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Maternal Math Talk in the Home and Math Skills in Preschool Children

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ABSTRACT

Research Findings: The current study analyzed the relation between the amount of mathematical input that preschool children hear (i.e., math talk) from their mothers in their homes and their early math ability a year later. Forty mother–child dyads recorded their naturalistic exchanges in their homes using an enhanced audio-recording device (the Language ENvironment Analysis System). Results from a sample of naturalistic interactions during mealtimes indicated that all mothers involved their children in a variety of math exchanges, although there were differences in the amount of math input that children received. Moreover, being exposed to more instances of math talk was positively related to children's early mathematical ability a year after the recordings, even after we controlled for maternal education, self-regulation, and recorded minutes. *Practice or Policy:* These findings improve the understanding of how mothers use math with their preschool children in naturalistic contexts, providing some insight for parents into how to foster children's math skills through verbal input in their normal routines. Moreover, these findings inform kindergarten teachers and practitioners about the math input that children receive at home, which may encourage them to adapt their practice by considering the home environment.

Math skills measured in preschool and at kindergarten entry are strong predictors of later math abilities and achievement in school (Bailey, Siegler, & Geary, 2014; Duncan et al., 2007; Watts, Duncan, Siegler, & Davis-Kean, 2014). Thus, knowing the factors underlying the variations in these mathematical skills before kindergarten is relevant for children's success in school (Hooper, Roberts, Sideris, Burchinal, & Zeisel, 2010). According to sociocultural theory (Rogoff, 2003; Vygotsky, 1978), these factors relate to the interactions that children have with caregivers at home as well as with other significant adults, such as teachers in the preschool setting (Anders et al., 2012; National Institute of Child Health and Human Development Early Child Care Research Network, 2004). Given the prominent role of parents in their children's academic achievement (LeFevre et al., 2010), the current study investigates the input and stimulation that children receive at home as a source of variation in early math skills.

Although the home environment of preschoolers is recognized as one type of influence in children's development, this context has been studied over the past decade with a greater emphasis on literacy in young children. Only recently has research devoted attention to the math experiences that children have at home before schooling (i.e., home numeracy) and how these encounters support numerical development (LeFevre et al., 2009; Niklas & Schneider, 2014). Although there are a few observational accounts of the use of math in the home (Levine, Suriyakham, Rowe, Huttenlocher, & Gunderson, 2010), those studies have been conducted with younger children. The majority of the studies in the field have used very structured situations, materials, or even the

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presence of the investigator to record the math input at home. There is still much to understand about how the ways in which mothers socialize mathematics in their homes are linked to early math skills. Therefore, using sociocultural theory (Rogoff, 2003; Vygotsky, 1978) as a framework, the current study investigates how mothers socialize math with their preschoolers during mealtimes and what relations with early math skills exist when math skills are measured a year later.

Math in the home environment of young children

The current research on math experiences at home shows that parents and their children are involved in a variety of math-related exchanges before children enter a formal school setting (Anderson, 1997; Saxe, Guberman, & Gearhart, 1987; Skwarchuk, Sowinski, & LeFevre, 2014). However, families vary in the frequency and types of math activities they engage in with their children at home. The amount and type of math exchanges vary by the data collection method (i.e., questionnaires, interviews, and observations of structured play activities).

In general, studies that use structured observations or experimental situations show a wider range of math-related exchanges than studies using other methodologies. For example, observations of parent–child interactions in play activities, such as cooking, reading, or playing with money, highlight math interactions related to buying or selling goods (e.g., explaining the cost of the good) as well as conceptual and procedural understanding of math (i.e., how to use mathematical objects; Vandermaas-Peeler, Boomgarden, Finn, & Pittard, 2012; Vandermaas-Peeler, Nelson, & Bumpass, 2007; Vandermaas-Peeler, Nelson, Bumpass, & Sassine, 2009). When one looks at the research that comes from self-report questionnaires, however, it seems that parents fail to recognize that some activities they participate in include math (Cannon & Ginsburg, 2008). They report a limited range of actions, mainly focused on foundational skills (e.g., counting, naming numbers, teaching numbers, recognizing written numerals; Cannon & Ginsburg, 2008; LeFevre et al., 2009; Skwarchuk, 2009), compared to the range captured via other research methods, such as observation or experiments.

Looking at how parents talk about math with their preschool children is another approach to studying math at home. Researchers who have observed and recorded naturalistic math-related language between parents and children have found that there is variability in the frequency of number words produced by parents (Levine et al., 2010; Ramani, Rowe, Eason, & Leech, 2015). For example, Levine and colleagues (2010) observed the frequency of number talk among mothers and their 14- to 30-month-old children in naturalistic contexts. They looked at the amount of number words from 1 to 10 as well as the parents' use of the words *count, how many*, and *number* (i.e., number elicitations) and found individual variability in number talk among families, ranging from a total of four to 257 number words and from zero to 30 uses of parent elicitation of child number talk.

Also, parents and children produce number words with different uses, which shows that the quality, and not only the amount, of math talk is a factor to consider when studying the verbal math input that children receive at home (Gunderson & Levine, 2011; Ramani et al., 2015). Other researchers have also looked at differences in math input in terms of the language used at home (Chang, Sandhofer, Adelchanow, & Rottman, 2011) or the gender of the child (Chang, Sandhofer, & Brown, 2011). They have found that boys receive more math talk involving cardinal values than girls (Chang, Sandhofer, & Brown, 2011) and that parents speaking Mandarin produce more number talk than parents speaking English (Chang, Sandhofer, Adelchanow, et al., 2011).

The mathematical verbal input that young children receive from their caregivers varies depending on the socioeconomic status (SES) and educational background of the families. Families with a low-SES background provide more input about counting, whereas parents in high-SES families place more emphasis on the cardinal value of sets in their talk with children between 14 and 30 months of age (Levine et al., 2010). But there is also variability within the same SES group. Indeed, Ramani et al. (2015) found that parents of preschoolers attending a Head Start center produced a wide range of math talk utterances in semistructured interactions involving a book, a puzzle, and a board game, ranging from 20 to 151.

Math talk and early math skills

The math-related verbal input that children receive at home before kindergarten is a positive predictor of early numerical knowledge and performance in early math tasks (Levine et al., 2010; Ramani et al., 2015). The amount of parental talk about numbers from 1 to 10 with children between 14 and 30 months has been found to be related to children's early mathematical understanding of the cardinal meaning of the number words at 46 months (Levine et al., 2010). But other studies indicate that not only the amount but also the quality of parental math talk is linked to early numerical knowledge. For example, Ramani and colleagues (2015) found that advanced math talk (i.e., math talk involving cardinality, ordinal relations, and arithmetic) is linked to preschoolers' understanding of numerical knowledge and magnitude comparison. Similarly, Gunderson and Levine's (2011) study highlighted the role of math talk involving large sets of present objects (i.e., sets of four to 10 objects) in predicting children's cardinal number knowledge.

Together, the results of these studies indicate that children who are exposed to number talk and to more advanced math talk at home have better mathematical knowledge and skills. Despite these findings, these studies have mainly been conducted in structured settings. Moreover, the relations between naturalistic math talk in the home and early math skills have not been explored beyond 4 years of age.

The current study

Although the field of home numeracy has been devoted to understanding the home-related factors linked to early math skills, there are several unresolved questions. Most of the data come from structured studies of mother–child interactions with mathematical objects (Saxe et al., 1987), short-term observation of free play (Vandermaas-Peeler et al., 2007, 2009, 2012), or parental reports (LeFevre et al., 2009). Less work has been done using nonintrusive methods that look at the breadth of the home context as it relates to numeracy (but see Tudge & Doucet, 2004).

The studies that analyze number talk at home do provide a more naturalistic picture of the math input to which young children are exposed. However, these studies have done this by studying children younger than 4 years of age (Levine et al., 2010) or by looking at very specific math interactions, such as math lessons (Tudge & Doucet, 2004). Less explored has been how mothers engage in math with their children in natural contexts during daily routines and how these exchanges are linked to children's early math skills.

Researchers looking at spontaneous math input in the home have recorded different types of activities in an attempt to obtain math input as naturally as possible. Indeed, studies have analyzed naturalistic interactions taking place during common activities, such as book reading, play time, or snack or mealtime (Chang, Sandhofer, Adelchanow, et al., 2011; Chang, Sandhofer, & Brown, 2011; Levine et al., 2010). However, analyzing all contexts as similar might ignore the advantages that some have for the socialization of math skills. In particular, the mealtime context is advantageous not only for learning social and cultural rules (Snow, Perlmann, Gleason, & Hooshyar, 1990) but also for engaging in explanations and narratives (Beals, 2001) that foster language and literacy skills (Snow & Beals, 2006). Thus, it was hypothesized that mealtimes could also be a key context for analyzing math talk in the home.

In addition to contextual factors, other child-related variables have also been studied when attempting to understand children's early math skills. One of them is self-regulation, which was documented by a recent meta-analysis as positively and significantly related to math skills in preschool and kindergarten (Allan, Hume, Allan, Farrington, & Lonigan, 2014). Because the development of self-regulation abilities occurs through interaction with social agents, such as parents and primary caregivers in the home (Morrison, Ponitz, & McClelland, 2010), the contribution of self-regulation must also be considered when looking at the socialization of math skills in the home context. For example, when parents engage their children in math activities, such as ordering numbered magnets on the refrigerator, they are promoting these self-regulatory skills. A child might inhibit his or her desire to play with other attractive toys in the room or with other unnumbered magnets, focusing instead on the game that he or she is playing with the mother and holding the relevant information in mind that is needed to order the magnets from 1 to 10. Despite the evidence linking math skills and self-regulation, however, most studies of naturalistic interactions with math at home do not include self-regulation as a covariate.

Accordingly, the aim of this study was to examine the ways in which mothers talk with their preschool children about math at home and how this math talk relates to children's early math skills a year later. Though the connection between home numeracy and early math skills has been studied, how home-based naturalistic math talk during mealtimes is linked to math outcomes remains unexplored. The present study offers a unique perspective on examining math talk in mother–child dyads by analyzing naturalistic talk in the home and its relation to children's early math skills 1 year after the study.

Method

Participants

The participant families were part of a larger study designed to investigate variation in parenting during the preschool years by using the Language ENvironment Analysis System (LENA), an enhanced audio recorder. Forty typically developing preschool children (27 boys and 13 girls) and their mothers participated in this study. The children ranged in age from 3 years, 10 months, to 5 years, 9 months (M = 4 years, 6 months; SD = 5.5 months) at the first wave of the study (Wave 1). In order to diversify the sample in terms of the educational and socioeconomic background of the families, recruitment was accomplished in three different ways: first, through direct mailings to mothers whose children were attending Head Start centers in the surrounding area of a midwestern city; second, through fliers and invitation letters in preschool centers in the same area; and third, through an advertisement posted in a free local parent newsletter. Families were invited to participate in a study of the different topics that they talk about at home. There was no mention of the math-related interactions that the present work examines.

Mothers and children were asked to record 3 days of conversation using the LENA tool and then to complete some questionnaires (mother) and assessments (child). The primary language of the mothers and children who consented to participate in the project was English. The participating children were attending preschool at the time of the study and had not been diagnosed with disabilities or major illnesses.

Descriptive statistics for the participant families are presented in Table 1. On average, mothers in the current sample had 15.5 (SD = 2.17) years of education, or slightly more than 2 years of college. Mothers' educational level ranged from 12 years of education (i.e., having completed high school) to 18 years of education (i.e., having earned an advanced degree, such as a master's, doctoral, or similar degree). The income of the participating families was measured through their income-to-needs ratio (Dearing, McCartney, & Taylor, 2001), computed by dividing the family income by the poverty threshold, considering the family size (U.S. Census Bureau, 2010). The average income-to-needs ratio of the participant families who reported their income in the first wave of the study was 3.32 times the poverty threshold (SD = 2.03), and this ratio ranged from 0.45 to 9.04. In terms of ethnicity, 26 of the children were Euro-American, eight were African American, one was Hispanic, another was Asian Indian, and three were multiracial. One of the families did not report the ethnicity of the participant child.

One year after the mothers and children recorded their conversations they were contacted by the research team and invited to participate in the second wave of the study (Wave 2), which involved parental questionnaires and child assessments but not recordings. A total of 35 of the 40 families decided to continue in the study. Three families had moved to other places, one declined to

Table 1. Descriptive statistics for child and family sociodemographic factors in waves 1 and 2.

	Wave 1 (N = 40)				Wave 2 (N = 35)			
Continuous Variables	M	SD	n	Range	M	SD	n	Range
Child age in months	53.75	5.47	40	46–69	67.43	6.30	35	58–84
Family income-to-needs ratio	3.32	2.03	33	0.45–9.04	4.19	2.65	27	0.49–12.93
Maternal education	15.50	2.17	40	12–18	15.71	2.16	35	12–18
Categorical variables	n	%			n	%		
Child ethnicity								
African American	8	20			6	17.1		
Euro-American	26	65			24	68.6		
Hispanic	1	2.5			1	2.9		
Asian	1	2.5			1	2.9		
Multiracial	4	17.5			4	11.6		
Did not report	1	2.5						
Child gender								
Male	27	67.5			24	68.6		
Female	13	32.5			11	31.4		
Child living with parents								
Living with mother only	8	20			8	22.9		
Living with both parents	32	80			27	77.1		
Number of siblings								
None	6	15			4	11.4		
One	23	57.5			20	57.1		
Two	6	15			8	22.9		
Three	4	10			3	8.6		
Did not report	1	2.5						
Child current schooling experience								
Currently in maternal care	1	2.5			0	0		
Preschool								
Head Start	10	25			2	5.7		
Other preschool	29	72.5			12	34.3		
Kindergarten	0	0			21	60		
Maternal employment								
No employment	20	50			17	48.6		
Part time	10	25			8	22.9		
Full time	10	25			10	28.6		

participate because of busy schedules, and another did not respond to the research team's messages. Of the 35 families that agreed to participate in the second wave, one was living outside the country. In that case, the mother completed the questionnaire online, but there were no corresponding child tests. Three fifths of the children (n = 21) were attending kindergarten at the time of the second wave. Descriptive statistics are presented in Table 1.

Procedure

During the first wave of data collection, mother–child dyads were visited twice in their homes by two researchers during the 2010–2011 school year. Mothers who completed a home visit received a small monetary incentive and a small gift for her child to show appreciation for their participation in the study. During the first visit, the researchers oriented the participants as to how to record their daily interactions using the LENA tool. The mother and child were also given specialized clothing and accessories to wear while using the recorders. Mothers wore either a lanyard around their necks, similar to an identification card holder, or a pocket clip in which they put the recorders. Children wore a T-shirt with a padded snap pocket on the front.

The mother and child were instructed to record the spontaneous speech that occurred during the time the child was at home with his or her mother. They recorded their interactions at home from the time the child woke up until he or she went to bed at night over 3 days (2 weekdays and 1 day on the weekend). Each mother and child recorded their daily conversations using different LENAs on each day.

Furthermore, at the end of each recorded day, mothers completed a brief questionnaire about the activities they did and the times they occurred (e.g., the time the child woke up, activities they did).

During this first visit, mothers were also asked to complete a demographic questionnaire while the child was evaluated on his or her early academic skills using an assessment lasting approximately 45 min. The assessments included tests of cognitive and academic skills that were part of the larger study, and these tests were administered in a counterbalanced order. During the second visit, the researchers collected the recordings that had been made, along with the questionnaires summarizing the recorded activities.

The second wave of data collection occurred during winter and spring of 2012, a year after the participant mothers and children recorded their daily interactions. This wave did not include recordings. Similar to the first part of the study, families were visited in their homes during the second wave, though only one visit was required at this stage. Mothers again received a small monetary incentive and a small gift for their children after the visit. Each mother was administered the same demographic questionnaire that was used in Wave 1, and her child's early math skills were assessed at the time of the home visit, with the assessment lasting 45 min on average. The administration of the child assessments was counterbalanced. Also, for the instruments that had parallel versions, Form A was used in the first wave of the study, whereas Form B was used in the second wave of the study.

Math talk at mealtimes

As this study focuses on the ways in which mothers talk with their children about math, only the recordings made by the mothers were used. A sample of the entire 3-day recorded period from the larger study was selected and analyzed for this study. For each dyad, 2 hr of the two available weekdays (i.e., 4 hr per dyad) were transcribed, coded, and analyzed in terms of math talk. One hour of each day corresponded to morning and breakfast time, whereas the other hour in both days corresponded to dinner time.

The talk about math that occurs during breakfast and dinner might not be representative of the talk occurring at other times during the day. However, both breakfast time and dinner time were chosen based on existing literature that shows the richness and sophistication of conversation during mealtimes (Tabors, Beals, & Weizman, 2001). Also, preliminary analysis of the pilot data showed that families talked more about math during both breakfast and dinner time compared to other structured times during the day, such as bedtime. Given the goal of the study, which was to examine and analyze maternal math talk, coding those times of the day in which mothers and children talked most about mathematics allowed for reaching that goal. Moreover, structured activity times were chosen over free time, as the variety of activities mothers and children engage in during their free time was deemed too diverse for comparison across families. Thus, breakfast and dinner time provided the least variable setting, allowing for cross-family comparisons. For much the same reasons, the 2 weekdays were chosen over the weekend day because family routines were generally more dissimilar on the weekends compared to the weekdays.

Each analyzed timeframe included up to an hour of recording time so that in total up to 4 hr per dyad were analyzed (i.e., 1 hr at breakfast and 1 hr at dinner for each of the 2 days). The total number of recorded minutes varied depending on the exact duration of each recording. Even though mothers and children were asked to record the entire time the child was at home, in the end some of them did not record a complete hour at the analyzed times. On average, breakfast or dinner lasted 47 min (SD = 20 min). The average length for each mealtime was similar across days as well as between breakfast and dinner. To control for variations in recorded time, we used the total number of recorded minutes to create a proportion of maternal math talk, used in the regression analysis.

The specific start and end times that corresponded to either breakfast or dinner were selected by a trained research assistant and confirmed by one of us. The decision was based on the notes written by the mothers, which served as guidelines for selecting the 1-hr timeframe. Yet because these notes included broad ranges that did not allow for establishing specific start and end times, the automatic LENA reports were used to determine the exact minutes to be analyzed from the range provided by the mothers.

The LENA device, as a digital language processor, provides automatic reports that include information about the number of words that are spoken by an adult to/near the child. Thus, these reports allowed the research team to see the time of the day in which most of the meaningful speech (i.e., direct speech from an adult that the child is exposed to) occurred in intervals of 5 min. This information was used to select the specific start and end times for each timeframe (i.e., breakfast or dinner time), as the goal was to include times in which families would talk the most. If a dyad showed similar amounts of meaningful speech for more than 1 hr, the 1-hr timeframe was selected by looking at the other reports produced by the LENA, such as the words spoken by the mother (i.e., adult's words), the child's vocalizations (i.e., child's speech), and the conversational turns between mother and child during the time the meaningful speech occurred.

In the majority of the cases, mothers and children were eating during the recorded breakfast and dinner times. That said, they did not spend the entire hour eating but were also engaged in preparing the meals, cleaning up, or doing other activities. Because the goal of the study was to capture naturalistic maternal math talk, it was expected that mothers and children would engage in a variety of activities during those times.

Math talk coding schema

Once the specific timeframes were selected, the audio files recorded by the mothers were transcribed using Transcriber (Boudahmane, Manta, Antoine, Galliano, & Barras, 2005), a computer software program that transcribes audio files while aligning the transcription with the corresponding audio. Each 1-hr audio file was transcribed at the utterance level. Utterances were defined as sentences by one speaker bounded by intonation, grammatical closure, prolonged pauses, or transition to another speaker (Melzi, Schick, & Kennedy, 2011; Pan, Rowe, Spier, & Tamis-Lemonda, 2004). The audio files were transcribed to include all spoken words by all speakers, but only the talk by the participating mothers was analyzed for this study. Trained, native-English-speaking research assistants transcribed all of the language used in this study. Two independently trained research assistants then verified 20% of the transcripts. The average reliability for the transcriptions among the research assistants was 97.3%.

The maternal input was coded for math content using an adaptation of Levine et al.'s (2010) coding schema. The types of math talk from Levine et al.'s (2010) work included in this study involved cardinal values, counting, naming digits, units of measure, conventional nominatives, and number comparisons. Because the children in the current study were older than the ones in Levine et al.'s (2010), some additional categories were identified and added to capture other types of math input that mothers provided to their 4- to 5-year-old children during the recordings. These additional categories were also based on prior research about math input and math development, and they included interactions involving ordinal numbers (Anderson, 1997) and calculations such as addition, subtraction, division, or percentages (Anderson, 1997; Klibanoff, Levine, Huttenlocher, Vasilyeva, & Hedges, 2006). Table 2 presents the types of math talk included in this study.

Intraclass correlation coefficients (ICCs) were used to estimate the interrater reliability among the coders (Shrout & Fleiss, 1979). A total of 20% of the transcripts were independently coded by two trained research assistants, and ICCs were calculated for the total math talk and for all of the different types of math talk (e.g., naming digits, ordinal numbers). The reliability for the total amount of math talk was high (ICC = .99), as was the reliability for the different types of math talk (ICCs = .92–.99). When disagreements occurred among research assistants, they were discussed until resolved.

Family demographics

The demographic aspects of the families were assessed using a self-administered questionnaire. This questionnaire included questions about family composition, income, educational background, ethnicity, gender, age, and child care experience. Age of the child and maternal education were included in the regression analysis as control variables.

Table 2. Math talk coding categories.

Category	Description	Example From Mother's Input
Cardinal values	Mentioning or asking for the number of objects immediately, without counting	"I'm going to put one [bottle] in the freezer so you can have it with dinner."
Counting	Counting objects or listing numbers in an increasing order of regular intervals	"Hey. Jane.[a] Get dressed. One … Two … Ready? Get dressed before I count to 3."
Naming digits	Referring to numbers, reading of numerals on paper and in other forms of media, recognizing names of written numbers when seen, or writing numbers	"There is a 3." [mother's response to child's question about what number was the one on the computer screen]
Units of measure	Using numbers to refer to units of measure	"You just turned 4." [after the child said he turned 5]
Conventional nominatives	Using numbers as labels for things or dates	"No, only high fives for me. Punch fives hurt me. Punch fives hurt me; could you give me a high five?"
Number comparisons	Comparing numbers in a sequence	"What number comes after 13?"
Ordinal numbers	Using ordinal numbers, such as *first, second, third*, etc.	"… the first one said, 'It's getting late' … and the second one said, 'There are witches in the air.'"
Adding/subtracting	Performing or asking to perform adding and subtracting calculations	"Okay, I will teach you, but we have to learn how to do 2 plus 2."
Division/fractions/percentages	Performing or asking to perform division calculations, or using fractional values or percentages	"Did you just ask 3 divided by 7?"

[a]A pseudonym.

Mathematical abilities

In the second wave of the study, children's mathematical skills were measured using the Test of Early Mathematics Ability–Third Edition (TEMA-3; Ginsburg & Baroody, 2003). The TEMA-3 is a standardized test designed to measure mathematical ability in children between 3 years, 0 months, and 8 years, 11 months. The test measures informal and formal knowledge of both concepts and skills in a variety of domains (Ginsburg & Baroody, 2003). *Informal mathematical knowledge* is acquired outside the context of schooling, and it underlies the basic mathematical knowledge that is taught in school, whereas *formal mathematical knowledge* represents the concepts and skills that children learn in school (Ginsburg & Baroody, 2003). *Concepts* are defined as the understanding of procedures, and *skills* refer to procedural knowledge, both of which are essential aspects for using mathematics effectively (Ginsburg & Baroody, 2003). This test has internal consistency alphas equal to or above .92 for the different age intervals (Ginsburg & Baroody, 2003). For this study, the raw score on the TEMA-3 was used as the outcome for the regression analysis. Children's mean on this test was 30.21 (SD = 13.02).

Self-regulation

A measure of the child's ability to regulate his or her behavior, the Head–Toes–Knees–Shoulders task (Ponitz, McClelland, Matthews, & Morrison, 2009), was obtained in the first wave of the study and included as a control variable. This task requires the child to control and direct his or her actions (i.e., inhibitory control), to pay attention, and to remember instructions (i.e., working memory). It is a structured observation of the child's performance of the opposite of a dominant response to one of four commands. For example, the child is asked to touch his or her toes each time the examiner says, "Touch your head," and to touch his or her head every time the examiner says, "Touch your toes." Similarly, when the examiner says, "Touch your knees," the child is supposed to touch his or her shoulders, and the child is supposed to touch his or her knees every time the examiner says, "Touch your shoulders."

Results

Analysis strategy

In order to examine how mothers talked with their preschoolers about math, we added the number of instances of maternal math talk occurring across the 4 hr to obtain a measure of the cumulative math talk in the home. Then, the most and least common math talk types among dyads during breakfast and dinner time were identified. Finally, to answer the research question about the relation between math talk and children's math skills, we performed correlation and hierarchical multiple regression analyses.

Description of math talk

As shown in Table 3, there was wide variability in the math input that mothers provided to their children, ranging from four instances to 195 in 4 hr of recordings. On average, mothers involved their children in almost 38 instances of math talk over the 4 hr during breakfast and dinner time (SD = 34.18). The most common type of math input involved using cardinal values (42%). Mothers also engaged in interactions including units of measure in a fifth of their math talk instances. The remaining 30% of the maternal math talk instances involved naming digits, ordinal numbers, and counting (10% each).

Moreover, math talk involving cardinal values was the only type of math talk present in all dyads, as all mothers engaged in one or more interactions that included cardinal values. On average, there were 16 instances of cardinal values during the 4 hr (SD = 12.41). For example, at dinner, the mother

Table 3. Descriptive statistics for the different types of math talk (*N* = 40).

Type of Math Talk	M	SD	Min	Max	%
Cardinal values	15.73	12.41	1	54	41.9
Counting	3.65	5.11	0	22	9.7
Naming digits	3.75	16.11	0	102	10.0
Units of measure	7.65	5.86	0	29	20.4
Conventional nominatives	0.65	1.33	0	6	1.7
Number comparisons	1.08	4.38	0	27	2.9
Ordinal numbers	3.83	3.27	0	14	10.2
Adding/subtracting	0.93	3.74	0	23	2.5
Division/fractions/percentages	0.30	0.82	0	4	0.8
Total	37.55	34.18	4	195	

told the child, "*One* bowl of ramen noodles coming right up!" In another case, the mother asked the child *how many* pieces of toast she would like, and then she said that she would make *two* pieces of toast for her.

Although mothers involved their children in math talk exchanges that included other categories of math input as well, these types of exchanges were less frequent. Mothers produced an average of eight instances involving units of measure (*SD* = 5.86; e.g., a mother told the child, "It's going to be a nice day as it is going to be almost *eighty degrees*") and four instances that included counting (*SD* = 5.11; e.g., the mother counted *one, two, three, four, five* to call the child to wash his hands before dinner). Also, on average, mothers used four instances of naming digits (*SD* = 3.75; e.g., when the mother and the child were spelling the name of a cereal brand and the mother told the child to spell the number *one*) or ordinal numbers (*SD* = 3.83; e.g., while eating breakfast the mother told the child that he had to *first* eat the eggs). Finally, there were only a few instances in the entire sample involving number comparisons and calculations.

Relation between math talk and children's early math skills

It was expected that the amount of math talk in naturalistic contexts would be positively related to children's early math skills a year after the recordings were conducted. To test this hypothesis, we used hierarchical linear regression using the proportion of maternal cumulative math talk produced in the 4 hr of interactions as the independent variable. This proportion variable was created by dividing maternal cumulative math talk by the number of minutes recorded to account for the variation in the amount of time recorded during the 4 hr. As this variable was not normally distributed and skewed, its natural log was used to ensure a linear relation with the outcome (Tabachnick & Fidell, 2007).

Table 4 displays the descriptive statistics for all independent, control, and outcome variables included in the regression analysis. As expected, correlation analyses indicated that the proportion of

Table 4. Descriptive statistics for variables included in the regression analysis predicting early math skills.

Variable	M	SD	Min	Max
Independent variable (Wave 1)				
Proportion of maternal cumulative math talk	0.21	0.21	0.04	1.08
Control variables (Wave 1)				
Child age (in months)	53.09	5.02	46	64
Maternal education (in years)	15.76	2.21	12	18
Self-regulation (HTKS)	16.64	13.71	0	38
Outcome variable (Wave 2)				
TEMA (raw score)	30.21	13.02	8	65

Note. N = 33. All control variables were measured at the first wave of the study. The natural log of the proportion of maternal cumulative math talk in the recorded minutes was used in the analysis to ensure a linear relation with the TEMA-3 raw score. None of the other variables required transformation. HTKS = Head–Toes–Knees–Shoulders task; TEMA = Test of Early Mathematics Ability.

Table 5. Hierarchical multiple regression analysis predicting the child's TEMA-3 raw score in the second wave of the study.

	Model 1			Model 2			Model 3		
Variable	B	SE B	β	B	SE B	β	B	SE B	β
Maternal control variable									
Maternal education (in years)	2.76	0.94	.47**	2.63	0.87	.45**	2.53	0.82	.43**
Child control variables									
Child age (in months)				0.59	0.42	.23	0.76	0.40	.29†
Child self-regulation (HTKS)				0.28	0.15	.29†	0.32	0.15	.34*
Proportion of maternal cumulative math talk							11.25	5.15	.31*
R^2	.22			.41			.50		
Change in R^2					.19			.09	
F for change in R^2		8.70**			4.68*			4.78*	

Note. $N = 33$. All control variables were measured at the first wave of the study. The proportion of maternal cumulative math talk was transformed to its natural log to be included in the analysis. TEMA = Test of Early Mathematics Ability; HTKS = Head–Toes–Knees–Shoulders task.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$.

cumulative maternal math talk ("maternal math talk" from here on) was positively related to the TEMA-3 raw score ($r = .17$), though this result was not statistically significant given the small sample size. Also, early math skills measured using the TEMA-3 were found to be related to maternal education ($r = .47$, $p < .01$), child self-regulation ($r = .46$, $p < .01$), and child age ($r = .30$, $p < .05$). Thus, all of these variables were included in the regression analysis as additional control variables.

In the regression analysis, the variables were entered in different blocks to predict early math skills. The first two models included different control variables whose links to early math skills have been documented. Model 1 included maternal education, measured in years at the time of the recordings, and Model 2 accounted for the child's age and self-regulation. Finally, Model 3 included the variable of interest, that is, maternal math talk (measured as the natural log of the proportion of cumulative math talk). Thus, this analytic approach, based on prior research, allowed for the building of a model that explored the relations between maternal math talk and children's early math skills after taking into account maternal education, child age, self-regulation, and minutes recorded.

As displayed in Table 5, Model 1 showed that the mother's educational level was a significant predictor of the child's mathematical knowledge, explaining 22% of the variance in the TEMA-3 raw scores. Model 2 pointed out that maternal education continued to be a significant predictor of early math skills, even after we took into account the child's age and self-regulation. This set of variables explained a significant 41% of the total variation in children's TEMA-3 scores. Furthermore, as expected, Model 3 showed that maternal math talk was related to the child's early math skills at $p < .05$, even after we took into account the control variables. Moreover, Model 3 explained a significant 50% of the total variance in the children's math knowledge and skills.

Looking at the incremental explained variance, we see that the addition of the child's age and self-regulation to the equation (Model 2) resulted in a significant increment of 19% of the variance in the scores of the TEMA-3, $F(2, 29) = 4.68$, $p < .05$. Model 3, which included the addition of maternal math talk as a proportion variable controlling for the recorded time, accounted for an additional 9% of the variance in children's TEMA-3 scores, $F(1, 28) = 4.78$, $p < .05$. Thus, these results support the hypothesis that maternal math talk predicts early math skills, even after the control variables are taken into account.

Discussion

Maternal math talk during mealtimes and early math skills

The naturalistic interactions between mothers and preschoolers in this study add to prior research by showing that families of older preschoolers do engage in math talk in many different ways during their regular routines at mealtimes. The findings of this study are consistent with prior research in showing a wide variability in the amount and types of math talk (Levine, Gunderson, & Huttenlocher, 2011; Levine et al., 2010; Ramani et al., 2015) and the fact that children have already been informally exposed to math in many ways and contexts by the time they start schooling (Ginsburg & Russell, 1981; Song & Ginsburg, 1987). The frequency of common types of math talk in the recordings illustrate that 4- and 5-year-olds are exposed to a great deal of informal mathematics at home at breakfast and dinner time. However, even though all children in this sample were exposed to informal mathematics at home, the results suggest that the varying amount of exposure to math talk creates different experiences in the home environment for these children.

Most of the mothers in this study involved their children in very few to no exchanges involving calculations or number comparisons, suggesting that these interactions might be uncommon in maternal input in the context of mealtimes. Considering the age of the children in this study and the existing literature (Ramani et al., 2015), the infrequency of these types of examples is not unexpected. The reasons for this might be that mothers are not focused on adding or subtracting during mealtimes, as these are not instructional or teaching times. Rather, mothers use numbers as a means of communicating information about the meals themselves (e.g., “Do you want *two* slices of bread?” or “You need to eat *three* pieces of broccoli before you leave the table”). The current study did not analyze the intentionality and quality of maternal math talk. Yet the distinction between direct instruction on the one hand and math vocabulary used in talk without the intention to teach math on the other hand should be addressed by future research.

As expected, the results of this study also found that maternal math talk is related to children’s math knowledge a year later, after the child’s self-regulation, maternal education, the child’s age, and the recorded minutes are taken into account. This means that the instances in which the mother’s input involved math talk played a role in the child’s formal and informal mathematical knowledge a year after the recordings. Mothers who produced math talk occurrences more often had children who performed better in tasks involving number facts, number comparison, calculation, and understanding of concepts.

In line with prior research (Clark, Sheffield, Wiebe, & Espy, 2012), self-regulation was a significant predictor of the child’s early numerical understanding and math performance. Thus, this finding adds to the growing body of research showing that self-regulatory skills are perhaps just as crucial in promoting children’s readiness for school as early math exposure (McClelland et al., 2007). The question of how families enhance these self-regulatory skills along with math skills is also critical for understanding the role that families play in promoting children’s academic skills from an early age. Thus, it would be interesting to explore not only how families socialize math at home but also the ways in which self-regulation is conveyed through talk in naturalistic settings.

In brief, the findings from this study propose that some children are exposed to more instances in which they can learn mathematics at home than other children. These opportunities, along with self-regulatory skills, relate to the development of early math skills. Some of the differences in mathematical skills were found to be related to the educational background of the mothers, such that more educated mothers had children with higher scores. However, after we controlled for this relation, maternal math talk at home was identified as a significant predictor of early math skills a year after these interactions.

Limitations of the study and future directions

The current study looked at maternal math talk during mealtimes in naturalistic interactions. As this study was a pioneer in the use of the LENA device as a method of gathering information about math talk, only mothers were included. However, it would be interesting to investigate how not only mothers but also fathers talk about math at home. Research with toddlers, for example, has found that mothers and fathers engage in different degrees of cognitively demanding questions with their children (Rowe, Coker, & Pan, 2004). Rowe and colleagues (2004) described the fact that fathers produce more “why” questions than mothers and that children talked more, used more diverse vocabulary, and produced longer utterances when talking with fathers compared to mothers. Other research, however, has found the reverse—that fathers use less complex language with their children and ask less demanding questions than mothers (Davidson & Snow, 1996; Tenenbaum & Leaper, 1997). Nevertheless, there is no evidence to date regarding fathers' math talk and the quantity and quality of math words that they produce with their preschoolers. Moreover, differences in math talk could also depend on the number of children in the home or on whether one of the children has school-related math homework. Follow-up studies that include not only mothers but also fathers, and even other family compositions and structures (e.g., triads; Benigno & Ellis, 2004), would contribute to an understanding of how families socialize math.

Despite numerous attempts to diversify the sample during the recruitment process, this study included a selected sample composed of a majority of highly educated mothers. Also, the gender distribution of the children in this study was not even. Therefore, the generalizability of these findings is limited to mothers and children with characteristics similar to the ones in this study. Thus, future research should replicate these findings across socioeconomic and educational levels and in samples with even numbers of boys and girls.

This study focused on math talk with preschoolers during mealtimes. Although there was interesting variation in math talk among families, these results might not be representative of other times during the day, when other types of math exchanges could occur. That is, the focus on cardinality and other types of math in this sample could be related to interactions that frequently arise while one is eating or preparing dinner. Other times of the day (e.g., before bedtime or a time during the weekend) or structured activities (e.g., playing with board games or with construction toys) could evoke higher instances of other specific types of math talk. Thus, analyzing other times and activities across families could allow for evaluation as to whether the current results are representative of the input that children receive in general or just the input received during mealtimes.

This study focused on maternal math talk, but it did not look at mathematical dialogues occurring during mealtimes (Hojnoski, Columba, & Polignano, 2014). How children were responding to maternal math talk, as well as the discussion and explanations around math, were not captured in the present study. Future research could better explore not only spontaneous math vocabulary and concepts produced by both parents and children but also the math conversations in which these mathematical concepts are embedded.

This study provides an interesting avenue through which to explore how mothers engage in math at home and the resulting links to children's math outcomes. What is less clear from this study, nevertheless, is the direction of the relations between math talk and children's early math skills. Given the correlational nature of the study, it is possible that mothers who use more math talk may have children who are more interested in numbers. Thus, their children might have a better understanding and knowledge of mathematics, which could lead mothers to respond to children by engaging them in more math. Another possibility is that mothers who incorporate more math words and concepts into their talk do so because of their beliefs about the importance of mathematics (Cannon & Ginsburg, 2008). Mothers who talk more about math may also engage in more math-related practices, which are linked to early math skills (LeFevre et al., 2009; Ramani et al., 2015). Experimental research could provide understanding with regard to the direction of the links found in this study. Some possible avenues of clarifying these causal mechanisms could be randomly assigning children to groups receiving different amounts and types of math talk, examining changes in math talk and math skills over time, or including child talk in follow-up studies.

In addition to the home environment, there are other contexts in which children are potentially being exposed to math input. For example, the mathematical input that preschool or day care teachers provide to children in educational settings before entering kindergarten has been found to be related to the growth of children's math knowledge (Klibanoff et al., 2006). Thus, future research should include the math input that children are exposed to through their educational experiences in addition to the home input, as both sources would contribute to an understanding of children's early math skills.

Even given these limitations, this study adds to prior research by showing how children are exposed to informal mathematics during mealtimes at home before entering kindergarten. Prior research interested in capturing naturalistic interactions at home has either physically observed mother–child interactions (i.e., by using online coding or field notes; Tudge & Doucet, 2004) or videotaped ordinary activities (Levine et al., 2010). Both of these types of approaches, however, require the researcher to be in the home for the entire length of the recording, which would not have allowed for the naturalistic data gathered in this study. Thus, one of the strengths of this study is that it analyzed the maternal math talk occurring in natural contexts without prompting any emphasis on math. Future research should build on these findings to further disentangle the nature of math talk as well as the links between the different types of math talk and math skills.

General implications

The results of this study shed light on the nature of mother–child interactions in the home that support children's early mathematics, offering some guidelines for parents, caregivers, and practitioners on how to engage children in math in the home. Research shows that kindergarten teachers engage children in low amounts of math in general, and, when teachers do offer exposure, they concentrate on aspects that their students have already mastered and that therefore are not beneficial (Engel, Claessens, & Finch, 2012). Thus, by knowing what math input children are exposed to at home, kindergarten teachers might tailor the strategies used to promote children's numerical development. This would require an increase in home–school communication and a better alignment between home and school instruction. Also, teachers could foster their children's math skills by incorporating more math talk themselves in their classrooms (Klibanoff et al., 2006).

Families can also be targeted and given tools to improve their children's math performance. In line with work by Ginsburg and colleagues that indicates how parents could use their daily activities to think about math with their children (Cannon & Ginsburg, 2008; Ginsburg, Duch, Ertle, & Noble, 2012), this study suggests that talking about math during mealtimes could be used as an opportunity to engage parents and young children in math as a means of promoting early math skills. Indeed, mealtimes offer a scenario to encourage children to not only use math words but also engage in cognitively stimulating conversations around math, ask questions about math concepts, and participate in problem-solving activities that involve math (Ginsburg et al., 2012).

Consequently, efforts should be placed on providing parents with some instruction as to how to get their children involved in math talk at home. Giving them examples and guidance on how to talk about math while preparing meals, setting the table, serving the food, and clearing the table could be a fruitful avenue for engaging preschoolers in math. This can be done, for example, by discussing specific examples in meetings or parent–teacher conferences or by sending home newsletters with detailed discussions of how to use conversations during mealtimes to engage in math talk. Thus, provided with knowledge of specific activities and guidance on how to talk about math (Vandermaas-Peeler & Pittard, 2013), as well as information on how to capitalize on what their children are doing or saying during mealtimes, parents could encourage their children's math skills in everyday situations (Cannon & Ginsburg, 2008).

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