puzzle.
– ***Ordinal relations.*** Ordinal relations related talk varied by activity, $F(1.36, 43.66) = 12.74$, $p < .001$, $\eta_p^2 = .29$. Caregivers engaged in a greater percentage of talk about ordinal relations during the puzzle than during book reading ($M = 2.55\%$; $SD = 3.39$ vs. $0.56\%$; $SD = 1.11\%$, $p < .05$), and talked about ordinal relations during book reading more than during the board game ($M = 0.04\%$; $SD = 0.16\%$, $p < .05$).

In sum, caregivers' math talk differed across the three activities. The book elicited a greater percentage of caregiver talk about counting and cardinality than the puzzle. The puzzle elicited greater caregiver talk about numeral identification and ordinal relations than the book. However, the board game elicited a higher percentage of both cardinality and numeral identification talk with caregivers engaging in more cardinality talk than both during the book and the puzzle.

### Child Math Talk Across the Three Activities

- **Overall child math talk.** A repeated measures ANOVA comparing the percentage of child math talk across the book ($M = 16.6\%$; $SD = 11\%$), the puzzle ($M = 15\%$; $SD = 13\%$), and the board game ($M = 19\%$; $SD = 11\%$) revealed no main effect of activity suggesting that total child math talk did not vary across activities.
- **Types of child math talk.** A repeated measures MANOVA with the four types of child math talk revealed a main effect for activity, $F(8, 25) = 15.68$, $p < .001$, $\eta_p^2 = .83$. Univariate analyses revealed effects of activity for each type of talk as discussed in the following section.

- ***Counting.*** Counting-related talk varied by activity, $F(2, 64) = 15.05$, $p < .001$, $\eta_p^2 = .32$. Children engaged in a higher percentage of counting-related talk during book reading ($M$ = 5.27%; $SD$ = 4.86%) than during the puzzle, (0.77%; $SD$ = 1.59%, $p < .001$), and used counting-related talk more while playing the board game ($M$ = 2.81%; $SD$ = 3.24%) than during the puzzle, $p < .05$. Children were equally as likely to count during book reading and the board game.
- ***Cardinal values***. There was a main effect of activity for cardinal values, $F(2, 64) = 46.46$, $p < .001$, $\eta_p^2 = .59$. Children engaged in a greater percentage of cardinal value talk during book reading ($M$ = 4.98%; $SD$ = 5.25%) than during the puzzle ($M$ = 0.14%; $SD$ =0.48%), $p < .001$. They also talked about cardinality more during the board game ($M$ = 7.19%; $SD$ = 5.57%) than during the puzzle, $p < .001$. There was no significant difference in the proportion of cardinal values talk during the book compared to the board game.
- ***Numeral identification.*** Talk related to identifying numerals varied by activity, $F(2, 64) = 6.73$, $p < .01$, $\eta_p^2 = .17$. Children talked about numeral identification more during the puzzle ($M$ = 10.72%; $SD$ = 8.09%) than during the book ($M$ = 5.19%; $SD$ = 6.76%, $p < .01$), and used more numeral identification talk while playing the board game ($M$ = 8.62%; $SD$ = 7.75%) than during book reading, $p < .01$. Children were equally as likely to talk about numeral identification during the puzzle as they were playing the board game.
- ***Ordinal relations.*** There was a main effect of activity for ordinal relations, $F(1.43, 45.84) = 9.92$, $p < .01$, $\eta_p^2 = .24$. Children talked about ordinal relations during the puzzle more ($M$ = 3.17%; $SD$ = 6.08%) than during the board game ($M$ = 0.06%; $SD$ = 0.37%, $p < .01$). There were no significant differences in ordinal relations-related talk between the book ($M$ = 0.85%; $SD$ = 3.08%) and the other contexts.

In sum, children's math talk differed across the three activities and generally mirrored caregiver math talk. Children engaged in a greater percentage of talk about counting and cardinality during the book than during the puzzle, and greater numeral identification talk during the puzzle than during the book. Children also talked more about ordinal relations during the puzzle than during the board game. However, the board game elicited a higher percentage of cardinality talk with children engaging in more cardinality talk than both during the book and the puzzle. Overall, children's talk paralleled the talk of caregivers.

### Relations Between Caregiver and Child Math Talk

To address our secondary aim, we examined the relations between overall caregiver math talk and child math talk. As predicted, overall proportion of caregiver math talk across the activities was significantly related to the overall proportion of children's math talk, $r = .45$, $p < .05$. Caregiver math talk during the book and the puzzle was also significantly correlated to children's math talk during those activities, $r = .78$, $p < .001$ and $r = .67$, $p < .001$, respectively. However, caregiver math talk and child math during the board game was not related, $r = .19$, *ns*.

## Discussion

This study examined variation in caregiver and child math talk in families from low-income backgrounds across three informal math-related activities. As predicted, we found that the frequency and types of caregiver and child math talk showed similar patterns to one another, yet varied across the three activities. The findings from the present study offer important insight into the kinds of numeracy-related activities that could be offered to low-income families seeking information about activities for use in the early home environment.

**Math Talk in Head Start Families Across Numeracy Activities**

During the three math-related informal activities in the current study, we found that the caregivers and children in our low-income sample engaged in rich mathematical discourse, accounting for 19% and 17%, respectively, of all of the utterances during the dyadic interaction. This suggests that engaging in everyday activities can provide opportunities for caregivers and children to engage in math talk. Importantly, we found that their talk about math varied in amount and type across the different numeracy-related activities. Overall, caregivers engaged in significantly more math talk during the board game compared to the book and the puzzle. Variations in the numerical content embedded into the activity are associated with differences in the amount and the type of math talk that occurs during the activity. Specifically, caregivers engaged in more talk about counting and cardinality during book reading than during the puzzle, and greater numeral identification and ordinal relations talk during the puzzle than during book reading. However, playing the board game elicited a greater percentage of both cardinality and numeral identification talk.

The findings suggest that caregivers talk about the mathematical concepts that they perceive to be an integral part of the activity. For example, the text on each page of the book described a number of items, showed a picture of the items, and provided the associated Arabic numeral. Caregivers used these cues while reading the book to count with their children and to name the set sizes on each page. Indeed, counting and cardinality were the predominant types of caregiver talk during book reading. Likewise, the expected types of caregiver talk based on the numerical content embedded in the puzzle and the board game matched the observed predominant types of caregiver talk for these activities. Our findings are consistent withprevious research on math talk that has found the type of activity that parents and children engage in can influence parents' math talk (Anderson, 1997; Bjorklund *et al.*, 2004; Gunderson & Levine, 2011; Vandermaas-Peeler *et al.*, 2009).

The frequency of the types of child math talk also varied across contexts and mirrored that of caregiver math talk. Caregivers' and children's math talk likely influenced each other, which is consistent with previous research (e.g., Levine *et al.*, 2010) and not surprising given the reciprocal nature of the dyadic interactions. Specifically for each activity, as predicted, caregiver math talk was related to child math talk overall and child math talk during the book and the puzzle. This suggests both the caregivers and the children were engaging in math talk during these activities. These relations, however, were not found for the board game. One possible reason for these differences is that the board game is a rich context for various types of math talk, especially when dyads were playing the game for the first time, and that caregivers took the opportunity to share mathematical information with their children, regardless of their children's talk during the interaction. Consistent with the ZPD, previous research has shown parents vary their assistance to their children after playing a board game multiple times by using fewer directives (Bjorklund *et al.*, 2004). Future empirical work could examine the relations between parent and child math talk during the board game over time to test whether parent math talk follows a similar pattern with math talk between parents and children becoming related in later sessions as children become more skilled at playing the game.

Overall, this study presents evidence for the influence of different activities on both caregivers' and children's math talk about a variety of mathematical concepts, and suggests their overall importance as contexts for caregivers to engage their children in mathematical discourse. The results also highlight the critical need in understanding factors that influence math talk given the importance of math input on children's mathematical development (Levine *et al.*, 2010).

## Conclusion

Limitations of the present study and future directions should be noted. First, the results of the study may be influenced by order effects since each of the caregiver-child dyads participated in the activities in the same order. A study that counterbalances the order of activities could confirm that the relations among talk and activity are due to caregiver sensitivity to task demands rather than order effects. Second, the results of the study cannot be generalized beyond families from low-income backgrounds in Head Start programs in the United States.

In sum, this study highlights that caregivers and children from low-income backgrounds are engaging in mathematical discourse across a variety of activities. Furthermore, caregivers are sensitive to the context in which they are engaging their children, as reflected in their frequency and type of mathematical talk. This study also shows that mathematical informal learning activities can differentially facilitate math talk frequency and type and that there is a relation between caregivers' and children's math talk. These findings indicate that interventions involving math-related informal learning activities targeting low-income families could help to increase the frequency and type of math talk used in the home. Interventions also could be catered to the children's level of numerical understanding by choosing activities that elicit the kind of math talk that will most beneficial to them. Further inquiry into this line of research could help to close the early achievement gap between SES groups at the start of kindergarten.

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## Resumen

*Algo matemático de que hablar: conversaciones de matemáticas entre cuidadores y preescolares en familias de bajos ingresos en los Estados Unidos*

**INTRODUCCIÓN. El ambiente temprano en el hogar es crítico para establecer una base numérica sólida para el desarrollo de los niños pequeños. La participación en actividades de aprendizaje informal relacionadas con las matemáticas en el hogar se asocia con el discurso entre el cuidador y el niño acerca de las matemáticas; sin embargo, no está claro cuales actividades promueven diferentes tipos de conversación matemática. MÉTODO. Observamos si las conversaciones de matemáticas en cuales participaron 33 familias de bajos ingresos de los Estados Unidos variaba entre tres actividades relacionadas a las matemáticas: la lectura de libros, la resolución de rompecabezas y el juego de mesa. La conversación matemática se codificó en cinco categorías: recuento, identificación numérica, cardinalidad, relaciones ordinales y aritmética. RESULTADOS. Hubo una variabilidad sustancial en la cantidad del discurso entre el cuidador y el niño acerca de las matemáticas. La cantidad y los tipos de conversaciones de matemáticas entre los cuidadores y los niños varían según la actividad. De las tres actividades, el juego de mesa provocó la mayor cantidad de conversación matemática. El tipo de conversación más frecuente durante una actividad correspondió al contenido numérico específico incrustado en cada actividad. DISCUSIÓN. Los resultados indican sugieren que los cuidadores están respondiendo al contexto de juego cuando participan en actividades de aprendizaje informal relacionadas a las matemáticas. Comprender los factores que influyen en las conversaciones de matemáticas podría informar el tipo de actividades utilizadas en futuras intervenciones del hogar destinadas a reducir el espacio entre los niños de bajos y mayores ingresos en la comprensión matemática temprana en los Estados Unidos.**

**Palabras clave:** *Matemáticas, Aportación de los padres, Brecha de logro, Jugar, Bajos ingresos.*

## Rèsumè

*Parlons un peu de mathematiques : conversations sur les mathematiques entre les assistants et les enfants de maternelle issus de familles à faibles revenus aux États-Unis*

**INTRODUCTION. Dans la petite enfance, le milieu familial est essentiel pour établir une base numérique solide dans le développement des jeunes enfants. La participation à des activités d'apprentissage informel liées aux mathématiques dans le foyer est associée à des conversations sur les mathématiques entre aidant et enfant: toutefois il n'est pas claire quelles activités suscitent**

**différents types de conversations sur les mathématiques. METHODOLOGIE. Nous avons examiné si les conversations sur les mathématiques auxquelles ont participé 33 familles de milieux défavorisés aux États Unis varient dans trois activités liées aux mathématiques –lecture de livre, résolution de puzzle et jeu de société. La conversation sur les mathématiques est classée en cinq catégories : calcul, identification des chiffres, cardinalité, relations ordinales et arithmétique. RÉSULTATS. Il existe une forte variabilité dans le nombre de conversations sur les mathématiques entre l'assistant et l'enfant. Le nombre et le type de conversations sur les mathématiques auxquelles ont participé aidants et enfants varient en fonction des activités. Sur les trois activités, le jeu de société est celui qui a suscité plus de conversations sur les mathématiques. Le type de conversation le plus fréquent lors d'une activité correspond au contenu numérique précis intégré dans chaque activité. DISCUSSION. Les conclusions semblent indiquer que les assistants répondent au contexte du jeu lorsqu'ils participent à des activités d'apprentissage informel liées aux mathématiques. Comprendre les facteurs qui influencent la conversation relative aux mathématiques pourrait éclairer le genre d'activités utilisés à l'avenir dans de futures interventions au foyer visant à réduire les écarts de compréhension initiale des mathématiques entre des enfants de milieux défavorisés et ceux de milieux plus aisés aux États-Unis.**

**Mots clés:** *mathématiques, influence parentale, écarts de résultats, jeu, faible revenu*

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