"MATH TALK" IN FAMILIES OF PRESCHOOL-AGED CHILDREN: FREQUENCY AND RELATIONS TO CHILDREN'S EARLY MATH SKILLS ACROSS TIME

by

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DEDICATION

To Alejandro and Olivia

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ABSTRACT

Early math skills are the strongest predictors of later math achievement in school. This two-wave study addressed three research questions about the role of families in fostering these skills in preschool-aged children. First, how do families talk about math at home? Second, how do these conversations vary across families with different educational levels? And third, how do math-related conversations and reported math-related practices relate to early math skills when children are attending preschool and a year later?

The current study analyzed four hours of mother-child naturalistic conversations about math (i.e., math talk) from each of 40 families, who recorded their exchanges in their homes using a recording device (Language ENvironment Analysis System, LENA). The results found variability in math talk, in terms of the number, length, type, and complexity of the conversations. Families frequently engaged in exchanges involving *naming numbers, ordinal numbers*, and referring to numbers in the context of *time*. However, the majority of the math talk did not involve a higher level of complexity.

The results also found that families with higher educational attainment engaged in more *naming numbers* math talk, had a larger amount of conversations about *fractions*, and were involved in longer exchanges including *fractional values*, compared to those with a lower educational level. Conversely, mothers with less education involved their children in a higher proportion of *counting* exchanges than their counterparts with more education.

Moreover, being exposed to more utterances of math talk involving *fractions* was related to children's math performance a year after the recordings, even after controlling for children's

cognitive and academic skills. In addition, the number of times in which families engaged in *naming numbers* was correlated with math achievement in the first wave of the study, whereas the length of *counting* exchanges was negatively correlated with math achievement in the second wave. Also, engaging in math-related activities at home was positively associated with children's math skills, whereas engaging in counting games was negatively correlated with children's math performance. Finally, other skills, such as children's early vocabulary, reading skills, and self-regulation, were relevant in explaining children's early math skills.

CHAPTER I: INTRODUCTION

The Role of the Home Environment in Promoting Children's Cognitive and Early Academic Skills

Research provides robust evidence that the home environment constitutes a powerful learning setting, and that the stimulation and support provided by caregivers are among the strongest factors related not only to the development of children's cognitive skills during preschool years but also to children's achievement in reading and math in elementary school (Hood, Conlon, & Andrews, 2008; Lareau, 2003; LeFevre et al., 2009; Morrison, Bachman, & Connor, 2005; Morrison & Cooney, 2001; Roberts, Jurgens, & Burchinal, 2005; Weigel, Martin, & Bennett, 2005). However, the home environment of preschoolers has been studied with a greater emphasis on family practices of literacy and their relation to language and reading in young children. Thus, most of the intervention programs that have been created during the past few decades have been designed to foster language and literacy in children from low income populations, who show lower literacy skills and have benefited from these programs (Britto, Fuligni, & Brooks-Gunn, 2006). Unfortunately, less is known about the relation between family-related factors and children's early math skills, and only recently has research devoted more attention to the math experiences that children have at home before schooling (i.e., home numeracy) and how they promote children's understanding of the number system and mathematical techniques to solve quantitative or spatial problems (LeFevre et al., 2009).

Along those lines, even though parents report to believe that math activities at home are important for their children's learning and that mathematics learning should be incorporated in their children's daily activities (Cannon & Ginsburg, 2008; Skwarchuk, 2009; Sonnenschein et al., 2012), they also mention that math learning is not as important for preschoolers as is learning about daily living skills and literacy (Cannon & Ginsburg, 2008; LeFevre, Polyzoi, Skwarchuk, Fast, & Sowinski, 2010; LeFevre et al., 2009; Skwarchuk, 2009), and that math skills are not as important for their children's later success in school when compared to learning about reading, social skills or comprehension (Musun-Miller & Blevins-Knabe, 1998). Moreover, parents report that they do not have any specific goals for their child's math learning and that they are uncertain about what mathematics their child could do or how they could help him or her to master those skills (Cannon & Ginsburg, 2008). Consequently, parents describe that they engage in and emphasize more activities related to literacy (e.g., letter-related activities) or social skills with their preschoolers, results that are not affected by the educational background of the family, ethnic group, gender of the parent, and even the parents own experiences with mathematics (Musun-Miller & Blevins-Knabe, 1998). Moreover, when parents engage in math activities at home, the frequency of those practices is low, compared to those that promote reading, and these activities are mostly focused on instructional interactions intended to teach the basics of the numeric system (Blevins-Knabe, Austin, Musun, Eddy, & Jones, 2000).

This lower parental endorsement of math activities, compared to the importance attributed to reading for preschoolers, and apparent parental lack of specific goals for their children's early math learning have been explained by looking at the parental understanding and knowledge about early math development and ways to foster preschoolers' mathematical abilities at an early age, as well as the parental lack of awareness of the importance of numeracy at home. Parents may not be as sensitive to numerical issues as they are to reading, and they may think of math as an area that is more prominent later in development (Musun-Miller & Blevins-Knabe, 1998). It might be the case that parents do not know how they can foster children's learning of math at home and the consequences of these interactions (Cannon & Ginsburg, 2008) or that they do not see math activities at home as a priority for their children (Blevins-Knabe et al., 2000). Parents might not be totally aware of the wide range of activities through which they can promote their children's math understanding and learning at home (Cannon & Ginsburg, 2008). This issue can also be related to the strong emphasis of messages from researchers and practitioners to involve parents in shared reading or other reading-related activities, for which math does not have a parallel (LeFevre et al., 2009; Tudge & Doucet, 2004).

Even though the promotion of early math skills at home has not received as much attention as the improvement of preschool-aged children's literacy skills, the math skills that children show at school entry are the strongest predictors of their later achievement in school, as shown by a recent meta-analysis that looked at six longitudinal datasets from the U.S and the U.K. (Duncan et al., 2007). Children who have been taught a basic understanding of numerical knowledge (e.g., counting forward and backward, understanding the number line, understanding the base-ten system) when entering school are better equipped to learn arithmetic skills and other important numerical operations, which allow them to do better at mathematical learning in school compared to children who do not have that understanding (Griffin & Case, 1996). On the other hand, children who start their schooling process with lower math skills than their peers are at a higher risk of having difficulties in school, as individual differences in early math skills are strongly related to later mathematics achievement (Jordan, Kaplan, Nabors Oláh, & Locuniak, 2006; Lee & Burkam, 2002). Starting school with lower math skills is especially damaging for children from families with low-socioeconomic and educational backgrounds who show lower performance in math at school entry (Griffin & Case, 1996; Lee & Burkam, 2002; see Starkey & Klein, 2008 for a review). In fact, significant differences in early math skills from as early as three years of age have consistently been reported as one of the elements that contribute to the achievement gap that exists between children from different socioeconomic and educational backgrounds (see Case, Griffin, & Kelly, 1999 for a review; Lee & Burkam, 2002). Thus, as in the case of literacy, one crucial approach to understanding these differences in academic performance and to narrowing the achievement gap is studying the ways in which early math skills, and not just literacy skills, might be promoted at home before children begin schooling.

The available research in the area of home numeracy to date shows that, despite the fact that parents think that math abilities comparatively are not as important as reading abilities, they believe that early math skills play a significant role in their children's development of later math skills (Blevins-Knabe & Musun-Miller, 1996; Cannon & Ginsburg, 2008; LeFevre, Polyzoi, et al., 2010). They also attribute importance to the development of early math skills at home (Blevins-Knabe et al., 2000; Musun-Miller & Blevins-Knabe, 1998; Skwarchuk, 2009), and engage in different types of math activities at home (Anderson, 1997; Cannon & Ginsburg, 2008; Saxe, Guberman, & Gearhart, 1987), although their frequency is lower compared to the practices that parents report related to literacy (Cannon & Ginsburg, 2008). In fact, these math-related interactions vary in their rate of occurrence; there are practices that occur very often whereas others rarely occur (LeFevre et al., 2009). They also range from activities in which parents teach their child specific number abilities that promote numeracy skills (e.g., teaching to count numbers down) to activities in which parents involve their child in indirect interactions with numeracy through real-life tasks that incidentally promote the development of math skills (i.e., the learning of numeracy knowledge occurs in an indirect way through real-life tasks, such as cooking) (LeFevre et al., 2009; Vandermaas-Peeler, Boomgarden, Finn, & Pittard, 2012). Moreover, these differences among families in terms of frequency, range, and complexity of their math-related interactions are associated with the educational and socioeconomic background of the families (Saxe et al., 1987; Tudge & Doucet, 2004; Vandermaas-Peeler, Nelson, Bumpass, & Sassine, 2009). However, early math skills have been shown to improve by interventions involving parents at home (Starkey & Klein, 2000).

Accordingly, the ways in which families socialize mathematics at home (Benigno, Ellis, & Saracho, 2008; Starkey & Klein, 2008) and how preschoolers interact with a numerical environment and engage in mathematical activities from an early age (Saxe et al., 1987; Seo & Ginsburg, 2004) seem to be essential factors in supporting children's numerical development (Blevins-Knabe et al., 2000; Blevins-Knabe & Musun-Miller, 1996; LeFevre et al., 2009; Levine, Suriyakham, Rowe, Huttenlocher, & Gunderson, 2010). However, most of the research with preschool-aged children to date has investigated the frequency and range of family practices with regards to children's early math development by using parental interviews, self-reports and/or short observations of lab tasks of families and children engaging in prototypical math activities or free play (LeFevre, Clarke, & Stringer, 2002; LeFevre, Polyzoi, et al., 2010; Saxe et al., 1987; Vandermaas-Peeler et al., 2012; Vandermaas-Peeler, Nelson, & Bumpass, 2007; Vandermaas-Peeler et al., 2009). Even though these studies provide evidence of the role that families play in the development of early numerical knowledge and the prediction of early math skills in school, they do not include a wide range of experiences or the variety of interactions to which children are exposed to at home during their daily activities. There are a few available observational studies of the ways in which families discuss numbers with their children in naturalistic settings and how these experiences relate to the development of early numerical development (Levine et al., 2010; Tudge & Doucet, 2004), but these studies have looked at mothers' number talk or math-related lessons with very young preschoolers (up to 36 months of age) (Durkin, Shire, Riem, Crowther, & Rutter, 1986; Levine et al., 2010; Tudge & Doucet, 2004) and it is not clear whether other types of interactions or conversations about math at home between parents and older preschool-aged children would predict individual differences in early math skills both when children are in preschool and in school. Thus, there is a crucial need to describe how families from different backgrounds promote their preschoolers' early math skills in their daily activities and routines at home, and how these aspects foster their children's math skills from an early age. It might be the case that the ways in which parents promote their children's early math skills at home are not captured through the methods that have been commonly used in this field.

Accordingly, this dissertation investigates how math talk at home, captured through mother-child naturalistic conversations over the course of a week, is related to children's early math skills at two time points (when children are attending preschool and a year later) in families with different educational backgrounds. This dissertation offers a unique perspective on examining math talk in families with different educational levels by analyzing rich naturalistic conversations over an extended period of time in the home to provide a better understanding of the mechanisms by which parents promote children's early math skills in natural contexts.

Parent-child Math-related Activities at Home

Even though parents report to engage more often in literacy and reading interactions with their preschoolers at home, research using parental questionnaires, interviews, and observations of structured and play activities between parents and preschoolers shows that parents and their children are involved in a variety of math experiences, although there is an important variability in terms of the frequency and type of activities that are more and less prominent among families, and the results vary by the method of collection used by researchers (Anderson, 1997, 1998; Blevins-Knabe et al., 2000; Blevins-Knabe & Musun-Miller, 1996; LeFevre et al., 2002; LeFevre, Polyzoi, et al., 2010; LeFevre et al., 2009; Plewis, Mooney, & Creeser, 1990; Saxe et al., 1987; Skwarchuk, 2009; Tudge & Doucet, 2004; Vandermaas-Peeler et al., 2012; Vandermaas-Peeler et al., 2007; Vandermaas-Peeler et al., 2009). In general, studies that use structured observations or experimental situations show that parents and children engage in a variety of math-related activities, whereas when parents are asked to report the activities with their child, it seems that the range of experience is more limited. When looking at the research that comes from self-report questionnaires, parents of preschoolers seem to rely exclusively on a few contexts that focus on numbers and operations (e.g., naming numbers, teaching numbers, recognizing written numerals, etc.) for the learning of math, instead of also promoting math through different activities that occur on a daily basis (e.g., cooking) or emphasizing different components of math, such as measurement or comparisons of object properties (Cannon & Ginsburg, 2008), that appear in other studies that use observational measures.

Activities related to the teaching of basic number skills have been reported by families as the most common practice that they engage in with their preschoolers. Parents are likely to report helping their preschool-aged children to learn ideas about mathematics by teaching them basic skills such as counting (Skwarchuk, 2009) or the names of numbers, instead of more complex skills such as how to print numbers (LeFevre et al., 2002). Moreover, lab studies show that when mothers are prompted to teach their child about specific math skills, such as counting and finding a number on a board, they are able to teach their child the required skills and provide the appropriate math assistance (Saxe et al., 1987). Teaching these basic skills has been reported to occur not only in structured learning experiences (i.e., through direct teaching and workbooks) (LeFevre et al., 2002) but also, and at a higher frequency, while reading books, while involved in more unstructured contexts such as doing household chores, and through educational television shows (Cannon & Ginsburg, 2008). Activities involving numbers skills (e.g., counting objects, sorting things by size or color, or identifying names of written numbers) are also reported by parents as occurring at a high frequency at home even when parents do not teach these skills to their child (LeFevre et al., 2009). Along these lines, counting objects is one of the most common events that parents report to engage in with their child in terms of math (Blevins-Knabe et al., 2000), occurring approximately a few times a week (Blevins-Knabe & Musun-Miller, 1996; LeFevre et al., 2009), a similar rate to the rate of occurrence of activities related to printing numbers (LeFevre et al., 2009).

Other common parent-child activities involving math that have been found in some studies, as reported by parents, are ordering the events of the day (Blevins-Knabe & Musun-Miller, 1996), and praising the child for using numbers (Blevins-Knabe & Musun-Miller, 1996). Saxe and colleagues in their seminal work on the influence of social processes on early math development (1987) also highlight the role of playing games with numbers in parent-child interactions, as all parents in their study reported engaging in playing a number game of their invention at least once a week. Nevertheless, activities focused on number operations appear to be more prevalent in the interactions that families and children have at home, as shown by different types of studies, including observational research. In fact, videotaped observations of parent-child play interactions have confirmed these results, as number and operation activities were the most common exchange among parents and children who were asked to spend at least

10-15 minutes a day during 14 days on a math activity with different materials (i.e., bag that contained coloring, mazes, connect the dots, tape measure, stickers of numbers, play money and craft flowers) (Skwarchuk, 2009), as well as to cook a recipe together by following some specific steps (Vandermaas-Peeler et al., 2012). Counting is the most prevalent activity among parents and their four-year old children even in studies in which parents are asked to play with the materials provided by the research team in the way they would normally do and without any explicit instructions about focusing on math (Anderson, 1997). For example, a study that asked parents and their four-year old children to play with some provided materials (i.e., multilink blocks, a child's book, blank paper, and preschool worksheets, in addition to a pencil) during four separate times for 15 minutes over a period of two days, found that counting was the most common mathematical event (it happened in 55 out of the 82 15-minutes sessions analyzed), followed by naming shapes (present in 39 sessions) and naming numbers (present in 34 sessions) (Anderson, 1997).

However, the context of these parent-child observations is crucial to understand how families socialize math at home, and their role in other math activities, in addition to number operations. For example, observational research of naturalistic parent-child interactions has shown that comparing size and noting equality activities also occur at a relatively higher frequency (Anderson, 1997). Moreover, when parents and children are asked to play in other contexts (e.g., with a cash register, pretend credit card, and play money; or with toys related to a book that parent and child read) and are not informed about the numeracy focus of the study, teaching of basic number skills does not appear as the most common activity (Vandermaas-Peeler et al., 2009), and counting (Vandermaas-Peeler et al., 2007; Vandermaas-Peeler et al., 2009) and adding (Vandermaas-Peeler et al., 2007) are the least common types of math interactions. In fact, observations of parent-child interactions in play activities, such as cooking, reading, or playing with money show that the activities in these contexts are more likely to be focused on cultural exchanges (i.e., concepts related to buying or selling goods, such as explaining the cost of the good), conceptual, and procedural (i.e., how to use mathematical objects) understanding of math (Vandermaas-Peeler et al., 2012; Vandermaas-Peeler et al., 2007; Vandermaas-Peeler et al., 2009), suggesting that mothers are most likely to involve their children in interactions through indirect or implicit teaching of math in these contexts.

These math-related experiences not only occur in different contexts such as teaching instances, daily routines (e.g., mealtimes) or parent-child play, but they also use different materials like children's toys, numerical intended materials (e.g., numbered magnets), or artifacts (e.g., calculator). In her study of parent-child interactions, Anderson (1997) found that playing with multi-link blocks helped parents and children to elicit many types of math, compared to books, paper, or worksheets. Also, parents and children engage in more numeracy activities while playing than during a story book reading (Vandermaas-Peeler et al., 2009).

Moreover, when parents are prompted to use mathematics in an activity with their child, such as cooking a recipe together by following some established steps (e.g., measuring cups of cereal), they provide not only more numeracy interactions, but also more numeracy guidance and opportunities for their children to be involved in more advanced mathematics (e.g., to learn and practice addition and subtraction) than parents who are not instructed to do this (Vandermaas-Peeler et al., 2012), showing that parents are likely to engage their child in math when they are aware of ways to interact about mathematics with specific materials. Along these lines, research has also reported that parents tend to initiate most of these math interactions at home (Vandermaas-Peeler et al., 2007) by asking children what they want to do with the materials or by setting math goals for an activity (Anderson, 1997). Thus, parents have an important role on injecting a mathematical concept to the activity (Anderson, 1997), although children also initiate interactions about math with some frequency, showing interest in math-related exchanges (Vandermaas-Peeler et al., 2007; Vandermaas-Peeler et al., 2009).

However, some research also shows that there are families in which math practices at home rarely occur. A study that observed the activities in which three-year old children were engaged in during 18 hours over the course of a week found that children did not engage in many academic lessons (i.e., explicit lesson with the goal of teaching information about math or promote math) about mathematics, or play with academic objects (i.e., objects designed to encourage mathematics, such as magnets with numbers, but when teaching of math was not involved), averaging less than one interaction over the 90 coded minutes, whereas 60% of the children were never observed playing with math-related objects or involved in a math-lesson (Tudge & Doucet, 2004). Similarly, another study that asked parents of five-to-six year old children about the amount of time their child spent on math activities on the prior day on three occasions, found that, on average, children spent fifteen minutes per week on math, but 69% of the children in the sample did not spend any time on math during a week (Plewis et al., 1990). Moreover, even when parents are explicitly instructed to focus on math during their interactions with their child, 25% of them do not engage in math interactions while being videotaped (Skwarchuk, 2009). There are also activities that have been reported as occurring at a lower frequency in parent-child interactions at home, such as wearing a watch or playing with calculators (LeFevre et al., 2009), measuring with a ruler or addition with numbers greater than two (Blevins-Knabe et al., 2000), and asking the child to order or to group objects (Blevins-Knabe & Musun-Miller, 1996). Observational studies, in addition, have shown that using fractions, using spatial words, and subtracting are the least common mathematical interactions among four-year olds and their parents while playing with materials that were not necessarily intended for math (Anderson, 1997).

In summary, even though some parents seem to spend less time on math activities with their preschool-aged children and engage in a narrow range of math exchanges at home, research shows that there are many instances that can lead to the learning of math, and relying just on what parents report can provide a less accurate picture of what is actually happening in terms of math at home. Moreover, observations from structured parent-child play with specific materials are not necessarily a fair representation of the everyday home activities in which parents and their children interact and discuss about math in an ongoing basis. For example, even though Tudge and Doucet (2004) observed naturalistic interactions of three-year old children during an extended period of time in their lives, they focused on very specific aspects of the math-related exchanges (academic lessons and play with mathematical objects) and did not look at other ways in which parents and children might be incorporating math, such as informal contexts and use of math words outside lessons and without math-objects. Levine and colleagues (2010) have also observed the frequency of number talk among mothers and their 14- to 30-month-old children in naturalistic contexts, but less is known about conversations between parents and their four-to-five year old children about math, understood as a broad construct that includes not only numbers but also other components such as money or math-games, and how this talk is related to early math skills in preschoolers. Thus, this dissertation attempts to provide a better understanding of how parents and their preschool-aged children talk about math at home, with a focus on their natural conversations in this domain.

Math Talk between Parents and Preschoolers

Looking at the ways in which parents talk about math with their preschool-aged children is another approach to study home numeracy and how families socialize math at home. Studies in this area have observed and recorded the naturalistic language used at home between parents and children, and provided the number of math words that children are exposed to at home. Durkin et al. (1986), in a longitudinal study of mother-child interactions, recorded fifteen minutes of nine dyads interacting in the lab every three months since the child was nine months old until he was 36 months old, and found that both mothers and children produced number words with different uses. More recently, studies with young children also show an important variability in the amount of parental talk about numbers with children (Levine, Gunderson, & Huttenlocher, 2011; Levine et al., 2010). Levine and colleagues (2010) observed and recorded naturalistic interactions between 44 children and their mothers for 90 minutes every four months since children were 14 months old until they were 30 months (five visits), and looked at the amount of number words 1-10 as well as the parent's uses of the words *count*, *how many*, and *number* (i.e., number elicitations). They found important 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 in the five sessions; on average, families produced 35 number word tokens and parents averaged six prompts (Levine et al., 2010). Levine and colleagues (2010) also looked at the context of the number talk when children were 30 months old and found that the most common types of parent talk were cardinal values (50% of the number talk) and counting (32% of the number talk), whereas the other interactions involved naming digits, using numbers with a unit of measure, using conventional nominatives (e.g., "give me five"), and making number comparisons. Other researchers have also looked at the differences in math input in terms of the language (e.g., Mandarin versus English) (Chang, Sandhofer, Adelchanow, & Rottman, 2011) or the gender of the child (Chang, Sandhofer, & Brown, 2011), but they have focused on even younger children. These studies have used transcripts from CHILDES, which is a database that contains an enormous amount of transcripts from interactional conversations between children and their parents in different contexts (Chang, Sandhofer, Adelchanow, et al., 2011; Chang, Sandhofer, & Brown, 2011), but unfortunately does not include children's outcomes with regards to early academic skills. Thus, although these studies provide a more naturalistic picture of the math input to which children at a young age are exposed to at home, how language focusing on not just on numbers but mathematical concepts and ideas (i.e., "math talk") is related to four-to five year old children's early math understanding and knowledge has been less explored.

Variations in Home Numeracy among Families from Different Socioeconomic and Educational Backgrounds

Research shows differences in the home activities to which children from different educational and socioeconomic backgrounds are exposed. Even though working-class parents promote activities at home such as counting or recognition of shapes, they are not as likely to be involved in more complex math activities as middle-class parents (Saxe et al., 1987). Saxe and colleagues (1987) asked middle-class and working-class (as defined by their occupation) mothers of two-and-one-half and four-and-one-half year old children to report the activities in which they engaged in at home and found that both groups of mothers reported that children engaged in number activities more than once per week (e.g., counting) and that they have seen their child engaging in self-initiated math activities more than three times per week. They did not find differences by social class in terms of the interest in number play, either, and the entire group played a number game invented on their own at least once a week (Saxe et al., 1987). Also, when mothers were observed during a laboratory session in which they taught their child two tasks, there were no social class differences in terms of providing appropriate assistance or making adjustments to their child's errors (Saxe et al., 1987). Along the same lines, Plewis et al. (1990) found that families spent approximately fifteen minutes on math per week, regardless of the mother's education.

However, when looking at other aspects of the home numeracy, such as the complexity of the activities, there are differences related to the background of the families. For example, mothers differ in terms of the goals they have for the activities they report engaging in with their child in terms of math. For example, middle-class mothers not only report activities with more complex goals but are also more likely to structure more complex goals for more difficult interactions than working-class mothers (Saxe et al., 1987). Also, a study that analyzed the naturally occurring activities of preschoolers with regards to math during a day of their lives, found that middle-class (based on the education and occupation of the families) children were more likely to be involved in academic lessons and middle-class white children were more likely to engage in conversations than other children (Tudge & Doucet, 2004). Observations of parent-child interactions during both number book reading and play also show that parents with higher income engage in more mathematical exchanges that support children's understanding of mathematical concepts, than parents whose children attended a Head Start center (Vandermaas-Peeler et al., 2009). Moreover, parents with higher income initiate more mathematical interactions during book reading than parents with lower income, although the same does not stand for parent-child play interactions, where there were no differences in the initiation of math exchanges related to the socioeconomic background of the families (Vandermaas-Peeler et al., 2009). The input that preschoolers receive from their mothers in terms of number talk has also shown differences associated with the socioeconomic background of the families, in the sense that mothers from a low-socioeconomic status provide more input about counting whereas parents from a high-socioeconomic status emphasize more the cardinal value of sets in their talk with children between 14 and 30 months of age (Levine et al., 2010).

Preschoolers from lower income backgrounds also differ from preschoolers from middle class homes in that the former report to have less experiences with board games at home than the later (Ramani & Siegler, 2008). Specifically, Ramani and Siegler (2008), in a study examining past experiences with board games in preschoolers, found that 80% of the middle class children reported having played board games either with relatives or friends outside school, compared to 47% of children from low-income families. Middle-class children also named more board games than Head Start children, which is an indicator of children's exposure to these games. In other words, most of the preschoolers from low-income families reported that they had never played board games at either their homes or their friends' or relatives' homes (Ramani & Siegler, 2008). Similar results were also found for playing card games; however, this activity was not linked to early mathematical abilities as it was playing board games (Ramani & Siegler, 2008).

Thus, although research shows differences in children's exposure to numeracy at home depending on the background of the families, these variations are also related to the methodology used in the studies. Therefore, there is a need for more research that allows for a better understanding of the parent-child dynamics regarding math in families from different educational backgrounds in naturalistic contexts.

Home Numeracy and Children's Early Academic Skills

The numeracy experiences that children have before schooling are related to their early numerical knowledge, their performance in early math tasks, and their acquisition of math skills in school (LeFevre et al., 2002; LeFevre et al., 2009; Levine et al., 2010; Y. Pan, Gauvain, Liu, & Cheng, 2006; Skwarchuk, 2009). However, not all numeracy practices at home are equally beneficial for children's performance in math. For example, LeFevre and colleagues (2002) found that parental reports of their frequency of teaching complex activities (e.g., teaching how to print numbers), compared to teaching of more basic activities such as counting or naming numbers, predicted their four-year olds performance on a number-recognition task as well as on a "how many task" in both French-speaking and English-speaking children; however, their scale of teaching skills also included parents' frequency of teaching complex literacy skills as well. In a similar vein, parental teaching of more sophisticated concepts in a lab session (e.g., ratio concept) was related to five and seven year old children's proportional reasoning in a Chinese sample, although this was not the case for their American counterparts (Y. Pan et al., 2006).

These results suggest that home activities that involve a more complex goal may be more relevant in promoting early numerical abilities than other activities. Other studies, nevertheless, show that direct experiences with numbers are also positive for children's early math skills (LeFevre, Polyzoi, et al., 2010). For example, in a study with Canadian and Greek families, LeFevre and her collaborators (2010) found that what predicted five-year olds performance in a composite measure of numeration and next number tasks, were the direct experiences that parents reported they had with their children with regards to math (i.e., activities in which math-processing is the goal, such as learning simple sums or counting money). Thus, parents who reported a higher frequency of direct experiences with numeracy had children who performed higher in numeracy (LeFevre, Polyzoi, et al., 2010). Similarly, Blevins-Knabe and Musun-Miller (1996) found that the frequency with which parents of kindergarteners report engaging in using the words "one," "two," or "three" with their children, as well as the frequency with which children use the same number words and mention number facts (e.g., “1+1=2”) were correlated with children’s scores on the TEMA-2, a standardized test of early math abilities that focuses on number-related knowledge (Ginsburg & Baroody, 1990). Another study with American preschoolers found that the frequency with which parents report that their children are involved in both simple skills (e.g., counting objects or reciting numerals) and complex skills (e.g., adding or comparing objects) at home explained unique variance in the child’s math knowledge and quantitative reasoning as gauged by a standardized measure (Skwarchuk, 2009).

The frequency with which parents of kindergarteners, first graders, and second graders report they participate in home numeracy activities has also been linked to their child’s math performance (LeFevre et al., 2009). A study that looked at the role that different activities, such as being engaged in number skills practices (e.g., counting, sorting things by shape, or printing numbers), games (e.g., card games, board games, or being timed), applications (e.g., using calendar and dates or measuring when cooking), and number books exchanges (e.g., using number activity books or reading number storybooks), found that involvement in these activities accounted for an additional four percent of variance in explaining children’s math knowledge (numeration knowledge and accuracy in arithmetic problems) and for an extra 13% of the variance in math fluency in an addition task, even after controlling for verbal ability or socioeconomic status of the families (LeFevre et al., 2009). But not all math activities had the same role in this study, as the numeracy experiences with games were the most relevant for the case of math knowledge, whereas the frequency of experiences with math applications, games, and number skills, were related to greater math fluency (LeFevre et al., 2009).

It is important to keep in mind that almost all of the reported results in this section so far but Y. Pan et al. (2006), come from parental reports and questionnaires, and that using different methodologies show other aspects of the relation between home numeracy and early math skills. For example, Skwarchuk (2009) asked parents and four-year old children to spend 10-15 minutes per day during two weeks on a math activity, but the time spent on numeracy during those sessions did not predict numeracy scores on a standardized test. Along the same lines, the quality of the parent-child interactions during a play session did not predict numeracy scores in the four-year olds either (Skwarchuk, 2009). Also, Vandermaas-Peeler and colleagues (2012) did not find that children whose parents provided more numeracy guidance during a shared-cooking activity showed better scores in the TEMA-3 (Ginsburg & Baroody, 2003). It might be the case, however, that this broad score does not capture the nuances and more specific relations between math activities at home and early math skills, and specific skills might be related to particular practices and numeracy activities. In fact, research that has looked at specific math skills has been able to show the importance of home numeracy through different methods.

For example, parental talk about numbers from one to ten with children between 14 and 30 months has been related to children's talk about numbers and their early mathematical understanding of the cardinal meaning of the number words at 46 months (Levine et al., 2010). The exposure to board games, measured through the number of board games that preschool children name, has been positively correlated to their numerical understanding (e.g., counting, comparison of numerical magnitudes, numeral identification, and understanding of numerical magnitudes) more than naming card games or video games (Ramani & Siegler, 2008).

Thus, research suggests that children who are exposed to both basic and more complex numeracy activities at home have more opportunities to practice math skills that in turn are related to better numeracy knowledge and skills. Which specific activities better foster numerical knowledge, math early skills, and math school achievement in four-to-five year old children, is a question that still requires more research to be fully addressed, as most of the research comes from either studies that use parents' self-reports and did not include a variety of experiences or activities at home or observational accounts of the use of math in the home but with younger children.

Home Numeracy among Families from Different Socioeconomic and Educational Backgrounds and Early Math Skills

Preschool and kindergarten children from poor backgrounds show lower numerical knowledge and perform lower in math-tasks with numerals that are verbally stated or written than children whose parents have higher educational and economic levels (e.g., Griffin, Case, & Siegler, 1994; Jordan et al., 2006). These differences in children's numerical competence associated with differences in families' backgrounds appear in children as young as two-and-one-half years of age (see Case et al., 1999, for a review), and are crucial for later achievement in school. At the same time, as described above, families vary in the ways in which they interact with their children in the domain of math at home, partly depending on their educational and socioeconomic backgrounds. There is some research, indeed, showing that the differences in early math skills are related to the differences in home numeracy activities in families from different backgrounds (Ramani & Siegler, 2008).

In their study on children's reported experiences with board games at home, Ramani and Siegler (2008) found that exposure to board games at home, as measured by the named board games that children reported in an interview, was correlated with children's performance in tasks about counting, number line estimation, numerical magnitude comparison, and numeral identification. Moreover, children who played board games in more informal contexts (their home and other's homes) performed better in the math tasks than the other children, and children who reported playing linear board games (Chutes and Ladders) had also better performance than the children who had not played this game in four of the five numerical knowledge tasks administered (Ramani & Siegler, 2008).

However, there are other studies showing that the prediction of children's math skills based on numeracy activities at home only applies to families from certain educational levels (Blevins-Knabe & Musun-Miller, 1996). For example, in their study of the relation between the parental reports about the frequency and variety of number activities that preschool children were exposed at home, Blevins-Knabe and Musun-Miller (1996) found that the mean of the frequency of the activities that parents reported for their children was related to their children's early math skills but only for the group of parents with higher educational levels, and not for the parents whose educational attainment was high school (Blevins-Knabe & Musun-Miller, 1996). Again, more research in this area is needed to clarify many of these unsolved issues.

Methods to Study Home Numeracy

One of the greatest difficulties in understanding the mechanisms through which families exert their influence in their children's early academic skills is finding the adequate methods for studying these processes. Most of the research that explores the family environment has used parental questionnaires, observation of specific lab-tasks, interviews, or single observations of the home environment (Caldwell & Bradley, 1984; Morrison & Cooney, 2001). In the case of home numeracy, most of the data comes from structured studies of mother-child interactions with mathematical objects (Saxe et al., 1987), short term observations of free play (Vandermaas-Peeler et al., 2012; Vandermaas-Peeler et al., 2007; Vandermaas-Peeler et al., 2009), or from parental reports (Blevins-Knabe et al., 2000; Blevins-Knabe & Musun-Miller, 1996; LeFevre et al., 2009). Less work using non-intrusive methods that looks at the breadth of the home environment as it relates to numeracy has been done (but see Tudge & Doucet, 2004).

Even though questionnaires and interviews provide important information regarding the math-related practices in which parents engage at home with their children, these techniques rely on reports of what parents recall doing with their children in terms of math-related activities, and on what they report based on researcher's prompts and questions. On the other hand, observations of lab activities such as parent-child interactions while doing a specific task (e.g. solving a puzzle or teaching math) provide rich information about the dynamics of their relationship in a highly controlled and structured setting, but there is an issue related to whether or not these interactions would happen in a more naturalistic setting. Observations of parent-child interactions in structured settings do not always provide realistic information about activities in which parents might engage in their daily contexts. Finally, although naturalistic observations of the home environment allow the researcher to collect data in real contexts avoiding biased information that depends on either what parents think is important to report or on what the stimuli provided by the researcher is, having someone observing parent-child interactions in the house is intrusive. Thus, parents might behave and perform in socially desirable ways (Pomerantz & Thompson, 2008).

Although different methodologies allow for the gathering of relevant data to understand the ways in which family processes are related to their children's early outcomes, these methods have not been able to capture certain aspects of the family environment. The ways in which parents from different educational backgrounds promote their children's development of early math skills in natural contexts during an extended period of time, and how these interactions relate to their children's early math skills, have received less attention. Most of the studies focus on either the relation between home numeracy and family background or the prediction of early math skills based on home numeracy but in non-diverse samples. The studies that have looked at mother-child interactions in naturalistic settings have done so by studying children younger than four years of age (Durkin et al., 1986; Levine et al., 2010) or by looking at very specific math interactions, such as math-lessons (Tudge & Doucet, 2004).

Moreover, most of the research on children's numerical competence associated with the socioeconomic and educational backgrounds of the families does not include a variety of the math experiences and activities to which children are exposed at home. Thus, there is a need to describe the naturalistic ways in which families from different backgrounds promote math at home through a methodology that provides a richer sample of data than the one that can be supplied by self-report measures and short term observations of structured mother-child interactions with mathematical stimuli or free play.

Using a non-intrusive method that captures the natural ways in which parents socialize their children in the arena of math, along with the ways in which these interactions are related to children's early math skills, is crucial to understanding the mechanisms through which families foster children's numerical skills and achievement in school. Studying these mechanisms through naturalistic conversations between parents and children will allow a better understanding of the family factors and processes that are related to the problem of school readiness and achievement gaps. Moreover, this understanding will provide the information necessary to formulate recommendations for parents, other caregivers, practitioners, and policy makers on how to bridge the achievement gap.

Research Questions and Hypotheses

The primary goal of this dissertation is to understand the roles that parental math-related interactions in naturalistic contexts play in the promotion of early math skills in preschool-aged children from parents with different educational backgrounds. There are three specific research questions.

Research Question 1

How do parents talk with their preschool-aged children about math? Families were expected to differ widely from one another in both the length of their conversations about math with their children and the frequency with which they talk about different aspects of math. Moreover, it was also expected that mothers will vary in the frequency with which they talk about math in complex versus simpler ways with their preschool-aged children. Finally, it was expected that mothers would initiate more interactions about math and were more likely to dominate the conversations about math, compared to their child.

Research Question 2

How does math talk in naturalistic contexts vary across families with different educational levels? Moreover, how do the length of math talk and the types of math-related conversations engaged in vary by educational level of the families? Substantial variation in the ways in which parents who have different educational levels interact with their child in the domain of math in naturalistic contexts was expected. In particular, it was expected that parents with different educational levels would vary in two ways: (a) the types of topics that they engage in when they talked about math with their child, and (b) the proportion of complex conversations about math in which they engage with their child at home. Parents with higher educational levels were expected to more likely engage in math talk with their child about other topics besides counting and number operation, compared to parents from lower educational levels that were expected to spend most of their talk on counting and numerical operations. Also, it was predicted that parents with higher educational attainment were more likely to be involved in complex interactions about math with their child than parents from lower educational levels. However, no differences in the total number of instances of math talk, relative to the total amount of talk, were expected between families with different educational levels.

Research Question 3

How are both (a) the practices that parents report about math and (b) the conversations that parents actually sustain about math with their child, related to child's early math skills, at two time points (when the child is attending preschool and a year later)? Consistent positive relations between the reported parental math-related practices and their child's early math skills at both times were predicted, even after taking into account the effect of the child's vocabulary and early decoding skills, the child's self-regulatory skills, the age and gender of the child, whether the child was attending kindergarten in the second wave, the total amount of talk, and the family educational background.

Also, positive relations between the frequency and length of the conversations about math and children's quantitative reasoning, math knowledge, and math achievement were expected at both times, after taking into account the control variables. Moreover, it was predicted that the proportion of complex conversations about math would be a positive predictor of children's quantitative reasoning, math knowledge, and math achievement at both times, beyond the control variables regarding the child's demographics, cognitive and language abilities, and family background. In more specific terms, it was expected that the frequency of interactions about number games would be related to the child's ability to understand numerical magnitudes at the second wave of the study. Since research has not been conclusive about other specific aspects of math interactions at home and early math skills, no other predictions were made in terms of particular instances of math talk and early math skills. Thus, the other analyses relating to specific aspects of math talk and children's outcomes were exploratory.

CHAPTER II: METHOD

Participants

First Wave of the Study

Forty typically developing preschool-aged children (27 boys, 13 girls), whose ages ranged from 3 years and 10 months to 5 years and 9 months (*M* = 4 years, 6 months; *SD* = 5.5 months) at the first wave of the study, and their primary caregivers (i.e., the mother) participated in the study. The participant families are part of the "A Week in the Life of Families Study," designed to investigate variation in parenting during the preschool years by developing a protocol for the use of a new, in-home data collection tool called the Language ENvironment Analysis System (LENA). Recruitment was accomplished through direct mailings to families whose children were attending Head Start centers in the Detroit area, Oakland County, Wayne County, and the Ann Arbor-Saline area; fliers and invitation letters in preschool centers in the same areas; and an advertisement in a free local parent newsletter. Families were invited to participate in a study on the complexities of a week in the life of a mother and her preschool-aged child. They were asked to record three days of conversations by using an innovative data collection method (LENA) and to complete some questionnaires (mother) and assessments (child). They were invited to participate if they had the following characteristics: their primary language in the home was English, the age of the target child was approximately between 4 and 5 years, the child was attending preschool, and the child had not been diagnosed with disabilities or major illnesses. Families who chose to participate in this study were asked to provide their address, phone number, and email address when they consented to participate in the study. Families who consented to participate in the project were visited in their homes and asked to record their normal conversations during three days of a week.

Children and mothers were included in this dissertation study if they recorded for at least two hours during the days that they were asked to record and if they completed the children's assessments and parent's questionnaires (see description of the instruments below). From the larger sample of 46 families, three families were not included because they were part of the pilot study that was conducted a year earlier than the final study and did not have all the assessments and measures included in the final study. Two families were not included because they were unable to record their interactions due to personal and conflicting situations, and one family was not included because the primary caregiver that participated in the interactions was the father. Because this is a time-intensive study that explores the ways in which families and preschool-aged children talk about math by using a new methodology, and because there is evidence that suggests that mothers' and fathers' interactions with their children contribute differently to children's cognitive development (Tamis-LeMonda, Shannon, Cabrera, & Lamb, 2004), the focus of the current study was only on mothers' talk with their children. The 40 remaining dyads were still representative of the original sample in terms of income and education. All children except one were attending preschool at the time of the first wave of the study. The child that was not attending preschool was temporarily staying at home with his mother but he was going to return to preschool because his mother was going to start work or classes again and would need him to be in care. Ten children were attending Head Start centers whereas the rest of the children were attending other preschool centers.

Eighty percent of the children (*n* = 32) were living with two parents at the time of the study. The participating 40 families were ethnically and educationally diverse. Mothers' educational levels ranged from having completed high school to having earned a master's, a doctoral, or a similar advanced degree. Even though this sample does not include families with a very low educational background, it is possible to differentiate three groups of families in terms of their maternal education, which has been reported to be a very important indicator of the family resources and stimulation at home (Davis-Kean, 2005). Approximately one third of the mothers had either a high school diploma (*n* = 1) or some college education including community college but without having earned a degree (*n* = 14). Another third of the mothers earned a four-year college degree (*n* = 12). The final third of the mothers earned a degree from graduate school or equivalent (*n* = 13). Half of the mothers were not employed at the time of the study (*n* = 20), 25% were working part-time (*n* = 10), and the other 25% were working full time (*n* =10) (see descriptives for the participant families in Table 2.1).

Thirty-three of the mothers (82.5%) reported their income as well as the income of the father, when applicable. The income of the participating families was measured through their income-to-needs ratio. The total family income was divided by the poverty threshold values taken from Census Bureau 2010 (U.S. Census Bureau, 2010), since the first wave of data was collected in that period of time. The threshold values are based on family size, the number of persons in the family under age 18, and the age of the head of household. An income-to-needs ratio of 1 means that the ratio family income-to-poverty threshold matches the poverty threshold for 2010, taking into account the number of members in that family. 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 it ranged from 0.45 to 9.04. Four families were under the poverty line and seven were near poverty (i.e., an income-to-needs ratio between 1 and 2).

In terms of ethnicity, 26 of the children were European American, whereas 8 were African American. Only one child was Hispanic, another one was Asian Indian, and three were multi-racial (African American and Arabic, African American and Caucasian, and Caucasian and Asian Indian). One of the families did not report the ethnicity of the participant child. Most of the children in the sample had one sibling (*n* = 23), whereas six were the only child in the family at the time of the first wave of the study. Six children had two siblings and four children had three siblings at that time. Only one of the families did not report the child's number of siblings.

Second Wave of the Study

One year after the first wave of the study, the participant families were contacted by the research team to invite them to participate in the second wave, which involved parental questionnaires and child's assessments but not recordings. Thirty-five of the families who participated in the first wave decided to continue in the study. Three of the families who did not continue in the study seemed to have moved to other places as it was not possible to reach them in any way during the four-month period of data collection for the second wave. One family declined to participate because of their busy schedule despite the different options the research team made available (e.g., complete the questionnaires online), and another family did not answer the research team's messages. Out of the 35 families who agreed to participate in the second wave of the study, one was living out of the country at the moment of the data collection, but the mother completed all the questionnaires online. However, the child's outcomes for the second wave of the study for this family were not available.

The age of the participant children (24 boys, 11 girls) in the second wave of this study ranged from 4 years and 10 months to 7 years 0 months (*M* = 5 years, 7 months; *SD* = 6.3 months). The gender distribution was similar among the children who participated in the second wave of the study and the children who did not participate, $t(38) = .37$, $p = .71$. Also, three-fifths of the children ($n = 21$) were attending kindergarten at the time of the second wave of the study. Due to the fact that children had to be 5 years old by the cut-off date of Dec. 1st to enter kindergarten, two thirds of the participant children ($n = 14$) didn't meet the criterion when this study was conducted, and were attending preschool at the time of the second wave of this study. Of those children, two were attending Head Start centers and twelve were attending other types of preschool centers. Since research shows schooling effects for different early academic skills (Burrage et al., 2008; Morrison, Alberts, & Griffith, 1997; Skibbe, Connor, Morrison, & Jewkes, 2011), whether the child was attending preschool or kindergarten at the second wave of the study was considered a control variable in the correspondent analyses in this study, as described in the analysis plan below.

Most of the children in the second wave of the study had one sibling ($n = 20$), whereas eight of them had two siblings, and three had three siblings. Four of the children were the only child in the family. The average number of siblings of the children who participated in the second wave of the study was similar to the average number of siblings of the children who did not participate of the second wave, $t(37) = .01$, $p = .99$ (descriptives for the participant families in the second wave of the study are presented in Table 2.1).

Similar to the first wave, most of the children (77.1%) were living with both parents at the time of the second wave, and their mother's education ranged from high school diploma to an advanced degree such as master's, doctoral, or another similar degree. One-third of the mothers had up to 14 years of education, whereas one mother earned a high school diploma, ten mothers had some college education including community college, and one mother earned an associate's degree. Almost one-third of the mothers had earned a bachelor's degree and a little more than a third of the mothers had earned an advanced degree at the time of the second wave. The proportion of mothers with some college education or less was similar between those who participated in the second wave of the study and the ones who did not continue in the study, $t(38) = 1.10$, $p = .28$. The same happened in terms of the proportion of mothers with a bachelor's degree, $t(38) = .51$, $p = .61$. However, the proportion of mothers with an advanced degree such as doctoral degree, master's degree or other was higher for the mothers who continued in the second wave of the study, compared to the mothers who were not part of the second wave of the study, $t(38) = 4.48$, $p = .00$. In fact, all mothers who did not continue in the second wave of the study did not have an advanced degree.

Almost half of the mothers who participated in the second wave of the study ($n = 17$) were not employed at that time, approximately a quarter of the mothers ($n = 8$) were working part-time, and a little more than a quarter of the mothers were working full time ($n = 10$). These proportions were similar between the mothers who participated in the second wave of the study and the mothers who did not continue in the study. There were no differences in the proportion of mothers who were not employed, $t(38) = .48$, $p = .64$; or were working either part-time, $t(38) = .42$, $p = .24$, or full-time $t(38) = .81$, $p = .42$.

The income of the families who participated in the second wave of the study was also measured through their income-to-needs ratio, but the poverty values corresponding to the Census Bureau 2011 (U.S. Census Bureau, 2011) were used this time. Twenty-seven families reported their incomes. The average income-to-needs ratio of the families was 4.19 times the poverty threshold (*SD* = 2.65), and it ranged from .49 to 12.93. Two families were under the poverty line (i.e., income-to-needs ratio lower than 1), and three were near poverty (i.e., an income-to-needs ratio between 1 and 2). The average of the income-to-needs ratio reported in the first wave for the families who participated in both waves of the study was not statistically different from the average income-to-needs ratio of the families who only participated in the first wave of the study, $t(31) = 1.46$, $p = .16$. However, this is probably due to the small sample size since the average income-to-needs ratio of the families ($n = 31$) who provided this information in the first wave and participated in the second wave of the study ($M = 3.45$, $SD = 2.02$) was numerically higher than the income of the two families who reported their income in the first wave and did not participate in the second wave of the study ($M = .67$, $SD = .48$).

In terms of ethnicity, 24 of the children were European American, whereas 6 were African American. There was one Hispanic and one Asian Indian child, while three were multi-racial (i.e., African American and Arabic, African American and Caucasian, and Caucasian and Asian Indian). The proportion of each of the children's ethnic/racial groups was similar between the families who participated in the second wave of the study and the families who did not participate in the second wave for all European American, $t(38) = 1.25$, $p = .22$; African American, $t(38) = 1.19$, $p = .24$; and other ethnic/racial groups, $t(37) = .80$, $p = .43$. The family who did not report the race/ethnicity of the child during the first wave was not a part of the second wave of the study.

Procedure

First Wave of the Study

At the time of recruitment, families were told that they were participating in a study of the different activities that mothers and children do and the things that they talk about at home during a regular week of their lives. The participation was voluntary, and families were told that they could withdraw their consent at any time in the study without penalty of prejudice. There was no mention of the particular aspects of math-related interactions that this study is examining.

During the first wave of data collection, mother–child dyads were visited twice in their homes by two researchers (one graduate student and one research assistant), during the 2010-2011 school year. Mothers who completed a home visit received a small monetary incentive and a small gift for her participating child as an appreciation for their valuable participation in the study.

During the first visit, the researchers oriented the mother and the child on how to record their daily interactions by using the LENA. The LENA is a voice-recording device and a digital language processor that has a digital memory capacity to record language continuously for sixteen hours. The mother and child were also given specialized clothing and accessories to wear while using the LENA recorders. Mothers wore either a lanyard around their necks, similar to an ID holder, or a pocket clip in which they put the recorders. Children wore a T-shirt with a padded snap pocket on the front. Since the device is light and simple to wear, parents and children could easily forget about wearing the recorders and being recorded after a couple of minutes, which allowed the research team to avoid both the intrusiveness of other naturalistic methods (e.g., video-recording of interactions) and the social desirability of similar methods of data collection.

The mother and child were instructed to record their spontaneous speech that occurred during the time the child was at home with her or his mother (from the time the child wakes up until he goes to bed at night, before and after the child goes to preschool) during three days (two week-days and one weekend day). The researchers left three packages (one package per day of recording), each containing one set of two LENAs (one to record the child's conversations and another for the mother's conversations), so that each mother and child recorded their daily conversations by using different LENAs every day. This allowed families to record their conversations without having the researchers go to their homes every day. Nevertheless, the researchers provided several instructional documents so that parents could refer to them if they had questions. They were also offered the option of getting calls or text-messages to remind them about the recordings. Parents did not have any issues with remembering how to use the LENA to record their interactions, with the exception of two families that were part of the larger study but not part of this dissertation study. Furthermore, mothers were asked to complete questionnaires about the specific aspects of each the particular day of recoding (e.g., time the child woke up, time he or she went to preschool, activities they did, time he or she went to bed at night, among others), at the end of each recorded day.

In this first visit, one of the researchers (the graduate student) also administered three parental questionnaires to the mother, whereas the other researcher (a trained research assistant) assessed the child's cognitive and early academic skills by using standardized tests of achievement and measures of cognitive abilities, as described below. The child's assessments required approximately 45 minutes on average, whereas the mothers completed the questionnaires in 30 minutes on average. The assessments were administered in a counterbalanced order.

During the second visit, the researchers picked the recordings up, and the mother was asked to fill in a parenting questionnaire, which took 20 minutes on average. Since this questionnaire included questions about the frequency with which families interact in the domain of math, among other parenting attitudes and behaviors, mothers filled in this information after they had completed the three days of recordings. This prevented any bias in their behaviors and normal interactions (e.g., if mothers knew that the study looked at the number of times per week in which they played math games with their child or talked about numbers, they could have tried to talk about these issues more often than usual).

Second Wave of the Study

The second wave of data collection occurred during winter and spring of 2012. In the early months of 2012, families were contacted through mail by the research team. Families received a newsletter with group-level results about the amount and duration of the conversations that occurred between mothers and children, and about the times of the day at which most of the families spent more time talking with their children during the first wave of the study. Families were also asked to update their contact information, and were invited to participate in a follow-up of the study that consisted of one home visit. The second wave of the study did not include recordings, and mothers were asked to fill in the same questionnaires that they filled in for the first wave. Children were assessed in their cognitive and early academic skills by using some of the same measures used in the first wave of data collection. Additionally, children were assessed more specifically in their quantitative reasoning, math achievement, and math knowledge.

Similar to the first part of the study, during the second wave of the study, families were visited in their homes by two research assistants, one graduate student and one trained research assistant, but only once. Mothers received a small monetary incentive and a small gift for their children after the visit. A graduate student administered to the mother the same four parental questionnaires that were used in the first wave, whereas a trained research assistant assessed the child's cognitive and early math skills by using the instruments described below. Both the child's assessments as well as the completion of the parental questionnaires required approximately 45 minutes on average. The administration of the child's assessments was counterbalanced, but the two math-related tests (see description of the child's assessments below) were either presented at the beginning or the end of the session (i.e., half of the children were presented with one of them at the beginning, and the other half had the same test at the end), since they took longer and the contents were somewhat similar. Also, for the instruments that had parallel versions, the form A was used in the first wave of the study, whereas form B was used in the second wave of the study.

There was only one mother who completed an online version of the questionnaires as she and her family were living abroad. Consequently, her child's cognitive and early math skills were not assessed in the second wave of the study.

Recorded Times and Selection of the Days and Time Frames for the Current Study

Since the LENA voice-recorder has the digital memory capacity to record language continuously for 16 hours, each family recorded from 2 hours and 18 minutes to 48 hours of naturalistic conversations during a week (M = 28 hours and 42 minutes, SD = 15 hours and 25 minutes). Most of the families recorded some time during three days (n = 32), but a small percentage of the families recorded just one and two days (n = 1, n = 2, respectively). Also, five families recorded four days, because they were not able to complete three whole days of recording.

For the current study, two one-hour long time frames (i.e., *breakfast time* and *dinner time*) of the two available week-days were transcribed, coded, and analyzed in terms of math talk. Even though both the mother and the child recorded their conversations by using their own LENAs, the mother recordings were used for this study as it focuses on the ways mothers talk with their children about math. There were a few cases in which the child's recording was listened to for a few minutes, as described below in the section about transcriptions. If families recorded more than two week-days, two of those days were selected for this study based on the amount of time that families recorded and the availability of time frames to analyze.

Both *breakfast time* and *dinner time* were chosen based on existing literature that shows that mother-child conversations during mealtimes are very important for their children's development of vocabulary because of the richness and sophistication of the conversations at that time (Tabors, Beals, & Weizman, 2001). Even though these findings come from the arena of language and literacy, it will be really interesting to evaluate if a similar pattern occurs in the domain of math. Also, preliminary analysis from the pilot data showed that families talked more about math in both *breakfast time* and *dinner time,* compared to other structured times during the day, such as bedtime. Mother-child interactions were less frequent, and less math-talk occurred during bedtime in the pilot families. Moreover, in order to compare families, structured "activity-times" were chosen over "free time" as families engage in many different activities during their free time. Thus, analyzing their math talk during "activity-times" such as breakfast or dinner allows for a comparison across families by looking at the least variable times among parents. In brief, based on the interest in comparing families, on the amount of math talk that happens in the different time frames, as well as the number of available time frames to analyze among families, only two time frames of duration of up to one hour were selected for the current study.

The two week-days were chosen over the weekend day because most of the families had completed the recordings for the selected time frames on those days. Moreover, family routines were more dissimilar on the weekends, compared to the week-days. Many families differed in the activities they did at different times of the day during the weekend, and ended up either not having the time frames to code (e.g., families did not have dinner at home) or having times that were not comparable among families (i.e., families did different things at the expected *breakfast time* so that it was not possible to choose a comparable *breakfast time* across families).

The length of each time-frame was up to one hour so that up to four hours per each family were analyzed in total (i.e., one hour per *breakfast time* and *dinner time* per each of the two days), depending on the available time frames, and time (i.e., minutes) within each time frame that families recorded. The specific minutes that corresponded to each time frame were selected based on the notes that parents wrote after each day of recording and the automatic reports that the LENA Software produces. As described above in this chapter, mothers completed a short questionnaire about the things that happened in each day of recording, at the end of the day. In these questionnaires, mothers wrote the time the child woke up, when they had breakfast, whether the child went to school and the respective times, and the times they had dinner, among other things that happened during that recorded day. These notes served as guidelines to select the one-hour long time frames for this study. However, these notes included broad ranges that did not allow selecting specific start and end times for each time frame. In order to determine the exact minutes that were going to be analyzed from the broad range of time that families provided, the LENA automatic reports were used.

The LENA System software automatically analyzes the audio files from the voice recorders and provides reports that include information about the number of words that were spoken by an adult to/near the child, both every five minutes and every hour. These reports also provide information about the number of *conversational turns* between the child and the adult (the mother) as well as information about the *audio environment* during the day, also hourly or in five-minute views. The *audio environment* report provides information about the proportion of the total time in the day of the families that can be classified as meaningful speech, distant speech, noise, TV and other electronic sounds, and silence/background. Finally, the LENA System also provides information about the number of the child's vocalizations per day, this is, the continuous speech spoken by the child in a five-minute segment, by hour or by day.

Thus, the LENA 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 five minutes. This information was used to select the specific start and end time of each time frame, as the goal was to include time frames in which families would talk the most. If families showed similar amounts of meaningful speech for more than one hour, the one-hour frame time was selected by looking at the other automatic reports produced by the LENA software, 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 "meaningful speech" time-frame. Again, the goal was to select the times at which the families are more involved in meaningful conversations with the children, because it was expected that they will be engaged in more math talk at those times as well.

Slightly more than half of the families recorded their conversations during the four time frames used for this study (n = 21). Ten families recorded during three time frames, eight families had data on two time frames and there was one family who recorded during only one of the time frames (see Table 2.2). There were different reasons as to why families did not record the complete four segments, such as that they went out of town to visit relatives during that time, or they went to other places during either breakfast or dinner time, among others. There were three cases in which families recorded during these specific time frames but they requested that these times not be included in the study. Thus, these time frames were considered as unavailable times and were not used in any analyses.

For most of the cases, *breakfast* and *dinner time* were selected because mothers and children were engaging in those meal times, but there were a few families (n = 4) that did not spend time eating dinner at the time of the recordings. Since the goal of the study was to capture naturalistic conversations among families, it was also expected that families would not follow the same routines and activities all the time. Therefore, in the cases in which families were at home during *dinner time* but they were involved in other types of activities instead of mealtimes at a similar time, those times were transcribed instead. This was done for only four families in the first day of recording during *dinner time*, and allowed for as many time frames as possible per family to be analyzed. In addition, there were a couple of families that did not have a one consecutive hour long of recording during those times frames (see Table 2.2). However, some of these families had other available times in either the prior or following hour and a half. Since most of the families who recorded one hour during the selected time frames did not spend the whole hour eating and talking about eating, it was expected that adding a few additional minutes to the segments of the families who did not record a consecutive hour would help the research team to have more comparable segments during a similar period of time. Thus, some additional minutes were added to the original selected times for seven segments so that each time frame was as close as possible to one hour long. The non-consecutive added-minutes for these seven time frames ranged from 2 to 21 (M = 11 minutes, SD = 8.3 minutes) and were distributed across days, although most of them were added in the first day (n = 5) and during the dinner time across days (n = 5).

On average, families recorded approximately 47 minutes per time frame across days (*DS* = 20 minutes). The average length for each time frame was similar among both days (approximately 48 minutes for each time frame during the first day and 45 minutes during the second day) and events (approximately 46 minutes for breakfast and 48 minutes for dinner across days). In general, the length of the time frames ranged from 13 to 60 minutes, but it varied per event. *Breakfast time* segments ranged from 13 to 60 minutes whereas *dinner time* segments ranged from 52 to 60 minutes. Families were more likely to have complete segments at *dinner time* compared to the *breakfast time*.

Transcriptions

Once the specific times were selected, the mother audio files were transcribed using Transcriber (Boudahmane, Manta, Antoine, Galliano, & Barras, 2005), a computer software that transcribed the audio files while aligning the transcription with the corresponding audio. This tool also allowed labeling specific speakers and distinguishing between mother, child, or other speech turn segments. Each one-hour 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; B. A. Pan, Rowe, Spier, & Tamis-Lemonda, 2004; Worzalla, 2012). This implied that utterances varied in their length as they sometimes were represented by a word only (e.g., “No!”), whereas other times they were longer sentences. The guidelines for transcribing at the utterance level are included in Appendix A. The audio files were transcribed including all spoken words by all speakers, but only the mother and child talk were analyzed for this study. The total number of utterances (mother and child utterances) was included in the corresponding analyses to control for the amount of talk happening in the families.

Trained research assistants, whose native language was English, transcribed all time frames used in this study. Two independently trained research assistants verified 20% of the transcripts. They listened to the originally transcribed timeframes and corrected any error in the transcripts, such as missing words, spelling errors or words mistakenly transcribed. They did this for all speakers, including other siblings, father, and or other people present at the point of the recording. The total number of errors was then calculated at the utterance level, but this included only the utterances spoken by the mother and the child, as only their conversations were coded and analyzed in this study. Also, since punctuation and spelling errors were fixed when the transcripts were exported to text files in order to code them, these errors were not included in the total amount of errors. The total number of utterances that contained errors was subtracted from the total number of utterances, and this result was divided by the total number of utterances to obtain a reliability percentage. The average reliability among the research assistants was 97.3% (DS = 2.52%) and it ranged from 87.7% to 99.8%.

There were two main challenges while transcribing the audio files: the presence of siblings really close in age to the participant child as their voices sounded similar, and a few recordings that did not have a very clear audio. When siblings were talking at the time of the recordings, research assistants were instructed to spend extra time making sure they could distinguish the participant child's voice from the siblings' voices. In a few cases in which this issue added difficulty to the transcription, research assistants also listened to the participant child's recording to check that they correctly transcribed each speaker's utterances. Since the child's recording was close to his or her mouth, it was easier to distinguish the child's voice by listening to his or her recording. The other major challenge during transcriptions was an audio file that was not clear, either because the family talked with a really low tone of voice or because the mother took away the recorder and then the LENA was not able to clearly capture all their conversations.

There were only two transcriptions that were below 95% of accuracy (87.7% and 91.8% respectively). The main errors in these transcriptions were some missing utterances and minor errors in the content that the research assistant who transcribed these audio files actually heard. The majority of the errors was related to the fact that the audio files were hard to hear since the family was not speaking that loudly. Because these transcripts did not have as many utterances in total as the other transcripts, the ratio of total utterances to utterances containing errors was higher despite the fact that the absolute amount of errors was not as high as in other transcripts.

After the transcriptions were finished, another research assistant exported the audio files to a text document and checked for spelling, punctuation marks, and other issues for all transcribed files. These exported word files were used to code for math talk.

Math Talk Coding System

The mother-child conversations in the domain of math during the two time frames (*breakfast time*, *dinner time*) in two week-days were coded in terms of math talk by reading the transcripts of their conversations during those times. As described above, the length of each time frame was up to one hour, so that up to four hours per each family were coded in total.

The purpose of this coding was to record the ways in which families talk with their preschool-aged children about math; in other words, how families socialize math at home. The original idea was to code by listening to the recordings (i.e., online coding) instead of coding based on transcripts. Research assistants were trained on the coding system (see instructions about the coding system in Appendix B) and coded the audio files from the pilot families as well as from a few participant families. The coding system captured variability in math talk as shown by the frequency of conversations in which families engage in with their preschool-aged children. Also, the coding system was able to capture some similarities among families in the categories of math talk that were most used by the families. Even though the coding system proved to capture math talk in these families, there were issues related to the reliability of the coding by using this online strategy. The main challenge with this strategy was that research assistants were likely to miss math talk when math words were used in a non-mathematical context or did not involve any further discussion. For example, families would use an ordinal number word such as "second" but in a context that did not involve any other math concept so the research assistants would miss it, despite the fact that they were supposed to code for this. However, when families engaged in long interactions about math, there were no main issues with reliability. Moreover, since a couple of recordings were hard to hear, the quality of the audio added an extra issue to the coding reliability as some research assistants were more likely to miss some math talk compared to others. Finally, it was difficult for research assistants to both listen and code at the same time for these one-hour long time frames. This process required distinguishing between talkers, understanding the talk, and coding at the same time for a long period of time. There were a couple of iterations in the process of training, coding, and comparing coding among research assistants, but the reliability among the coders did not improve. Therefore, the corresponding audio files were transcribed and the coding was done based on these transcriptions.[1]

[1] Since transcribing audio files added a significant amount of time to the process of coding, this was an additional issue considered when deciding to code for up to four hours per family.

Math Talk Coding Categories

The coding scheme that was used in this study was initially developed based on prior literature examining the types of activities that parents report engaging in at home with their preschool-aged children in the domain of math (Anderson, 1997; Jennings, Jennings, Richey, & Dixon-Krauss, 1992; LeFevre et al., 2009; Vandermaas-Peeler et al., 2007; Vandermaas-Peeler et al., 2009). Preliminary categories were developed and then revised in light of the conversations that mothers and children from the three pilot families had at home. This coding scheme was revised a couple more times as clarifications and more specific examples were needed when coding the pilot transcripts and the first participant families. The main issues that emerged while revisiting the coding scheme were related to some math words that were used by mothers in a non-numerical context and without representing math. In those cases, a very strict criterion was used and only math words that were used in numerical ways were coded as math talk. For example, the word *one* can be used numerically and non-numerically and even some of its uses can be ambiguous with respect to their numerical content, as in the case of some idioms such as “one day” or “one of these days” or when the use of *one* is as a direct object (e.g., “do you want one?”) (Levine et al., 2010). In the cases in which math words were used in non-numerical ways, these words were not coded as math talk, following the criterion used by Levine and colleagues (2010). The same happened with deictics, such as “this one” or “that one,” because these words are not being used in numerical ways. In brief, the main revisions to the coding scheme attempted to make the categories as clear as possible so that they will include math words that are being used in numerical ways only.

The categories included in this revised coding scheme are the following:

- Naming numbers: describing the number of objects immediately, without counting (Anderson, 1997). For example, the mother tells the child to eat four pieces of broccoli. Objects can be physical objects, actions or abstract things, but they need to refer to a specific number of these things. As described above, in the case of the word "one", this category was coded for only when "one" was used to describe numerical objects.
- Ordinal numbers: using ordinal numbers such as "first", "second", "third", etc. (Anderson, 1997). For example, the mother asks the child what he wants to do first, and he says he wants to go to the bathroom first.
- Adding/Subtracting: using additive language as in combining two or more numbers together, or taking one or more numbers away from another number (Anderson, 1997). For example, the mother and the child talk about what six plus one is, or the child asks about taking one away and the figures out its three.
- Counting: listing numbers in an increasing or decreasing order of regular intervals (Anderson, 1997). For example, the mother counts 1, 2..., while telling the child to go to his room.
- Monetary exchange: talking about the value of money or how it works, using or counting money, discussing how much something costs, playing store with money and a cash register, or comparing amounts of different coins (adapted from Vandermaas-Peeler et al., 2007; Vandermaas-Peeler et al., 2009). For example, the mother says to the child that five cents is a nickel.
- Dates: talking about the day, month, week, etc., with the idea of a calendar in mind (adapted from LeFevre et al., 2009). For example, the mother says that the child's birthday is the 12th of October, and right now the calendar is on February 2nd.

- Estimating: guessing approximately how much or how many in terms of quantity, predicting or personal judgment of an amount (Anderson, 1997). For example, the child says she thinks she saw about twenty birds on the way to school.
- Fractions/Percentages: verbalizing fractional values (Anderson, 1997). For example, the mother tells the child that her sibling is only one-and- one- half years-old.
- Comparing attributes: comparing items in terms of size, weight, length, width, or height. Talking about similarities or differences among items based on those attributes or judging sizes or quantities (e.g., numbers) of one item based on another (adapted from Anderson, 1997). For example, the child says to the mother that there is a big toothpaste and a small one.
- Noting equality: describing sameness in terms of size, weight, length, width, height, or number (adapted from Anderson, 1997). For example, the mother says that now the sets of blocks are the same height.
- Grouping, sharing, or distributing: putting objects in a group according to any of the following attributes: shape, size, weight, length, width, or height, etc. (adapted from Anderson, 1997). It also includes sharing or distributing things or objects. For example, the mother explains to the child that one nugget is for her and another for her sibling.
- Measuring: determining size or weight by using a unit or numerical measurement, or specific tools or other means such as cooking utensils, tape measures or scales (adapted from Anderson, 1997; LeFevre et al., 2009). For example, the mother talks to the child about a baby who weights 9lbs 6oz and then she says that it was a big baby.
- Naming shapes: identifying conventional geometric shapes by their name (Anderson, 1997). For example, the child tells the mother that she made a square in the attic.

- Number books/Number games: reading books about numbers or playing games involving numbers, such as board games, card games, matching games, etc. (adapted from LeFevre et al., 2009). For example, the mother reads to the child a book about counting.
- Printing numbers/Recognizing written numerals: writing and reading of numerals on paper and other forms of media, recognizing names of written numbers when seen, or making physical representations of numbers (adapted from Anderson, 1997; LeFevre et al., 2009). For example, the mother and the child type numerals on the computer.
- Time: telling time or talking about when something happened or will happen with regards to a specific time (adapted from Jennings et al., 1992). For example, the child tells the mother that it is 8:30.
- Purpose of math: talking about why math concepts such as measuring are important, discussing the use of numbers or the reasons for doing something regarding numbers. For example, the mother tells the child that learning to count is important because then he will always be able to tell how many of something there are and if he needs more, such as with money or food.

More examples and a detailed description of the specific aspects of the categories are provided in Appendix B (i.e., Instructions for Coding Math Talk), whereas the Coding Sheet that includes all the coded categories and other coded aspects is included in Appendix C.

Since these categories attempt to represent the broad range of math talk in which children and parents are engaged in their normal routines, many of these math interactions involved more than one aspect of math. For example, the mother and the child could be talking about measurement while also comparing the sizes of the objects after being measured. Therefore, these categories are not necessarily exclusive. For this study, if an instance of math talk fitted two categories, that conversation was coded within both categories (i.e., dual coding) to take into account the complexity of the conversations involving more than one math aspect.

Also, since the purpose of the coding was to record math talk between mothers and children, any conversation that took place between the participant child and father, the participant child and the siblings, the mother and the siblings, the participant child and the siblings, etc. was not coded. If other people were present during the mother-child interactions, only the mother-child portions of math talk were coded. However, there were cases in which the mother was talking to the child and the other siblings at the same time. Those interactions were coded for math talk as both the participant child and his or her mother were part of the conversation. Moreover, if either the child was talking to himself or herself, or the mother was talking to herself, and there was no interaction between the mother and the child, those segments were not coded. Finally, the coding was based on verbal interactions, and trained coders were explicitly asked to code based on the transcripts and not based on assumptions, inferences, or metaphors that did not intend to discuss math as a topic.

In order to code for math talk, research assistants coded while reading the transcripts. After coding, they checked that they did not miss any conversations about math by searching for specific math words from a list of words commonly used in conversations about math. They did so by using the *find* feature of Microsoft Word (see list of key words in Appendix D). This list was created after coding the pilot families because there were some numerical words that were likely to be missed by the coders, as these words were not a part of a conversation about math but were used incidentally in the conversation. If research assistants found that they had missed any conversation about math, they coded them while searching for this list of words. This list of key words was used as a guide, and the words listed under each category were only used as examples. The actual conversations found by using this list were coded under the corresponding categories, as many of these words could elicit conversations about different math topics.

Length of Math Talk

In addition to coding for math talk within the described categories and providing a brief description of the conversation being coded, the length of the math talk was also accounted for. Since the coding was done based on transcripts, the total number of utterances involved in math talk was used as a measure of the length of the conversations about mathematics (please see above for a description of how utterances were counted). The total number of utterances involved in math talk included both the utterances said by the mother as well as the utterances said by the child, as it was a measure of length of math talk. However, the total number of the child's utterances and the total number of the mother's utterances were also obtained. To estimate the interrater reliability of the coders who counted the utterances, intraclass correlation coefficients (ICCs) were calculated (Shrout & Fleiss, 1979) by using IBM SPSS Statistics for Windows, Version 20.0. Two independent coders counted the mother and the child utterances for 20% of the segments, and their ICCs were .99 for both cases.

In the cases of dual coding, in which more than one category was involved in the same conversation, the number of utterances for each of the categories could be the same (if the conversation involved more than one code in all utterances) or different (if there was at least one utterance that was uniquely coded for one category, despite the fact that the rest of the conversation involved more than one category). The total number of utterances per category and the total number of utterances per family were then calculated by adding the number of utterances involved in each case.

Initiation and Dominance of Math Talk

Each instance of math talk was also coded in terms of the person who initiated the exchange, as either *mother-initiated* or *child-initiated* (Anderson, 1997; Vandermaas-Peeler et al., 2007; Vandermaas-Peeler et al., 2009). This initiation was seen at the beginning of the interaction, by whoever first mentioned a math word within the math talk, either by asking a question or making a statement that involved math. For example, if the mother asked the child a question about math or initiated a conversation about fractions, it was coded as mother-initiated. On the contrary, if the child was the one prompting the math interaction, it was coded as child-initiated.

Also, based on the number of utterances, the person who talked the most about math was also accounted for. If the mother spoke *two or more* math utterances than the child, she was considered as the person who dominated the conversation and that math talk was coded as *mother-dominated*. On the contrary, if the child used *two or more* math utterances than the mother, it was coded as *child-dominated* as the child was the person who talked the most in that exchange. In the cases in which the amount of math utterances was the same between the mother and the child, or there was only one utterance of difference, the code *both* was used. The frequency and proportion of mother-initiated and child-initiated math talk was calculated per each category and per each family, as it was the frequency and proportion of mother-dominated, child-dominated, or both.

Math Talk Complexity

Finally, the coding scheme attempted to distinguish between the conversations in terms of their complexity. This involved distinguishing between math talk in which an explicit explanation or discussion about math occurred and the conversations in which math words were used without any intention of explaining or discussing math. This distinction was done by adapting the conceptual framework proposed by Pianta and colleagues to classify classroom instruction (Crosnoe et al., 2010). They define *inferential* or *higher order instruction* as any instructional technique in the classroom interaction that includes analysis, inference, and synthesis so that students would engage in activities that require reasoning, problem solving, or deductive reasoning, among others. On the contrary, Pianta and colleagues (Crosnoe et al., 2010) define *basic skills* instruction as any classroom activity in which students are prompted to provide yes-no responses or responses that are correct or not. Following this framework with the idea of distinguishing between math talk that involves deeper conversations between mothers and children and math talk that is mainly incidental, in which math words are used but without any attempt to explain or discuss math, all math talk interactions were classified as either *higher order* math talk or *basic skills* math talk. Since Pianta and colleagues were interested in observing classrooms instead of mother-child dyads and they looked at kindergarteners instead of preschoolers, their categories were adapted to younger children in the context of mother-child interactions about math.

For this study, *higher order* math talk was defined as any conversation about math that involved an explanation or further discussion about mathematics, a conversation about math procedures, or a demonstration about math. *Higher order* math talk could vary in terms of depth depending on the conversation, but a deeper level of talk was meant to be accomplished in *higher order* math talk, compared to *basic skills* math talk. One example of *higher order* math talk was when the mother explained to the child that “third follows second, and then that the second shelf would be shelf two…” Other examples that could imply deeper levels of math talk are when the mother explains reasons for a mathematical concept to her child, or if the mother and child discuss why the child got something wrong on a math worksheet.

Basic skills math talk refers to conversations that involve math words, but these words often occur when families use math-related language in an implicit way but not necessarily with the intention of talking about math. Although these words are math related, they are not discussed in the way that *higher order* math talk is. One example of *basic skills* math talk was when a child asked his mother what the sign plus means and the mother answered that they were going to talk about that at a different time and they did not end up discussing it at the time of the recording. Other examples of basic skills math talk were naming shapes or using ordinal numbers without any further discussion about math.

The complexity of the math talk, either *higher order* or *basic skills* was recorded for each conversation, and then the frequency and proportion of *higher order* and *basic skills* math talk per category and per family were calculated. There were a few cases in which either the mother or the child asked something math-related but there was no answer from the other side when expected. Those cases where coded as *No Response* and the frequency and proportion of *No Responses* per family were calculated.

Math Talk Coding Reliability

To ensure that the coders were using the same criterion while categorizing math talk, all coders were trained before coding the transcripts of the participant families. In addition, intraclass correlation coefficients (ICCs) were used to estimate the interrater reliability among the coders (Shrout & Fleiss, 1979). Twenty percent of the transcripts were independently coded by two trained research assistants, and ICCs were calculated for all the categories (e.g., naming numbers, ordinal numbers, etc.). The average ICC for the frequencies of these categories was .90

(*SD* = .10), and they ranged from .70 to 1.00. The average ICC for the number of utterances involved in these categories of math talk was .92 (*SD* = .72), and it ranged from .72 to 1.00.

When adding all categories of math talk, the ICC for the total amount of math talk (i.e., sum of all interactions about math) was .95, and the ICC for the total amount of utterances involved in math talk across all categories was .98. Finally, ICC coefficients were estimated for all other codes (complexity, initiation, and dominance of math talk) in terms of their totals per family. The average ICC for these codes was .87 and it ranged from .65 to 1.00.

Out of the 44 ICCs, there was only one ICC that was below .70 (ICC = .65), which corresponded to the total of conversations in which neither the mother nor the child dominated the interaction. The main issue with this code was distinguishing the person who talked the most during the interaction in a reliable way. Taking into account the length of the utterances, in addition to the number of utterances involved in the conversation made the coding harder and less reliable, as utterances by the mother and the child were very close in length on many occasions. Thus, this code was revised and the dominance of the conversation was coded in terms of the number of utterances only (see description of this code above), which improved the reliability. Disagreements were discussed until resolved.

Family Variables

The demographic aspects of the families and parenting variables were assessed using two self-administered questionnaires during both waves of data collection. The *Background questionnaire* (see Appendix E) included general questions about family composition, family income, educational background of the parents of the child, ethnicity, gender, age of the parents and the child, child-care experience, among other aspects that helped to contextualize the families.

The *Parenting questionnaire* (see Appendix F), adapted from Morrison and Cooney (2001), gathered information about parents' practices, values, and beliefs regarding their preschool children. In terms of math, a couple of additional questions about math-related practices at home were also included. These questions were based on recent findings about specific home numeracy experiences that are related to children's early competence in school (LeFevre et al., 2009). Specific questions about math included the frequency with which the mother does math activities (e.g., math workbooks or simple math problems, as well as activities such as connect-the-number pictures, mazes, and puzzles) or plays number games (e.g., "This Old Man" or "1, 2, Buckle My Shoe"), counting games, board games or card games with the child. Also, mothers were asked to report the frequency with which they engaged in counting (i.e., counting things or playing counting games) or sorting (i.e., sorting things by size, color, or shape) activities with their children, as well as identifying written numbers or printing numbers. Moreover, to collect information about math application activities, mothers also reported how often they talk about money with their children when shopping (e.g. "which costs more?"), measure ingredients with their children when cooking, play with calculators or use calendars and dates with their children, or have their child wear a watch. All of these were Likert-type scale questions that ranged from *almost never* (1) to *daily* (5).

Even though there was an original attempt to observe the availability of math-related items in the home to account for the child's exposure to a home numeracy environment, families differed in the places and rooms in which they allowed researchers to administer the assessments and questionnaires. Therefore, observations were not comparable across families, and that data were not collected. However, to capture the presence of math-related items at home that could promote math skills in children, some questions were added to the parenting questionnaire in the second wave of the study. In particular, mothers were asked for the presence and number of puzzles, clocks, calendars, number magnets, and calculators, among others.

Child Variables

Children's cognitive and early academic skills, including early math skills, were measured in the first wave of the study. At the first wave of data collection, measures of receptive vocabulary, early decoding skills, and self-regulation were obtained to be used as control variables, whereas measures of math knowledge and achievement were gauged and analyzed as outcome variables. A year later, children were assessed in their math knowledge and achievement using the same instrument from the first wave of the study plus two additional measures of children's quantitative reasoning and understanding of numerical magnitudes.

Math Knowledge, Quantitative Reasoning, and Math Achievement

In the first wave of the study, math knowledge, quantitative reasoning, and math achievement were measured by using the Applied Problems Subtest of the Woodcock-Johnson III (WJ-III) Tests of Achievement (Woodcock, McGrew, & Mather, 2001). The WJ-III Tests of Achievement have standardized administrative and scoring protocols, and are designed to provide a normative score that shows the child's abilities in comparison to the national average for the child's age. They can be administered to children as young as two years old as well as to adults and have specific start points depending on the age. Also, they have a ceiling criterion so that after a certain number of incorrect consecutive responses to the items (6) the test is stopped. The *Applied Problems* subtest measures the child's quantitative reasoning, math knowledge, and math achievement by using either an auditory (question) or a visual (numerical text) stimulus. It requires that the child (a) accesses and applies mathematical calculation knowledge to perform math calculations, (b) applies quantitative reasoning in response to problems that are presented both orally and visually, and (c) gives an oral answer. It also requires the construction of mental models via language comprehension of the presented problems (Schrank, 2006). Thus, being able to solve these applied problems requires the child to access not only the calculation abilities but also complex cognitive processes, such as language comprehension and visual working memory processes (Ashcraft, 1995). This subtest has an internal consistency of .93, calculated by the split-half reliability procedure (Schrank, McGrew, & Woodcock, 2001).

In the second wave of the study, the child's mathematical skills were measured using the same subtest of the WJ-III (i.e., *Applied Problems*), plus two additional measures of children's mathematical reasoning and mathematical understanding, respectively: the *Test of Early Mathematics Ability-Third Edition* (*TEMA-3*) (Ginsburg & Baroody, 2003) and a *Number Line Estimation* task (Thompson & Siegler, 2010). These measures were added to offer a better understanding of the links between math talk and the different aspects of children's mathematical knowledge and skills a year later.

The *TEMA-3* measures the mathematics performance of children between 3 years 0 months and 8 years 11 months. This is a standardized test designed to measure mathematical ability that has entry points based on the age of the children to minimize the testing time. The *TEMA-3* also uses basal (the child answers five correct answers in a row either after the entry point or before that) and ceiling (the test is stopped after six consecutive incorrect answers). The test measures both informal and formal knowledge and both concepts and skills in different domains. *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 the procedural knowledge, both essential aspects to use mathematics effectively (Ginsburg & Baroody, 2003). The items of the TEMA-3 measure informal mathematics knowledge in four domains: numbering skills, number-comparison facility, calculation skills, and understanding of concepts; whereas formal mathematics knowledge is measured in the domains of numeral literacy, mastery of number facts, calculation skills, and understanding of concepts. This test has internal consistency alphas equal to or above .92 for the different age intervals that ranged from 3 to 8 years of age (Ginsburg & Baroody, 2003).

The *Number Line Estimation* task assesses the child's knowledge of the number system and understanding of numerical magnitudes of numerals (Siegler & Booth, 2004), and it has been shown to be related to children's math achievement (Siegler, Fazio, & Pyke, 2011). For this task, different ranges of numbers have been used (e.g., 0-10, 0-20, 0-100, 0-1,000), depending on the age and socio demographic characteristics of the children in the studies (Berteletti, Lucangeli, Piazza, Dehaene, & Zorzi, 2010; Booth & Siegler, 2006; Siegler & Booth, 2004; Thompson & Siegler, 2010). For this study, children were required to select the appropriate position on a number line of a number between 0 and 20. First, children were shown where both 0 and 20 go in a horizontal line with "0" below the left end and "20" below the right end on a sheet of paper. Then, all numbers from 1 to 19 were presented, one at a time, in a random order, and they were asked to estimate the position of each number on the line, one number per number line. To assess the accuracy of the child's estimates, each child's percentage of absolute error was calculated following the procedure described by Siegler and Booth (2004). For each number being estimated, the estimated quantity was subtracted from the estimate, and the result was divided by the total number of estimates (scale of estimates). Then, the mean of the percent of error per child was calculated and used for this study.

Vocabulary Comprehension

The child's expressive vocabulary was measured by using the *Peabody Picture Vocabulary Test* (PPVT) (Dunn & Dunn, 1997) at the first wave of the study only. The *PPVT* is a widely used standardized measure of vocabulary comprehension that has published norms. It has a mean of 100 and standard deviation of 15, with a reported internal consistency (Cronbach's alpha) of .94. In this measure, children are presented with a verbal stimulus (i.e., a word) and are asked to indicate the picture (out of four possible pictures) that best describes the verbal stimulus. The child's expressive vocabulary was used in the predictive analyses to control for the linguistic skills that have been shown to be predictors of early mathematics skills as well (LeFevre, Fast, et al., 2010).

Early Decoding Skills

The child's early word decoding skills were assessed at the first wave of the study by using the *Letter–Word Identification* subtest of the WJ-III (Woodcock et al., 2001). By presenting a visual stimulus (text), this subtest requires that the child identifies printed letters and words, recognizes visual word forms from a phonological lexicon, accesses pronunciations associated with visual word forms, and gives an oral answer (letter name or word). This subtest has a median reliability coefficient of .94, calculated through the split-half procedure (Schrank et al., 2001), and was included as a control measure of the child's decoding skills in the corresponding analyses.

Self-Regulation

Since self-regulatory skills have been shown to predict early achievement in math (McClelland et al., 2007), two measures of the child's ability to regulate his or her behavior were used in the first wave of the study as control variables: the *Head-Toes-Knees-Shoulders* (HTKS) task (Ponitz, McClelland, Matthews, & Morrison, 2009), and an *Operation Span* task (Blair & Willoughby, 2006; Willoughby, Blair, Wirth, & Greenberg, 2010). The *HTKS* is a behavioral measure of self-regulation that 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 to touch his or her shoulders every time the examiner says "touch your knees".

The *Operation Span* task measures working memory span in children. Each stimulus is presented on one page that contains a picture of an animal figure with a colored dot above it. Both the animal and the colored dot are located within the outline of a house. The child is required to name both the animal and the color of each picture, and then the examiner turns the page so that the child can only see the outline of the house from the previous page. The examiner then asks the child which animal was/lived in the house. Children receive trials with 1 item (a house with an animal and color inside it), 2 items, 3 items, and 4 items. This task requires the child to name and hold in mind two pieces of information simultaneously and to activate the name of the animal while overcoming interference occurring from naming the color.

CHAPTER III: RESULTS RESEARCH QUESTION 1

Analytic Strategy to Describe Math Talk between Mothers and their Preschoolers

In order to answer the first question about the ways in which mothers and their preschool-aged children talk about math, the types of math talk that occurred in two days of conversations between the mother and the child were examined. Two time frames (i.e., up to four hours of conversations per family) were coded using the coding scheme described in the previous chapter. The number of conversations about math between mothers and their preschoolers was described both in each of the four segments and as an average of these segments, in order to get a measure of the frequency of math talk in the home and the most common math topics among families. The length of these exchanges about math was also looked at to illustrate how much of the total conversations families had at home pertained to mathematics, and to distinguish which types of math talk captured most of the interactions about math. Finally, the conversations between mothers and their preschoolers were described in terms of their complexity, as well as the role that mothers and children played in initiating and dominating the exchanges, to provide a better understanding of the nature of the math talk occurring in naturalistic settings.

Frequency of Math Talk in Different Days and Time Frames

The total frequency of math talk and the frequencies of specific types of math talk for each of the four segments were calculated by averaging the number of times in which the 40 families talked about both math in general and specific aspects of math, in each particular recorded hour. For example, during breakfast time of day 1, families, engaged in an average of nine math talk instances, whereas they talked about *time* only once (see Table 3.1). As shown in Table 3.1, on average, mothers and their preschoolers engaged in approximately seven to nine math talk instances in each of the four segments analyzed. Even though there were similarities across segments in terms of the frequencies with which families talked about math, the specific frequencies by day and time frame are briefly described in the sections below to provide a broader picture of the ways in which math talk happened in naturalistic settings among mothers and their preschoolers.

When an interaction included more than one type of math talk, it was dual coded so that it was counted in all the corresponding categories. For instance, if the mother and child were talking about geometrical shapes and used fractional values while drawing (e.g., they mention they were going to draw half of the circle), that interaction would be coded both as *naming shapes* and *fractions*. Dual coding happened in almost 20% of the interactions, such that 20% of the math talk instances were coded in more than one category (i.e., they were coded for all the categories involved in that interaction, such as *naming shapes* and *fractions* in the prior example). Even though it might seem that dual coding could inflate the total amount of math talk, the conversations that involved more than one aspect of math were distinct enough from the conversations that were only about one topic (e.g., only *naming shapes)* in that the families producing the former category of conversation used language that involved different facets of math (e.g., *naming shapes* and *fractions*). Thus, it was crucial to account for the occurrence of more than one type of math talk within one conversation to provide a more precise picture of the amount and different types of math talk in the families.

First Day of Recording: Breakfast Time

During the breakfast time of the first day of recording, families who recorded their conversations (*n* = 35) talked about 14 out of the 17 math categories coded (see Table 3.1). On average, the most common category for this segment (i.e., breakfast time of day 1) was *naming numbers*, averaging approximately four and one-half interactions during the hour of recording (*M* = 4.43, *SD* = 3.00). The next most common categories were *ordinal numbers* (*M* = 1.40, *SD* = 1.42) and *time* (*M* = 1.29, *SD* = 1.36), in which families engaged, on average, a little more than one instance per hour. Also, 43% of the mother-child dyads talked about *counting* at least once during the recorded time frame (*M* = .63, *SD* = 1.11), whereas a third of them engaged in some conversations about *fractions* (*M* = .46, *SD* = .74). The majority of the families (i.e., ranging from 83 to 97%) did not talk about *naming shapes*, *adding and subtracting*, *comparing attributes*, *dates*, *grouping and sharing*, *monetary exchange*, *measuring*, *equality*, and *printing or recognizing numerals* (see Table 3.1). Finally, none of the exchanges discussed *estimating*, *number books and games*, or *purpose of math* during this time frame.

First Day of Recording: Dinner Time

The families who recorded during dinner time of the second day (*n* = 32) engaged in ten of the math talk categories that were examined (see Table 3.1). Again, the averages show that the most common category was *naming numbers* (*M* = 3.09, *SD* = 2.72), although the average was only slightly more than three times during the whole hour (i.e., one interaction less than during the breakfast time of this day). At the mean level, families also engaged in conversations involving *ordinal numbers* (*M* = 1.13, *SD* = 1.66) and *time* (*M* = 1.00, *SD* = 1.22), at a rate of about once per hour. A little more than a third of the families (i.e., 34.4%) engaged in *counting* interactions (*M* = .63, *SD* = 1.13), a quarter of them talked about *fractions* (*M* = .28, *SD* = .52), and an eighth of them engaged in *adding and subtracting* interactions (*M* = .19, *SD* = .59) during this time. Most of the families, however, did not engage in conversations about *comparing attributes*, *number books or games*, *measuring*, *naming shapes*, *printing and recognizing numbers*, *estimating*, or *grouping and sharing* (see Table 3.1). There was no talk about *monetary exchange*, *dates*, *equality*, and *purpose of math*.

Second Day of Recording: Breakfast Time

During the breakfast time of the second day of recording, the 32 families who recorded at that time engaged in eleven types of math talk (see Table 3.1). Similar to the previously described segments, *naming numbers* was the most common coded category, averaging 3.41 exchanges (*SD* = 3.42) during the hour of recording, followed by *ordinal numbers* (*M* = 1.34, *SD* = 1.31) and *time*, which families discussed, on average, only once during the recorded hour (*M* = 1.22, *SD* = 1.39). Also, approximately 44% of the families engaged in one or two instances involving *counting* (*M* = .56, *SD* = .72), whereas 34% of them talked once or twice about *fractions* (*M* = .38, *SD* = .55). Again, families talked with a very low frequency about *adding and subtracting*, *number books and games*, *naming shapes*, *grouping and sharing*, *dates*, and *estimating* in this recorded hour (see Table 3.1). There were six categories that were absent in the conversations of the families during the breakfast of the second day: *monetary exchange*, *comparing attributes*, *equality*, *measuring*, *printing or recognizing numerals*, and *purpose of math*.

Second Day of Recording: Dinner Time

During the coded hour happening at dinner time of the second day of recordings, families (*n* =32) talked about almost all categories, with the exception of *estimating* and *purpose of math* (see Table 3.1). Again, the most common category was *naming numbers* (*M* = 3.81, *SD* = 4.05), showing that, on average, families named numbers almost four times per hour. Families also talked, on average, almost once per hour about *ordinal numbers* (*M* = .81, *SD* = .97), *counting* (*M* = .91, *SD* = 1.40), and *time* (*M* = .91, *SD* = .96). *Fractions* (*M* = .44, *SD* = .91) was a category used by 28% of the parents, whose use of them ranged from one to four instances during the recorded hour. Almost all families did not engage in math talk involving *adding and subtracting*, *monetary exchange*, *dates*, *equality*, *comparing attributes*, *printing or recognizing numerals*, *grouping and sharing*, *number books or games*, *measuring*, and n*aming shapes* during the dinner time of the second day of recording (see Table 3.1).

Average Frequency of Math Talk across Days and Time Frames

There were no specific hypotheses in terms of the differences across days and time frames, as both selected days corresponded to a weekday that was chosen by each family according to their preferences and schedule, and could be the either the first, second, or even the third day that they recorded. Both times frames were meal times chosen because of the research showing that families engage in more conversations and use more sophisticated words during these times (Tabors et al., 2001), as well as their potential to elicit more conversations about math among families. Since the frequencies with which mothers talked about specific aspects of math with their preschoolers had a similar pattern across days and times (in terms of the most common, least common, and not observed types of math talk) (see Table 3.1), these frequencies were averaged across segments. In other words, the frequencies with which each family talked about every coded aspect of math (e.g., *naming numbers, ordinal numbers, fractions*, etc.) during the breakfast of day 1, dinner of day 1, breakfast of day 2, and dinner of day 2, were averaged and the segments were analyzed as a group. This average describes the types and frequency of math talk that occurred, at the mean level, in the four hours of recordings, which provides a more realistic picture of the math talk occurring during meal times in these families. Therefore, the remaining reported analyses in this study consider the average among the four segments in terms of math talk.

As some families did not record their conversations in all segments (21 families had data in four segments, 10 families had data in three segments, eight families had data in two segments, and one family had data in one segment only), the average across days and times was used to describe the types of math talk that families engaged in, instead of the cumulative frequency (i.e., adding the frequencies across time). Thus, the reported frequencies in this section represent the average of what families did during the four hours of recording. For the cases in which families did not record during the four segments, it was assumed that mothers and children would talk about mathematics similarly to how they did during the recorded time. Although there are some limitations with this approach (i.e., one could underestimate or overestimate the frequencies of math talk that were not recorded and coded), the frequencies of the different types of math talk previously presented in this chapter support the assumption that families had a similar pattern of interactions across time frames. On average, mothers and their children were likely to talk about math in a comparable way across time.

As shown in the left columns of Table 3.2, the most common type of math talk across segments was *naming numbers*, with an average of almost four exchanges in a period of one hour (M = 3.75, SD = 2.11). Considering that this is the average per hour, it could be assumed that families talked about *naming numbers* fifteen times during the analyzed segments. Moreover, all families engaged in one or more interactions, on average, about *naming numbers* during an hour of recording, and 30% of them engaged in four or more conversations of this type, including two families who talked more than nine times about *naming numbers* in an hour. *Naming number* interactions included using number words to refer to cardinal values (e.g., "read me one book"), age (e.g., "when you were three"), number comparisons (e.g., "that's not ten, that's zero"), among others. One example of a way in which families' practice of *naming numbers* overlaps with the cardinal values is this interaction of a mother and her child while eating dinner[2]:

Mother: John, you're not "gonna" get up without eating that broccoli.

Child: I don't like it. I don't want broccoli.

Mother: Okay, well eat <u>*four*</u> pieces.

Child: No!

…Mother: Alright, we're "gonna" take the milk away.

Child: No!

Mother: <u>*Four*</u> pieces of broccoli.

Child: No.

Mother: Let Daddy take the milk away. I know you don't want it. Take the milk away, Daddy.

Child: I'm thirsty!

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[2] Participants have been given pseudonyms in all examples; boys were all named "John" and girls were all named "Jane." Mothers were not referred to by their names so there was no need to give them pseudonyms.

…Mother: Eat *four* pieces of broccoli.

Another example of *naming numbers*, but with a different use, is this conversation about taking vitamins:

Mother: Want a Flintstones vitamin? No? Want a SpongeBob vitamin? Here I want you to pick *one* and you go take the same *one* to Jane and give it to her okay?

Child: I don't want to pick the *one* same *one*...

After *naming numbers*, the next most frequent types of math talk were *ordinal numbers* (*M* = 1.25, *SD* = 1.04) and *time* (*M* = 1.17, *SD* = .87), in which families were involved, on average, at least one time during an hour, or four times during the total time of recording. Only 12.5% of the families did not use *ordinal numbers* in an hour; moreover, 65% of the mother-child dyads engaged in one or more exchanges involving *ordinal numbers*. Following are two examples of exchanges involving *ordinal numbers* in the dyads of this study, one when discussing a dentist appointment and the other while drawing.

Mother: Did you hear me tell John that we have dentist appointments today?

Child: Mmhm.

Mother: Okay.

Child: Can I get mine done *first*?

Mother: I think so. I don't think it matters who goes when.

…Mother: Oh. And you don't want that this time? You want to be ***first***? You “wanna” wait?

Child: Mmhm.

Mother: Okay.

Child: I want to see- Can I see what toys there are even when it's not my turn?

***

Mother: Here. Here's your water, there's your brushes, here's a paper towel. I should've grabbed a new roll of paper towel. There's one to rinse when you switch colors, okay? You're all set?

Child: Yeah.

Mother: Okay.

Child: Now do I do this? Mom, do I draw on this ***first***?

Mother: Did you already put paint on there? Then you can go ahead and paint.

In terms of the math talk about *time*, 7.5% of the mother-child dyads did not engage in conversations about when something happened or will happen in the averaged segments, and 37.5% of them talked about *time* less than once per hour. At the mean level, 35% of the families engaged in exchanges involving *time* between one and less than two times, 12.5% talked about *time* between two and less than three occasions, and 7.5% of the families were engaged in three or more exchanges related to *time*. The exchanges about *time* mostly included units of measure as shown in the next two examples, the first occurring during dinner and the second one when talking about going to the beach.

Child: I don't want anymore.

Mother: You got a couple bites left finish it up.

Child: I don't want it.

Mother: You still have time to play, you still have <u>*fifteen*</u> minutes.

Child: I don't want it.

***

Mother: Because they're easy for you to put on and easy for mommy to wash if you play with them at the beach. For beach shoes.

Child: …takes them off before we play in the water.

Mother: Right.

Child: If we bring our water shoes there we can just walk… run in there with our water shoes on.

Mother: Yeah. Those are different.

Child: Yeah.

Mother: Those are for places that have rocky bottoms to swim in.

Child: So when I stepped in without, without my crocs I feel rocks, rocks, rocks. So I climbed up side and I…Because, when when..when…the <u>*first*</u> time I was scared of that one, but....

Mother: But you're not scared anymore?

Child: No. I disliked it.

Preschoolers and their mothers also talked about *counting* with some frequency (*M* = .75, *SD* = .78), although they averaged less than one interaction per hour. On average, only 17.5% of the families did not participate in *counting* during the averaged hour of recording, whereas the majority of families (55%) engaged in conversations including *counting*, though with a frequency of less than once per hour. Nevertheless, 17.5% of the families counted between one and less than two times per hour, and 10% of them did so more than two times per hour. For example, the conversation below illustrates these interactions as the child counts candles.

> Mother: Yeah I don't want the ball anywhere near over here cause... Look how many candles are there?
>
> Child: Three, four, five!

Fractions was somewhat present in the mother-child exchanges, but the average was approximately one interaction in three hours (M = .38, SD = .48). In fact, 40% of the families did not engage in exchanges involving fractional values, and 45% of them engaged in less than one *fractions-exchange* in one hour of recording. Only 15% of the families averaged between one and a little more than two interactions involving *fractions*. Most of the interactions involved the words *whole* and *half* (used to represent fractional concepts), although a few families also used other fractional values, as shown in the following examples.

> Child: Good job, you did it!
>
> Mother: Okay you "wanna" do your <u>*half*</u> hour of games right now?
>
> Child: Yes…right now.

***

Mother: Okay guys let's be nice and stop talking about it. Okay, six ounces is *three-quarter* cup. Dinner's almost ready.

...Child: What?

The rest of the categories were not very common in the mother-child conversations. On average, during an hour of recording, families barely engaged in interactions about *adding and subtracting*, *monetary exchange*, *dates*, *estimating*, *comparing attributes*, *equality*, *grouping and sharing*, *measuring*, *naming shapes*, *number books and games*, and *printing or recognizing written numerals*. In fact, the vast majority of families did not talk about these math ideas during the time of the recording. In the case of *adding and subtracting*, 75% of the families, on average, did not engage in these types of conversations, and only five percent of them engaged in one or more interactions involving either addition or subtraction of numbers. Similarly, on average, 72.5% of the families did not name *shapes*, and only one family talked about *shapes* in a context different than comparing attributes. However, some examples of the few interactions recorded in the family exchanges about *adding and subtracting* as well as *naming shapes*, respectively, are provided below to illustrate what these interactions looked like in the few families who discuss these topics.

Child: Mommy?

Mother: Yes, my love.

Child: Would you like any chicken nuggets?

Mother: No thank you. Thank you for asking.

Child: Because daddy wanted three.

Mother: Umm... so if you have four for you, or four for your brother and three for you, and one two three for daddy, how many do you need?

Child: Ten.

***

Mother: Okay. So, here's dinner.

…Child: Yeah, Mom. I want it cut up in <u>*squares*</u>.

Mother: Okay, it's already cut up in <u>*squares*</u>.

Child: I mean <u>*triangles*</u>.

Mother: Okay, I'm "gonna" turn your thing off because I'm getting ready to leave.

Child: I want it in <u>*triangles*</u>.

Mother: Okay, you can cut it into <u>*triangles*</u>.

Dates as a topic of math was even less frequent, and 85% of the families did not engage in it; only six families, on average, talked about *dates*, and the frequency was about one time in four hours. Even though this was not a common code, an example illustrating how the few exchanges about *dates* occurred in the participant families is provided here.

Mother: Let's go, it's Friday, and tomorrow we can sleep in.

Child: Tomorrow is Friday?

Mother: No, today is Friday. Tomorrow is Saturday.

Child: It's the end of the week.

Mother: Today is the end of the week, you're right. Are you excited for the end of the week?

Child: After the end of the week, is Jane.. stay for a whole week.

Mother: A whole weekend is how many days?

Child: 200.

Mother: Not 200.

Child: And then, after it's done, she'll have “goed” to first grade.

Mother: No, not after…

Child: Huh? After what weekend?

Mother: After a weekend in summer.

Child: I wish a year was only 5 weeks.

In addition, 82.5% of the families did not *compare attributes* in their interactions, and those that did engaged in this type of exchange less than once per hour, averaging slightly more than one time in four hours.

Mother: …Get your toothpaste…Well, then you do it.

…Child: That's not the same toothpaste I have.

Mother: Yeah, let's go upstairs. Can we take it up....

Child: There's a big one and a small one!

Mother: Well, we can take ***the small one*** for the trip…

There were a few families who also engaged in interactions involving *number books and games*. On average, however, 87.5% of the mother-child dyads did not participate in these types of activities while being recorded. At the mean level, 5% of this sample engaged in *number* *books or games* at a rate of once every three hours, and the remaining 7.5% between once every other hour to once per hour. Below is an example of a *number game* type of exchange, in which the mother asks the child if he wanted to play “Shut the Box” and explains the game.

> Mother: Do you want to play Shut the Box? Alright.
>
> Child: What does Shut the Box mean?
>
> Mother: Well...
>
> Child: How many dice do we need?
>
> Mother: We need two six siders to play this game.
>
> Child: Two six siders?
>
> Mother: Yep.
>
> Child: Why do we need it all?
>
> Mother: Because what you do is you roll the die. And then you get to put down the number or some numbers that add up to your number. So you got one two...
>
> Child: Three.
>
> Mother: Three, four. Because this is a two. This dice is silly.
>
> Child: So I have one, two, three, four!
>
> Mother: Right, so you could put down the four or you can put down the three and the one. “Cause” one plus three makes four…

Even though this code was intended to capture interactions with numbers in the contexts of games or books, there were two instances in which families sang a song with their children as a game. Since these interactions involved playing around numbers by using a song, these two interactions were coded as *number games* as well. One of the number songs is illustrated in the following example.

Child: Um... I wanna sing songs.

Mother: What songs would you like to sing?

Child: I want to…little…and apples.

Mother: I don't know that one.

Child: "Four little apples sitting on a tree, five little apples fall down to me, so I shook that tree as hard I could and down..."

Mother: [inaudible audio]

Child: Lucky!

Mother: No.

Child: Can you sing that song, teacher?

Mother: Huh?

Child: Can you sing the song that I just did?

Mother: Sing it again.

Child: "Five little apples sitting on a tree, five little apples fall down to me, so I shook that tree as hard I could and down came the apples and..."

Mother: Ha-ha-ha it's so cute. "Five little apples sitting on the tree, five little apples falling on me?" Right? Right? Now...

Child: And, "so I shook the tree"...

Mother: "So I shook the tree as hard as I could."

Child: And down...

Mother: "Came the apples, mmmm they were good."

Child: Yeah…the pumpkin one.

Mother: I don't know the pumpkin one.

Child: "Five little pumpkins sitting on the…, 'oh my, it's getting late' the second one said 'There are witches in the air'". "The second one said 'let's run, run, run and the third one said 'it's Halloween fun!'".

Mother: "Five little pumpkins, sitting a gate, the first one said 'oh my it's getting late' the second one said 'There are witches in the air'".

Child: No, the third one said... "Oh my, it's getting late."

Mother: What'd the first one say?

Child: The first one said "oh my, it's getting- there are witches in the air."

Mother: "Five little pumpkins sitting on the gate, the first one said 'oh my, it's getting late', the second one said 'there are witches in the air', the third one said 'let's get out of here', the fourth one said"...

Child: "Let's run, run"...

Mother: "Run, the fifth one said 'it's Halloween fun'".

Conversations about *measuring* were also not very common among the recorded conversations, and only 12.5% of the families were involved in some math talk about this topic, with the average occurrence being less than one time every two hours. An example of a mother-child exchange using units of measure is below.

Child: Whoa. Whoa. These are heavy.

Mother: Mmhm. Those are ten pounds. That's very heavy for you.

Child: [inaudible audio]

Mother: No, no. Let's not do that. You and Jane can do the five pounds. Here.

Child: Five pounds?

Mother: Yes.

Child: Five pounds is not heavy.

Mother: Five pounds is heavy, too.

Child: But not too heavy for me and Jane.

Only 15% of the families, on average, talked about *grouping, sharing, or distributing*, and the frequency ranged from once every four hours to once every two hours. The following conversation from one of the participant families during breakfast time provides a sample of a *distributing* math talk instance.

Mother: …So do you want me to do the bacon then? Yes?

Child: Yeah.

Mother: Ok.

Child: One for daddy, one for Jane, one for me, and one for you.

Mother: Well I think it's just one for you and one for Jane this morning.

Child: Why?

Mother: "Cause" you guys need to eat breakfast before you go to school right now.

The rest of the mentioned types of math talk were even less frequent in the mother-child interactions, as more than 90% of the families did not talk about them in the averaged hour of recording. For example, only three families engaged in *monetary exchanges*, *noting equality,* or *printing or recognizing numerals,* with an average frequency of less than once per hour in all cases. *Equality* was discussed for only one family during the averaged hour, but the average was about once per three hours. As described above in this chapter, none of the families engaged in any interaction concerning the *purpose of math*.

Average Proportion of Math Talk Corresponding to Each Type of Math Talk

In order to provide a clearer picture of how the number of times in which families engaged in specific types of math talk was distributed among families, the number of math talk instances within a specific category was divided by the total frequency of math talk (i.e., proportion of each type of math talk). Again, the average across days and time frames was described to provide a more representative picture of the math talk among the families in the sample. The right columns of Table 3.2 present the average percentage of each category among segments. On average, almost half of the conversations about math were coded as including *naming numbers*, whereas 15% of the math talk corresponded to *ordinal numbers* and another 15% included conversations about *time*. When talking about math, mothers and their preschoolers, on average, spent 10% of their interactions in *counting exchanges* and almost 5% of them in exchanges involving *fractions*. The remaining 7% of the math talk instances corresponded to all other categories, ranging from 1.69% (i.e., *adding and subtracting*) to .24% (i.e., *estimating* and *equality*). As mentioned earlier, none of the families talked about the *purpose of math* during the recorded time.

Total Number of Utterances and Amount of Utterances Including Math Talk

The number of times that families talk about math could be related to the fact that some families talk more in general, and not only about mathematics. To account for the length of the conversations within each family, the total number of utterances that both mothers and children used in their conversations in each of the four segments was calculated. As shown in the left columns of Table 3.3, families used approximately an average of 596 utterances (*SD* = 204.07) per segment; they used 628 utterances during breakfast time in day 1 (*SD* = 251.47), 553 utterances during dinner time in day 1 (*SD* = 225.04), 566 utterances during breakfast time in day 2 (*SD* = 251.98), and 579 utterances (*SD* = 308.93) during dinner time in day 2. On average, of the total number of utterances that families used in their conversations, almost 20 utterances involved math talk (see Table 3.4). However, the total amount of utterances of math talk varied widely across families, ranging from nearly 4 to approximately 120 (see Table 3.4). As shown in the right columns of Table 3.3, these approximately 20 utterances of math talk corresponded to almost 3% of the total utterances involved in the conversations across segments, and they ranged from a minimum of 1% of the utterances to a maximum of 11% of the total talk[3]. The average percentage of math talk was similar across segments (*M* = 3.22, *SD* = 4.14, for breakfast in day 1; *M* = 2.59, *SD* = 3.52, for dinner in day 1; *M* = 2.58, *SD* = 2.22, for breakfast in day 2; and *M* = 2.63, *SD* = 2.23, for dinner in day 2, respectively).

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[3] To calculate the proportion of total talk that corresponded to math talk per segment, the average of the number of utterances involved in math talk was divided by the total number of utterances (i.e., mother plus child utterances) per segment. Then, the proportion of math talk across segments was averaged to obtain the total proportion of math talk across days and time frames. These proportions were converted to percentages to facilitate the description of the results.

Math Talk Utterances Corresponding to Different Types of Math Talk

The length of the conversations about math was also of interest, as some categories that are very common among families (i.e., *naming numbers*) could involve less talk. Another consideration is that families may engage in few exchanges about a topic (e.g., *number games or books*), but when they do so, they use more math utterances. To explore these issues, the number of math talk utterances (i.e., length of math talk) that families used in each category across segments was determined. The means, standard deviations, and ranges of the average number of math talk utterances are presented in the left columns of Table 3.4. On average, families used more than eight utterances that included *naming numbers* in an hour of conversation (*M* = 8.30, *SD* = 7.84), or approximately 33 utterances in the four-hour recoded time. They also used, on average, 3.5 utterances that included *counting* (*M* = 3.53, *SD* = 5.66), close to two utterances about *time* (*M* = 1.80, *SD* = 1.48) and *ordinal numbers* (*M* = 1.78, *SD* = 1.62), slightly more than one utterance concerning *number books or games* (*M* = 1.26, *SD* = 5.87) and *printing or recognizing numerals* (*M* = 1.03, *SD* = 5.76), and less than one but more than a half utterance about *adding and subtracting* (*M* = .65, *SD* = 2.09), during one hour of recording. On average, families used a half utterance or less per two hours related to the other types of math talk during the recorded time.

The 3% of the total utterances between mothers and their children that corresponded to math talk was also described in terms of the distribution among the different types of math talk to provide a clear picture of the prominence of some categories. At the mean level, almost half of the math talk utterances were used in the context of *naming numbers* (*M* = 47.21, *SD* = 18.19), as shown in the two right columns of Table 3.4. Approximately 15% of the math utterances, on average, were spoken in the context of *counting* (*M* = 14.81, *SD* = 15.18), 12% were related to *time* (*M* = 11.64, *SD* = 10.02), and 10% concerned *ordinal numbers* (*M* = 9.86, *SD* = 6.70). The remaining 16% of the utterances were distributed, on average, among the other categories, ranging from 3.9% of the utterances for *number books or games* to .12% for the case of *equality*.

When comparing the proportions of the number of times that families talked about a specific type of math talk (i.e., proportions of the frequencies) (see Table 3.2) versus the proportion of utterances involved in those types of math talk (see Table 3.4), there are some differences to note. Looking at the utterances involved in math talk, compared to the number of times that families engaged in those exchanges, there is an increase in the proportion of math talk related to *counting*, *dates*, *number games*, and *printing and recognizing numerals*. This difference relates to the higher number of utterances involved in these specific types of math talk, compared to other types. For example, most of the conversations coded as *counting* included more than one utterance, whereas the exchanges involving *ordinal numbers* –that showed a decreased in the proportion, from 15.04% when looking at the amount of exchanges, to 9.86% when talking about utterances– on the other hand, usually had only one utterance per interaction. Also, there were no interactions coded as *dates* that had only one utterance, and the average for this category was about five utterances per exchange. The math talk involved in *number books or games* exchanges also involved an important amount of utterances, ranging from 3 to 47. In the case of *printing numerals*, again, all interactions had more than one utterance including math, and one actually had 109 such utterances.

Proportion of Complexity, Initiation, Dominance, and No Response in Math Talk

In addition to the number of times that families engaged in math talk and the length of their conversations, the nature of the interactions was also described. There were families who engaged in more sophisticated exchanges involving math (i.e., *higher order* math talk), whereas others used math words in a more incidental way without further discussion (i.e., *basic skills* math talk). Of the averaged instances of math talk across segments, the largest majority of the interactions were coded as *basic skills* (*M* = 93.76, *SD* = 10.48), and only a small percentage of them corresponded to *higher order* interactions in the domain of math (*M* = 6.24, *SD* = 10.48) (see Table 3.5). In fact, 60% of the families did not engage in any *higher order* type of math talk, and 15% of them engaged in less than one of these interactions in the same period of time. The remaining 25% of the families discussed math at a deeper level in a range of one to almost four math talk instances, on average, during one hour. Even though *higher order* instances of math talk were less common in the mother-child interactions, when they occurred, most of the time they included more than one type of math talk and more than one utterance, as in the following example that involves *naming numbers*, *ordinal numbers*, *counting,* and *dates*.

> Mother: Hey what happened to your stuff up here? Your birthday was on the eleventh. That was your birthday. You don't want to lose those little pieces honey. Next year when you have a birthday we need to be able to put the thing on it. Right there. That's March eleventh is John's birthday.
>
> Child: Ten, Eleven.
>
> Mother: March. Look.
>
> Child: Ten is my birthday because I am ten years old.
>
> Mother: And this is Saint Patrick's Day. March seventeenth is Saint Patrick's Day.
>
> Child: That's my number. Ten.
>
> Mother: And look at this day. It says "Play with friends". That's this week. March. See. Look at the first date- Now this has moved. The first day of spring is the 26th is it? I

think it's over here. Did you move it? And then you got a haircut on this day. Look, "get a haircut" March 6th.

The complexity of the math talk was also related to the coded category. The most common category among the *higher order* math talk instances was *counting*, with a total of 15 exchanges across segments, followed by *naming numbers* with 14 instances, *adding and subtracting* with ten interactions, *ordinal numbers* with eight exchanges, and *time* with six exchanges. Even though *naming numbers* was the most common category when analyzing the total frequencies across segments, it was not the most common when looking at the *higher order* interactions. In fact, the proportion with which the different types of math talk occurred within higher order interactions was relatively evenly distributed among *counting* (23%), *naming numbers* (22%), *adding and subtracting* (16%), and *ordinal numbers* (13%), highlighting the fact that parents and children in this sample talked about these issues in the context of longer conversations about math that might include a deeper level of talk. Most of the *higher order* conversations included a more detailed exchange about math but they varied in the depth of the interaction about math. For example, the following exchange shows how a child and his mother name numbers in a more detailed way than just mentioning them, so it was coded as *higher order*, although they did not discuss numbers in much detail.

Mother: Oh good. Hey could you..? John? …. You are good. You are better than a third grader at that. Blow.

Child: How old are third graders?

Mother: Usually seven or eight. Or no I'm sorry, usually... seven or eight?

Child: Or ten or eight.

Mother: They're usually eight or nine. Sorry I got mixed up. Thanks John.

Again, since there were no interactions about the *purpose of math*, there was no *higher order* math talk coded within that category. However, despite the fact that there were several occurrences of other types of math that were coded in the mother-child interactions in this sample, there were no instances of *monetary exchange*, *estimating*, and *equality* coded as higher order math talk.

On the contrary, all families engaged in a little more than two instances of *basic skills* math talk during the averaged hour of recording. *Basic skills* conversations consisted mostly of exchanges in which families used math words but they did not follow up with any discussion about math. These conversations also involved using number words in an incidental way, where math was not the prominent topic of the conversation. *Basic skills* conversations were distributed among all the types of math talk that were found in the conversations between mothers and children in this study. On average, most of the conversations coded as *basic skills* were about *naming numbers*, in line with the general pattern found for math talk among these families. In almost all cases, the *basic skills* interactions involved just one or very few utterances and were characterized as being math words used in the context of conversations that did not include much math or in which the goal was not to talk about mathematics. The following two examples illustrate *basic skills* math talk.

Mother: Hard to balance with no arms. Ugh. Okay.

Child: And look what I can do.

Mother: What? No arms and only *one* leg. And you can balance if you stay still. Try stepping off the rug. You're *half* on and *half* off it, it makes it hard. There. You are very good at balancing.

***

Child: Mom. Ba ba ba!

Mother: You want her down? Look at he's standing like that.

Child: Down? *One*, *two*, *three*. There "ya" go! Jane.

Mother: Yeah.

Much as the complexity of the math talk has illustrated the nature of the conversations, describing the person initiating the math talk instances is also beneficial towards understanding how families socialize math in naturalistic contexts. Considering the developmental stage of the children, the type of exchanges, and the research in the area, it was expected that mothers would initiate more math talk than their children. In fact, on average, mothers initiated the majority of the interactions about math (M = 64.36, SD = 14.87), but preschoolers did initiate approximately 36% of them (M = 35.64, SD = 14.87) (see Table 3.5). Mothers initiated most of the conversations in the large majority of the math talk categories, with higher proportions for *dates*, *estimating*, *measuring*, *time*, and *fractions*. There were no categories in which children initiated more conversations than their mothers; moreover, interactions involving *dates*, *estimating*, and *measuring* were initiated only by mothers. Only in conversations involving a few types of math talk (*comparing attributes*, *number books or games*, and *printing numbers*) did mothers and children initiate the same proportion of exchanges, though there were just a few such interactions in each category. In addition to these categories, children initiated conversations with a higher frequency when *counting*. The following two examples illustrate both a mother-initiated math talk instance that includes *time* and a child-initiated interaction about *printing or recognizing numerals* while typing on a computer, respectively.

Mother: Ok, We'll turn it, hold on *one* *second*.

Child: I get to pick it.

Mother: Hold on. Why don't we all pick it together?

Child: No momma, I'll pick it.

Mother: Well there's not much on in the morning. Hold on.

Child: I will pick it this day.

Mother: Only *five minutes* of little bill, and then TV is off.

***

Child: …One, two, three, four, five, six, seven, eight, nine, ten. See, that's not ten. That's zero!

Mother: Zero, right. But it seems like, right?

Child: Yeah.

Mother: What makes it ten? What number makes it ten?

Child: One and zero.

Mother: A one and a zero?

Child: One and zero.

Mother: Yeah. What makes eleven?

Child: Two ones.

Mother: No.

Child: Two ones?

Mother: Two ones? Yeah. Good. Okay, what makes seventeen?

Child: A seven. And a three.

Mother: Seventeen?

Child: Yeah.

Mother: No. What makes seventeen?

Child: A seven and an eight.

Mother: No. Look, John. Concentrate.

Child: One. And a seven. What's twelve?

Mother: What does twelve have?

Child: A one. And a zero.

Mother: What's that?

Child: A ten.

Mother: Yeah. What's twelve?

Child: That's seventeen…

It is interesting to note that, despite the large number of conversations that were initiated by the mother, mothers dominated the math talk in only 57% of the interactions (see Table 3.5), although this percentage was higher when discussing *estimating*, *fractions*, *time*, *ordinal numbers*, *measuring*, *equality*, and *dates*. Both the mother and the child talked in comparable ways (i.e., the number of math utterances was the same between the mother and the child or there was a difference of only one utterance) in 15% of the cases. This percentage was even higher when the interactions were about *number books or games*, *printing numbers*, *adding and* *subtracting*, and *dates*. On average, children dominated the conversations about math 27% of the time, especially in conversations about *comparing attributes*, *adding and subtracting*, *equality*, and *counting*. The following extracts of transcripts of the recorded conversations exemplify a mother-dominated conversation, a child-dominated conversation, and a conversation that was dominated by both, respectively.

Mother: Banana or something. We got about 15 minutes until we need to go. Don't mess with the…, don't don't.

Child: … enough time to do stuff. "Whatcha" doing right now?

Mother: I'm done here. We just don't have to be there until 6:30, and what time is it now?

Child: Uh, 6:00.

Mother: So how long do we have?

Child: Uhhh...

Mother: Before we need to be there.

Child: I don't know.

Mother: How many minutes? We don't have to be there until 6:30. How many minutes away is that? It's 6:00 right now.

Child: I don't...

Mother: We don't need to be there until 6:30. You're not sure what time that might be?

Child: What is it?

Mother: I think you boys should go downstairs and use your clock, and put 6:00 on it, and then 6:30.

Child: Well where is the...? I don't, I don't know…to use.

Mother: Well what would 6:30 look like? Six, dot dot, and then what?

Child: Three.

Mother: And then what, a three, and what?

Child: [inaudible audio]

Mother: Yeah six dot dot three. Yes, three zero. Come on down babe.

***

Child: If you took... If you took one away how many would there be left?

Mother: I “gotta” see.

Child: Two!

Mother: Count again. Oh if I took one of those away?

Child: Uh huh.

Mother: Oh you're right. Two.

Child: One, two. And if you had the other one, and then you took one away and then it would still be two.

Mother: Yeah.

Child: No, it would be... Three because look at. There's three left already.

***

Child: Yay! I love math.

Mother: Five plus three. Seven plus two. Eight plus one. Okay. You remember how to do it?

Child: Yeah.

Mother: So you see, you put up how many fingers?

Child: Two.

Mother: And what do, how you count?

Child: Two.

Mother: No four.

Child: Four.

Mother: Five.

Child: Five. Six.

Mother: Six, so four plus two equals?

Child: Six!

Mother: Good job. Now you know how to do the other one right?

Finally, only a small percentage (.87%) of the math talk instances corresponded to conversations that did not have a response from the other member of the dyad, when that was expected (e.g., a question) (see Table 3.5). Of the total number of interactions, there were only four conversations in which the other interlocutor did not respond. All but one of these instances were about *naming numbers* (the other one was a *counting* math talk instance), and all four were initiated by the child and coded as basic skills, as shown in the following example.

Child: I have three birds. Can I have three birds?

Dual-Coded Math Talk

Families also engaged in conversations that involved more than one aspect of math within the same exchange, providing an interesting sample of the complexities of their conversations about math. As described earlier in this chapter, these instances of math talk were coded in more than one category (i.e., dual coding) to account for this complexity.

Approximately 20% of the interactions involved more than one aspect of mathematics, and almost all of the types of math talk were dual coded in at least one interaction, with the exception of *estimating*, which did not occur in a dual-coded interchange (but its frequency as a category was very low in the total number of exchanges). The most frequent of the dual-coded categories was *naming numbers,* as approximately 30% of the dual-coded exchanges included an aspect in which families named a number, but this only represented approximately 12% of the *naming numbers* interactions. Of the remaining percentage of dual-coded conversations, *counting*, *ordinal numbers*, and *time* accounted for approximately 45% of them. The other codes had a lower frequency of dual coding relative to the other math talk categories. There were also categories in which half or more of the coded interactions were dual coded, such as *adding and subtracting*, *dates*, *measuring*, *equality*, and *number books or games*. Thus, when families engaged in math talk involving these topics, they were likely to use more than one type of math talk. On the contrary, even though interactions about *naming numbers*, *ordinal numbers*, *comparing attributes*, and *time* accounted for an important proportion of the dual-coded interactions, with the exception of *comparing attributes*, less than 20% of the these interactions corresponded to dual coding. In other words, these categories were frequent within the dual-coded exchanges because of their prominence in the mother-child interactions, but when analyzing the proportion of dual coding within each category, this type of overlapping coding was not as frequent as in the other math talk types mentioned above.

In addition, some of the dual-coded conversations involved two different codes, whereas others involved more than two types of math talk (i.e., they were triple or quadruple coded). The first example below illustrates one dual-coded interaction about *time* and *counting*, whereas the second example shows a conversation that included aspects of *naming numbers*, *time*, *addition*, and *counting* within a mother-child interaction.

Child: It was 9:10 and now it's 9:11!

Mother: Mmhm. Time goes forward one minute by one minute. So ten, then eleven, then twelve. And then after fifty-nine it goes to? And if it's 9:59 the next thing is? 10:00!

Child: And then we get to do...

Mother: Get to do what? Oh the finger... That's not until 4:00.

Child: 4:00?

***

Mother: Hold on one second John. Okay, so you have six. Okay? What's five plus three? Put up three fingers.

Child: [inaudible audio]

Mother: No five...

Child: Five, four.

Mother: No six.

Child: Six...

Mother: Seven.

Child: Seven, eight...

Mother: Put eight right there.

Child: I did my eight.

Mother: Good job.

Child: [inaudible audio]

Mother: Huh sweetie?... Sure you can go on the computer afterwards. What's 7 plus 2?

Child: Teach me AA math?

Mother: Yeah…So 7 plus 2 put up 2...

Child: Two...

Mother: Two...

Child: Three...

Mother: No two... No I'm sorry. Seven...

Child: Eight...

Similar to the total math talk interactions, most of the dual-coded instances were mother initiated, though children did initiate almost 30% of the exchanges that were coded in more than one category. Slightly more than half of the dual-coded interactions were dominated by the mother, as in the total math talk instances. However, children dominated fewer conversations when analyzing the dual-coded exchanges (approximately 18%) than when looking at the total number of interactions both dual and single coded (30%). Nevertheless, there were more conversations that were dominated by both the child and the mother among the dual-coded (27%) than the total math talk (15%). In terms of complexity, it is interesting to note that, even though the majority of the dual-coded conversations were classified as *basic skills*, consistent with all of the math talk interactions, the percentage of *higher order* math talk was greater when looking at the dual-coded interactions (27%), compared to the total of higher order instances across the coded segments (6%).

Summary of Findings about Math Talk between Mothers and their Preschoolers

All the participant families engaged in math talk during the recorded time, although there was a large variability in the frequency and types of math talk across families, ranging from a minimum of zero instances of math talk in both time frames of the second day to a maximum of 25 interactions in the breakfast time of day 1. There was also variability in the number of utterances that families used to transmit their messages during the recorded time. On average, the total number of utterances that included math talk ranged from almost 4 to 120, so that families engaged in conversations that had very different lengths. In other words, during an hour of recording, there were families who engaged in conversations that included more utterances of math talk than others, a conclusion that held after taking into consideration the total amount of talk. These variations in the number of utterances were also present when looking at the specific types of math talk during an hour of recording. On average, they ranged from eight for the case of *naming numbers* to less than one for different types of math, such as *monetary exchange*, *estimating*, *equality*, or *grouping*, among others. Out of the total number of interactions about math, approximately 20% of them included more than one type of math talk.

There were similarities across all four segments, in terms of the frequency with which families talked about math and the different topics they covered in their conversations. Mothers and their children named numbers in almost half of their math talk instances, and all the participant families engaged in some sort of *naming numbers* interactions during the recorded time. Therefore, *naming numbers* was the most common type of math talk, followed by *ordinal numbers* and *time*, though with a lower frequency for these last two cases. In their naturalistic conversations, mothers and their preschool-aged children did not talk about the *purpose of math*, and they talked with a very low frequency about *monetary exchange*, *dates*, *estimating*, *comparing attributes*, *equality*, *grouping and sharing*, *measuring*, *number books or games*, and *printing or recognizing written numerals*.

Also, the largest majority of the interactions was coded as *basic skills* math talk, as most of the mathematical exchanges included conversations with only one math word or little math discussion. All parents engaged in at least two *basic skills* math exchanges, after averaging the four recorded hours of this study. Notwithstanding, it is worth noting that 6% of the interactions involved a more detailed discussion and included more than just few-word exchanges about math related to *counting*, *naming numbers*, *adding and subtracting*, and *ordinal numbers*. The depth of these higher order conversations varied, however, so that there were cases in which families engaged in discussions that involved many aspects of math or many math words corresponding to the same type of math talk, whereas other families did not have long discussions, but the math content that they covered was explained in more depth.

Most of the math talk instances were initiated and dominated by the mothers in the naturalistic conversations analyzed in this study. However, on average, children in this sample initiated 36% of the exchanges and dominated more than a quarter of the math talk instances. There was a comparable amount of math talk between the mother and her child in about 15% of the interactions. Finally, all but a few instances of math talk were a part of a mother-child conversation, so that practically every time that either the mother or the child initiated an exchange that included math, there was a continuation in the dialogue about the corresponding subject.

CHAPTER IV: RESULTS RESEARCH QUESTION 2

Analytic Strategy to Describe Math Talk among Families with Different Educational Levels

One of the primary questions of this study was how parents of different educational levels talk with their children about math. The hypothesis was that more educated mothers would engage in more types of math talk (i.e., in addition to number operation types of math talk) and use more complex math concepts with their children. Because of the distribution of the sample in terms of maternal educational background (i.e., more than a third of the mothers had a high school diploma or some college, whereas slightly more than 60% of them had a bachelor's degree) at the time of the recordings, two groups of families were compared in terms of their math talk: families whose mother had less than a four-year college degree (i.e., lower educational background) and families whose mother had a bachelor's or advanced degree (i.e., higher educational background). Independent sample *t* tests were performed between families with lower educational level and families with higher educational level to compare their math talk in terms of the frequency and proportion with which they engaged in specific types of math talk, the amount of math talk that they used in their conversations across segments, the length of their conversations about specific aspects of math, the complexity of their interactions about math, and the role that mother and child played in both initiating and dominating the math talk instances.

Average Frequency of Math Talk in Families with Different Educational Levels

As shown in Table 4.1, the number of times that families with different educational levels talked about math was averaged across the four segments. In general, families with different levels of education talked about math in a similar way, but there were also some important differences between the two groups. There were statistically significant differences in two specific types of math talk, *fractions* and *naming numbers*, among families with different educational levels. As expected, families with mothers with a higher educational level talked with their children about *fractions* at a higher frequency than families with mothers with lower education, $t(35.95) = -2.31$, $p < .05$, $d = -0.69$. Even though it was predicted that mothers with lower educational attainment would engage in more conversations about number operations due to the emphasis research shows they place in activities such as counting and teaching the basics of the number system, the families with more educated mothers were the ones who actually engaged in more interactions about *naming numbers*, $t(33.98) = -3.31$, $p < .01$, $d = -0.98$.

Due to the small sample size of this study and lower statistical power for detecting statistically significant differences between the two groups of families with different educational levels, it was difficult to find significant results for anything but very large effects (Cohen, 1988). Thus, some of the mean differences that were not found to be statistically significant but did have moderate effect sizes (Cohen, 1988) are also discussed in this section. For example, although *fractions* and *naming numbers* were the only two types of math talk for which statistically significant mean differences were found, it is worth noting that there were moderate effect sizes for the differences between the means of the families in several other types of math talk. This is in line with the hypothesis that families with a higher educational level would be more likely to engage in other topics about mathematics in addition to number operations, compared to families with lower educational backgrounds. In fact, families with mothers with less education did not talk about *monetary exchange* or *equality*, whereas families from a higher educational background did (d = -0.47 for *monetary exchange*; d = -0.47 for *equality*), though the very low frequency of these math talk exchanges did not result in statistically significant mean differences. Also, moderate effect sizes for the mean differences between families were found in the amount of conversations about *dates* and *naming shapes*, where families whose mother had a bachelor's or advanced degree engaged more often in interactions including *dates* (d = -0.37) and geometrical *shapes* (d = -0.32) than did families whose mother had less than a bachelor's degree, although again these differences were not statistically significant. On the contrary, and as predicted, families with lower education *counted* numbers more often compared to their counterparts with a bachelor's degree or higher educational attainment (d = 0.33), although this mean difference did not reach statistical significance. A finding that was not predicted was the higher frequency of *estimating* conversations in families with less educated mothers. Although this difference was not statistically significant, families with more educated mothers did not engage in conversations about *estimating*, whereas families with lower education did, albeit it at a very low rate (d = 0.51). Finally, even though families with a higher educational level talked more on average about math in general, as shown by the moderate effect size of the mean differences between the two groups (d = -0.52), this difference was also not statistically significant.

Average Proportion of Different Types of Math Talk by Educational Background of the Families

In order to provide a clear picture of the emphasis that families with different educational levels placed on different aspects of math while talking in naturalistic settings, the proportions with which families engaged in specific types of math talk relative to their total amount of math talk instances were also analyzed. Similar to the previous results regarding frequencies of math talk, mothers who had different educational levels talked with their preschoolers about specific aspects of math with a similar proportion in many cases. However, there were also moderate to large effect sizes for the mean differences between both groups in several types of math talk – though few of them were statistically significant, as shown in Table 4.2.

As expected, the proportion of math talk involved in *counting* was higher in families with lower educational background than in families with more education, $t(38) = 2.69$, $p < .05$, $d = 0.88$. Similarly, the proportion of *monetary exchanges* was also as anticipated, $t(24) = -1.80$, $p < .10$, $d = -0.51$, where families with higher educational attainment engaged in some conversations about money, whereas families with a lower educational level did not engage in this type of interaction. Also, families with more education talked about *naming numbers* at a higher proportion, compared to families from a low educational background, $t(38) = -2.41$, $p < .05$, $d = -0.77$, a result that was not predicted.

Even though there were no other mean differences in the proportions of different types of math talk between families with different educational levels that reached statistical significance, there were moderate effect sizes for the proportions of several other types of math talk in line with the hypotheses (see Table 4.2). There were moderate differences in the proportion of math talk between families with different educational levels, in that more educated families engaged in a higher proportion of math talk involving *dates* (*d* = -0.39), *fractions* (*d* = -0.56), and *equality* (*d* = -0.48), than families where the mother had less than a four-year degree (see Table 4.2). In addition, families with a lower educational level engaged in a higher proportion of math talk in the contexts of *estimating* (*d* = 0.53) and *number games* (*d* = 0.39) compared to families with higher education, although these differences were not statistically significant and not predicted. In fact, considering the research that shows that children from higher educational backgrounds are exposed to number games at a higher rate, it was expected that more educated mothers would engage with their children in these types of conversations at a higher rate than mothers with lower education.

Amount of Math Talk Utterances in Families with Different Educational Levels

Families with different educational levels have been shown to differ in terms of the amount of language that they provide to their children. To evaluate this issue in naturalistic interactions and in the context of math talk, the total number of utterances that families with different educational backgrounds produced in every segment, and on average across segments, were obtained (see upper section of Table 4.3). Families with higher educational levels used more utterances (i.e., total utterances) in all segments than families with less education, although only two of these differences were statistically significant (see Table 4.3). However, and as predicted, when looking at the proportion of math talk out of the total number of conversations (see bottom section of Table 4.3), families with different educational levels did not statistically differ in the amount of their talk that corresponded to math talk.

Math Talk Utterances Corresponding to Different Types of Math Talk

The differences in the length of the math talk among families with different educational levels were also of interest in this study, as it was hypothesized that families with higher education could talk about math at a rate similar to that of families with lower education, but by using extended interactions. To evaluate these differences, the average lengths with which families with different educational attainment engaged in specific types of math talk were also compared (see Table 4.4). Along the lines of the hypothesis, more educated families did use more utterances on average when talking about *fractions*, compared to lower educated families, $t(33.32) = -2.48$, $p < .05$, $d = -0.73$. In addition, an unexpected result was that families with lower education talked more about *estimating* than families with higher education, who actually did not engage in *estimating* conversations across segments, $t(14) = 1.78$, $p < .10$, $d = 0.63$.

Even though there were no other statistically significant mean differences between families with different educational attainment in terms of the length of math talk, several of these differences had moderate effect sizes, in concordance with the hypotheses. On average, families with a higher level of education used more utterances in conversations involving *money* ($d = -0.45$), *dates* ($d = -0.48$), *equality* ($d = -0.47$), *grouping and sharing* ($d = -0.32$), *naming shapes* ($d = -0.40$), and *time* ($d = -0.49$) than did families with lower education, but the absolute average number of utterances in each case was very low and these differences did not reach statistical significance (see Table 4.4). Also, although not predicted, families with higher educational backgrounds used more utterances when *naming numbers* than less educated families ($d = -0.38$), and families with lower education used a larger amount of utterances while talking about *number games* than families with higher education ($d = -0.56$). But again, these mean differences were not statistically significant (see Table 4.4).

In order to evaluate the prominence of the number of math talk utterances that families with different educational levels engaged in when discussing specific aspects of math (i.e., length of math talk), the proportions of utterances involved in each type of math talk were compared among families (see Table 4.5). Along the lines of the hypotheses, families with more educated mothers engaged in a higher proportion of utterances involving *fractional* values than families with lower educational background, $t(34.40) = -2.70$, $p < .05$, $d = -0.79$. Despite the lack of statistical significance among the other mean differences in the proportion of utterances involving math talk between families with different educational background, there were several moderate effect sizes for these differences. In line with the predicted results, families with more educated mothers engaged in a higher proportion of math talk including *monetary exchange* (d = -0.38), *dates* (d = -0.38), *equality* (d = -0.47), and *grouping and sharing* (d = -0.39) (see Table 4.5). Also, mothers with less than a bachelor's degree used more utterances involving *counting* with their children (d = 0.53) than mothers with a bachelor's degree or higher. Although not anticipated, families with lower education also used a higher proportion of utterances about *estimating* (d = 0.62) and *number books and games* (d = 0.34) than families with higher education.

Proportion of Complexity, Initiation, Dominance, and No Response of Math Talk by Educational Background of the Families

Families with different educational backgrounds were also expected to differ in terms of the complexity of their math talk. It was hypothesized that more educated mothers would engage in a higher proportion of sophisticated conversations about math with their children than mothers with lower education. Unexpectedly, families with a lower educational background sustained a comparable proportion of *higher order* and *basic skills* conversations as families with a higher educational background (see Table 4.6). This lack of difference in *higher order* math talk might be related to the low frequency of complex interactions among families in general, but it might also be the case that families engage in *higher order* exchanges at times other than meal times; however, more research is needed to explore these and other possibilities.

Another way to look at the nature of the math talk in this study was by comparing the role that mothers and children from families with different educational levels had in initiating and dominating the exchanges. The results show that mothers with less than a bachelor's degree initiated the same proportion of math talk than mothers with a bachelor's or higher degree (see Table 4.6). Consequently, their children also initiated a similar proportion of math talk. In terms of dominance, families with different educational levels did not differ in the proportion of conversations dominated by the mother, by the child, or by both (see Table 4.6).

Comparison of Math Talk between Families with a Bachelor's Degree or Less and Families with an Advanced Degree

Considering that the mothers of almost a third of the families in this study had an advanced degree at the time of the first wave, it was of interest to look at the differences in terms of math talk between families whose mother had an advanced degree (n =13) and families whose mother had a bachelor's degree or less (n = 27). Even though there were no hypotheses with regards to these differences, group comparisons were performed to explore whether highly educated mothers differed from mothers with a college degree or less in terms of math talk. The results of these analyses show that families in which mothers had a bachelor's degree or less sustained more and longer conversations that included *naming shapes* compared to families with mothers that had an advanced degree; $t(30.68) = 2.38$, $p < .01$, $d = 0.65$, and $t(33.17) = 2.62$, $p < .05$, $d = 0.74$, respectively. On the other hand, families with highly educated mothers used a higher proportion of interactions involving *fractional* values than families with mothers who earned a bachelor's degree or had less education, $t(38) = -2.09$, $p < .05$, $d = -0.66$. There were also some marginally significant differences between the two groups in terms of math talk, where families with mothers who had an advanced degree used more utterances when talking about *fractions* and had a higher proportion of utterances about *fractions* compared to other types of math talk. On the other hand, families with mothers with a bachelor's degree or less education showed a higher proportion of *grouping and sharing* interactions, and of utterances involving *estimating*, although again, these differences did not reach statistical significance.

Summary of Findings about Math Talk in Families with Different Educational Backgrounds

As expected, families with mothers who had different educational levels showed several differences in terms of math talk during their naturalistic interactions. The effect sizes for these differences ranged from small to large, but most likely due to the sample size and power issues, only large effects were statistically significant. As hypothesized, families with higher education engaged in types of conversations besides counting and number operations at a higher frequency than families with less education. In fact, families with a higher educational level engaged in more conversations involving *fractions,* had a higher proportion of *monetary exchanges* compared to other types of math talk, used more utterances involving *fractional* values, and had a higher proportion of utterances involving *fractions*, than families with a lower educational level. Also in line with the hypotheses, families with mothers who attained less education engaged in *counting* at a higher proportion than families with more educated mothers. As anticipated, families with different educational levels did not differ in the amount of math talk relative to total talk.

Contrary to the predictions, families with a higher educational level also engaged in more conversations involving *naming numbers*, had a higher proportion of *naming number* interactions relative to other types of math talk, and used more utterances in their general conversations than families with mothers with less education. Despite the prediction that families with a higher educational background would engage in more complex math talk, there were no statistically significant differences between families in terms of proportion of *higher order* math talk.

CHAPTER V: RESULTS RESEARCH QUESTION 3

Analytic Strategy to Evaluate the Relation between Both Math-related Practices as Well as the Math Talk and Children's Early Math Skills

In order to answer the research question about the relation between home numeracy practices as well as math talk and children's math skills measured at two time points, correlation and hierarchical multiple regression analyses were performed. These concurrent and longitudinal analyses evaluated the relation and predictive value of the types of math talk, the length of math talk, and the math-related practices, as reported by mothers, with respect to children's early math skills when children were in preschool and a year later. Considering the research about home numeracy and number talk, it was expected that the ways in which families talked about math in naturalistic contexts as well as their home numeracy practices would be positively related to children's early math skills across time. To test these hypotheses, different independent variables were used for the analyses: (a) the frequencies with which families engaged in specific types of math talk, (b) the length of specific types of math talk, (c) the proportion of complex math talk, and (d) the frequencies with which families engaged in math-related practices at home. With the aim of analyzing the predictive value of these variables across time, children's early numeracy skills were measured using different assessments, depending on the wave of the study. The child's quantitative reasoning, math knowledge, and math achievement were studied at both waves by using the Applied Problems score of the Woodcock-Johnson III Tests of Achievement. The child's informal and formal mathematical knowledge as well as the child's knowledge of the number system and understanding of numerical magnitudes were analyzed at the second wave by looking at the TEMA[4] and Number Line Estimation task scores, respectively. To assess the predictive value of math talk and home numeracy, several other factors that were related to the outcomes in prior research were considered in the analyses. To account for the child's cognitive and academic skills that have been related to math outcomes in previous research, the regression analysis controlled for the child's self-regulatory skills, vocabulary comprehension, and early decoding skills. Also, this analysis took into consideration the amount of talk in which families engaged, as well as the child and family demographics that are related to the development of math skills (i.e., the age of the child, whether the child was in kindergarten or preschool at the second wave of the study, and maternal education attainment at the time of the recordings). Since the sample of this study is small and not many variables can be entered into the regression analyses without losing statistical power, the correlations between the outcomes and both the predictors and the control variables were examined to identify any variables that may not be showing a relation at the bivariate level. This helps to eliminate any variables that are simply unrelated to the phenomena and play little to no role in the prediction of the outcomes of interest.

[4] The TEMA informal items and the TEMA formal items were combined to create two scales about children's informal mathematics and formal mathematics, respectively. The scales were highly related to each other, $r(31) = .86$, $p < .001$, and had very high correlation with the total TEMA score, $r(31) = .97$, $p < .001$, for the correlation between the TEMA informal mathematics scale and the TEMA total score, and $r(31) = .95$, $p < .001$, for the correlation between the TEMA formal mathematics and the TEMA total score. Since this involves serious multi-collinearity issues for the subsequent analyses, only the TEMA total score will be used in the following analyses.

Relation between Math-related Practices and Children's Early Math Skills

Since the math-related practices that families report have been linked to children's early math skills, the correlations between these variables were explored. In Table 5.1, the correlations between the practices that mothers reported they engaged in at home with their children at the time of the recordings (e.g., activities such as workbook or math problems; connect the number-pictures, etc.) and their child's early math skills measured at both waves are reported[5]. Most of the correlations between maternal reported math practices and children's math outcomes were low, but there were a couple of moderate correlations. Mothers who reported engaging more often in math activities such as *math workbooks or simple math problems* with their child had children with both higher scores in the TEMA-3, $r(31) = .30$, $p = .09$, and lower percentages of error in the Number Line estimation task, $r(32) = -.32$, $p = .06$. Also, mothers who reported *playing counting games* with their child had children with a better understanding of numerical magnitudes, as shown by the lower percentages of error in the Number Line estimation task, $r(31) = -.32$, $p = .07$. Children whose mothers reported that they played with calculators showed lower scores in the Applied Problems subtest of the WJ-III at the time of the reports, $r(36) = -.47$, $p < .01$; however, almost half of the families reported almost never spending time playing with calculators.

Even though the reported frequencies with which parents engaged in different aspects of math at home are related to each other in several ways, suggesting the presence of one or more underlying factors, it seems that there are specific aspects of math interactions that are being

[5] Even though some questions about the home numeracy environment (i.e., presence and number of specific artifacts and materials, such as puzzles, clocks, calendars, number magnets, and calculators, among others) were asked to mothers in the second wave of the study, the variability of the frequencies was very low, as almost all mothers reported having those math-related items at home. Thus, since the distributions of these variables were extremely skewed and most of them remained as constants, these variables could not be analyzed in terms of their correlations with the outcomes and were not included in the analyses.

captured by each individual item or by a few of the items only. Exploratory factor analyses were performed to investigate possible underlying latent factors, but there were issues with regards to the communality values due to either the small sample size or the number of extracted factors. After performing a series of exploratory factor analyses with fewer factors, the extracted solutions did not provide factors with a coherent set of items in terms of their content or rationale. In other words, items were loading in factors in ways that were not related to the research in home numeracy (for example, see LeFevre et al., 2009), and there were many items with complex loading (i.e., items loading on multiple latent variables). Therefore, the correlations between the children's early math skills and the reported frequencies of specific math practices at home were used to select the specific items to be considered in the regression analyses. Although it would be preferable to evaluate all of the different ways in which families report to engage in math with their children, the sample size of this study is too small to include all the different aspects. Thus, a smaller set of variables was examined in order to increase the statistical power of the regressions to find differences when they existed.

As described earlier, one of the family activities that was significantly correlated to children's early math skills in the second wave of the study (measured through the TEMA-3 and the Number Line Estimation task) was engaging in *workbooks or simple math problems*. There were also other math-related practices, such as the reported frequency of *connecting the number-pictures or doing mazes or puzzles* that were correlated with the same outcomes (i.e., correlation coefficients were over .25) and in the same direction than were engaging in *workbooks or simple math problem*. Even though the correlations between the reported frequency of *connecting the number-pictures or doing mazes or puzzles* and the outcomes were not statistically significant, the correlation between both types of reported activities (*math workbooks and simple math* *problems*, on the one hand, and *connect the number-pictures, mazes or puzzles,* on the other hand) was positive and moderate, r = .41 (38) p < .01. Therefore, both variables were combined to account for the frequency with which mothers reported that they engaged in *math-related activities* with their child at home, and used in the subsequent analyses. Since the frequency with which mothers reported to engage in *playing counting games* with their child was significantly correlated with children's understanding of numerical magnitudes, this variable was also included in the regression analyses to predict children's early math skills. Finally, even though the reported frequency with which parents played with calculators with their children was significantly correlated with the child's math achievement in the first wave of the study, the distribution of this variable was skewed. In fact, almost half of the families did not engage in this activity and most of the rest of them only played with calculators with a very low frequency, thus this variable was not included in further analyses.

Relation between Math Talk and Children's Early Math Skills

To describe how math talk was related to children's early math skills, the correlations between the frequencies with which families engaged in math talk during the first wave of the study and the children's early math skills were obtained at both waves (see Table 5.2[6]). There was a significant positive correlation between the frequency with which families engaged in *naming numbers* and the children's scores in the Applied Problems subtest of the WJ-III in the first wave of the study, $r(37) = .30$, $p = .06$. Also, the frequency with which families used *fractional* values in their conversations was positively correlated with the children's early math abilities measured through the TEMA-3 score in the second wave of the study, $r(31) = .38$, p <

[6] Since two aspects of math talk (importance of math and estimating) were either not present or constant due to the low frequency, the correlations with those variables could not be computed.

.05. Finally, the frequency of math talk about *measuring* was negatively correlated with the child's Applied Problems score in the second wave of the study, $r(32) = -.30$, $p = .09$. However, the distribution of this variable (i.e., math talk about *measuring*) differed greatly from a normal distribution, as it had high skewness (2.45, *SE* = .37) and kurtosis (4.45, *SE* = .73) values. In fact, on average, almost 88% of the families did not talk about *measuring* at all. Therefore, the frequency with which families engaged in *measuring* math talk was not included in further analyses.

Since it was also of interest to look at the length of math talk, in addition to the frequencies with which families engaged in conversations about math, the correlations between the average number of utterances involved in each specific type of math talk and children's early math skills were obtained (see Table 5.3). Similar to prior results, the number of utterances that involved *fractional* values was positively correlated with the child's informal and formal mathematical knowledge measured through the TEMA-3, $r(31) = .47$, $p < .01$. The correlation between the average number of interactions about *fractions* (i.e., frequency) and the length of the interactions about *fractions* (i.e., utterances) was .91; therefore, and based on the distribution of the variables, only the *number of utterances involving fractional values* was considered in the regression analyses to avoid multi-collinearity issues. Also, the length of the conversations involving *counting* was negatively correlated with the child's score in the Applied Problems subtest in the second wave, in the sense that the more utterances involving counting in the family conversations, the lower the child's math achievement, $r(32) = -.30$, $p = .08$. Thus, in terms of math talk, the number of utterances involved in *naming numbers* as well as the amount of utterances involved in *fractions* and *counting* exchanges were considered in the regression analyses described below.

The complexity of math talk was also explored in terms of its relation with children's early math skills to evaluate whether engaging in more complex exchanges about math was correlated with the child's math understanding and skills. Table 5.4 shows the correlations of the complexity of math talk, and other aspects of math talk such as initiation and dominance, and children's math outcomes measured in both waves. Despite the prediction that families who engaged in more complex or sophisticated conversations about math would have children with higher scores in early math skills, there was no a significant correlation between these two variables. Thus, the proportion of *higher order* math talk was not included in further analyses. It is important to keep in mind, however, that only about 6% of the math exchanges were coded as *higher order* math talk, which might be related to this lack of correlation, but further research is needed to clarify this issue.

Relation between Math Talk and Amount of Language, Children's Cognitive Skills, and Demographic Variables

Since families who talked more in general might be also talking more about math during the recorded segments, the correlations between the amount of talk that both mothers and children produced during their conversations –measured through the total amount of utterances spoken– and children's early math skills were explored (see Table 5.5). Even though there were no significant correlations between the total amount of utterances and the child's outcomes, this variable was still included as a control variable in the regression analysis to take into account the fact that some families in this sample talked more than others and that the amount of math talk might be affected by the total amount of talk.

Based on the research showing that other child's cognitive and academic skills are related to the child's performance in math, the children's self-regulatory, early decoding, and vocabulary skills were also analyzed in term of their correlations with children's early math skills. As shown in Table 5.5, the child's self-regulation, measured through the HTKS, was positively correlated with the child's math achievement at both waves. The higher the child's self-regulatory skills, the higher the child's scores in the Applied Problems subtest of the WJ-III in the first wave, $r(37) = .57$, $p < .001$, as well as in the second wave, $r(32) = .50$, $p < .01$. Also, the better the child is at self-regulating his or her behavior, the better his or her math performance, measured through the TEMA-3, $r(31) = .46$, $p < .01$. Thus, the child's self-regulatory skills, measured through the HTKS, were included in the subsequent regression analyses as a control variable. On the other hand, working memory, measured through an Operation Span task, was only marginally correlated with the child's understanding of the number system, $r(32) = -.33$, $p = .06$, in the sense that the better the scores in the Operation Span task, the lower the percentage of error in estimating the appropriate position of a number on a number line. However, since the child's score in the Operation Span was not significantly correlated with any of the other outcomes (see Table 5.5) and the sample size of the current study is small (i.e., it allows for a limited amount of variables in the regression analyses), this variable was not included in further analyses[7].

The child's vocabulary skills were positively correlated with the child's math achievement measured through the Applied Problems subtest of the WJ-III in both waves, $r(37) = .63$, $p < .001$, and $r(32) = .39$, $p < .05$ (see Table 5.5), for first and second wave, respectively. The child's early decoding skills were also positively correlated with early math skills, measured through the Applied Problems subtest at both waves and the TEMA-3 in the second wave (see

[7] To make sure the exclusion of this variable did not affect the results of this study, the same regression analyses reported in the next sections were run including the child's score in the Operation Span task from the first wave of the study. When this variable was included in the analyses, the major findings were not different from the ones obtained in the analyses that did not include this variable. Therefore, the child's score in the Operation Span task will not be analyzed further in this study.

Table 5.5). Moreover, children who had better decoding skills at the first time of the study showed lower percentages of error in the Number Line Estimation task in the second wave, $r(32) = -.56$, $p < .01$. Therefore, both the child's early decoding and the child's vocabulary skills, measured in the first wave of the study, were included as control variables in the regression analyses.

The role of other demographic variables with regards to the development of early math skills was also examined by looking at the correlations between the child's gender, age, school experience, and early math skills (see Table 5.5). The age of the child was related to his or her math achievement and early math abilities, in the sense that the older the child, the higher the raw scores in the Applied Problems subtest in both waves. Also, children who were in kindergarten at the time of the second wave of the study, compared to those who were in preschool, had higher scores in both the Applied Problems subtest and the TEMA-3 in the second wave (see Table 5.5). The gender of the child was not correlated with the measures of early math skills; consequently, only the child's age and whether the child was in preschool or kindergarten were entered as control variables in the regression analyses.

To explore the links between early math skills and maternal education (i.e., measured in the first wave of the study through a dummy variable where 1= bachelor's degree or more education and 0= less than a bachelor's degree), their correlations were explored (see Table 5.5). As expected, there was a significant correlation between maternal education and all of the math outcomes in both waves. Mothers with higher education, compared to those with lower educational level, had children with higher scores on all the Applied Problems subtest in the first wave, $r(37) = .54$, $p < .001$; in the Applied Problems subtest in the second wave, $r(32) = .50$, $p < .01$; and in the TEMA-3, $r(31) = .51$, $p < .01$. Moreover, children whose mothers had higher educational levels showed lower levels of error in the Number Line Estimation task, compared to children whose mothers had less than a bachelor's degree, $r(32) = -.40$, $p < .05$. Thus, maternal education was also included as control variable in the regression analyses.

Prediction of Children's Early Math Skills

Multiple hierarchical linear regressions were employed to determine if math talk and math-related practices predicted children's early math skills at the time of the recordings and a year later, after accounting for the child's cognitive skills and demographics. Table 5.6 displays the descriptive statistics for all independent, control, and outcome variables included in the regression analyses. The analyses were performed using IBM SPSS Statistics for Windows, Version 20.0. In all regressions, the variables were entered in different blocks to predict the outcomes. The first block included only the independent variables regarding math talk and home numeracy to evaluate how they related to the outcomes, without taking into account other variables. Based on the correlations presented earlier, the first block included the frequency of *naming number* math talk, the length of *counting* math talk, the length of math talk about *fractions*, the reported frequency of *math-related activities* (math workbooks or simple math problems and connect the number-pictures, mazes, or puzzles), and the reported frequency of *playing counting games*. Then, each subsequent block added another substantive variable or set of related variables to the equation. Block 2 accounted for the amount of language (i.e., total number of mother and child utterances) produced by families during their coded conversations. The child's self-regulation skills measured through the HTKS were taken into account in block 3, whereas the child's early decoding and vocabulary skills were incorporated in block 4, to control for the child's cognitive and academic skills. The child's demographics were entered in block 5, which accounted for the child's age (measured in months) as well as whether the child was attending kindergarten at the time of the second wave of the study[8]. Finally, the role of maternal education was considered in block 6. Thus, the model for this study explored the relations between math talk and math-related practices and children's early math skills after taking into account all of the control variables added in blocks 2 to 6.

Early Math Skills at the First Wave of the Study

The results regarding the prediction of the children's math achievement at the time of the first wave of the study, measured via the raw score of the Applied Problems subtest of the WJ-III are presented in Table 5.7. Self-regulatory skills, $\beta = .39$, $t(28) = 3.18$, $p < .01$; vocabulary skills, $\beta = .48$, $t(28) = 3.50$, $p < .01$; and early decoding skills, $\beta = .25$, $t(28) = 1.80$, $p < .10$, were all positive predictors of the child's math achievement at the first wave of the study, after taking into account math talk and math-related practices (i.e., block 4). The variables entered in the first four blocks (i.e., math talk and math-related practices, total language, child's self-regulation, and child's vocabulary and decoding skills) accounted for a significant portion of the variance in the child's math achievement, adjusted $R^2 = .66$, $F(9, 28) = 8.83$, $p < .001$. The remaining two blocks of variables (i.e., child's demographics and maternal education) did not add to the prediction of the Applied Problems' score in the first wave of the study, as the change in the R^2 did not reach statistical significance. In other words, the amount of variance in children's math achievement in the first wave that was explained by adding the child's demographics was not statistically different from the portion of variance explained by the variables entered in the first four blocks, and the amount explained by all of the variables of this model was also not statistically significant different from that explained by all variables but maternal education (i.e., block 5).

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[8] Whether the child was attending kindergarten at the time of the second wave was entered as a control variable only when the analyzed outcomes were measured at the second wave.

This suggests that having the sets of variables included in the first four blocks (i.e., math talk and practices, total language, and child's cognitive and academic skills) was the most parsimonious way to explain the variance in children's math achievement at the time of the recordings.

These results did not support the hypothesis that, after entering the control variables, math talk and math-related practices would predict math achievement at the time of the recordings. In fact, even though math talk and math-related activities were positive predictors of the child's math achievement, this set of variables (see block 1 in Table 5.7) did not explain a significant portion of the variance in the child's math achievement and math knowledge scores at the first wave of the study.

Early Math Skills at the Second Wave of the Study

Applied Problems. Multiple hierarchical regressions were conducted to predict the child's quantitative reasoning, math knowledge, and math achievement in the second wave of the study, measured through the Applied Problems subtest of the WJ-III. Table 5.8 summarizes the results. Similar to the prediction of math achievement in the first wave of the study, the child's self-regulatory skills, $\beta = .31$, $t(23) = 1.89$, $p < .10$, and vocabulary skills, $\beta = .35$, $t(23) = 1.81$, $p < .10$, were both marginally significant predictors of the child's Applied Problems score a year after the recordings. The variables included in the first four blocks (i.e., math talk and math-related practices, total language, and child's cognitive and academic skills) accounted for a significant amount of the variance in the child's math achievement at the second time of the study, adjusted $R^2 = .47$, $F(9, 21) = 3.94$, $p < .01$. Again, including the child's age and whether the child was attending kindergarten (i.e., block 5) and maternal education (i.e., block 6) did not add to the explained portion of variance in the child's math achievement, as the change in the R^2 did not reach statistical significance after adding either of these two sets of variables. Thus, it seems that math talk, math-related practices, total language, and child's cognitive and academic skills explain the child's math achievement a year after the recordings in a more parsimonious way. These findings, however, did not align with the hypothesis about the role of math talk and math-related practices in predicting early math skills. Similar to prior results, math talk and practices were significantly related to the outcomes but only before controlling for the amount of language and the child's cognitive and academic skills (see Table 5.8).

Number Line Estimation task. Table 5.9 presents the results of the analyses conducted to predict the child's knowledge of the number system and understanding of numerical magnitudes in the second wave of the study, measured through the percentage of error in the Number Line Estimation task. Even though the child's early decoding skills and maternal education were negative predictors of the child's percentage of error in the Number Line Estimation task after entering all the variables, these variables did not account for a significant proportion of the variance in the child's understanding of numerical magnitudes, adjusted R^2 = .17, $F(12, 18) = 1.50$, $p = .21$.

TEMA-3. To predict the child's informal and formal mathematical knowledge at the second wave of the study, measured through the total score of the TEMA-3, multiple regression analyses were conducted following the procedures described in the sections above. As displayed in Table 5.10, the results support the hypothesis of the role of math talk in predicting early math skills, even after controlling for the child's self-regulation, vocabulary, and early decoding skills. In fact, the length of math talk about *fractions* was a positive predictor of the child's mathematical knowledge, $\beta = .43$, $t(22) = 2.45$, $p < .05$, after controlling for the amount of language, self-regulation, vocabulary, and decoding skills. Also, both the child's early decoding skills, $\beta = .42$, $t(22) = 2.29$, $p < .05$, and the child's self-regulatory skills, $\beta = .28$, $t(22) = 1.76$, p

< .10, predicted significant amounts of variance in the child's math performance at the second wave of the study. All the variables included in the first four blocks explained a larger portion of the variance in the outcome than the variables corresponding to only some of these blocks, adjusted $R^2 = .51$, $F(5, 25) = 2.78$, $p < .05$. Again, adding the child's demographics and maternal education to the equations (i.e., blocks 5 and 6) did not add to the explained variance in the child's math performance in the second wave of the study.

Summary of Findings about Relations between Math Talk, Math-related Practices and Child's Early Numeracy Skills

Positive relations were expected between parental math-related practices, as reported by the mother at the time of the recordings, and children's early math skills, measured at both waves of the study. The correlation analyses showed that the frequency of mother-child math activities, such as a *math workbooks or simple math problems*, was indeed positively correlated with the child's math performance and understanding of numerical magnitudes. Also, the frequency of *playing counting games* was negatively correlated with the child's percentage of error in the Number Line Estimation task. Math talk was also expected to be related to the child's math outcomes measured in both waves, which was supported by the correlation analyses. In fact, the ways in which families talked about mathematics corresponded to their children's math skills over time. Families who had higher amounts of conversations involving *naming numbers* had children with higher math achievement in the first wave of the study. Similarly, families who engaged in more and longer interactions involving *fractional* values had children with better math performance in the second wave of the study. The length of the math talk about *counting*, however, was negatively correlated with the child's math achievement in the second wave.

Contrary to the predictions, other types of math talk and the complexity of math talk were not correlated with any of the child's math outcomes.

As expected, the regression analyses also showed that math talk was related to the children's early skills. Specifically, the length of math talk about *fractions* was a positive predictor of the child's math performance, measured through the TEMA-3, even after controlling for the child's demographics and cognitive and language abilities. Even though math talk and math-related practices were positive predictors of the child's early math skills for all analyses, they did not remain significant after controlling for the amount of talk and the child's cognitive and academic skills. In fact, the child's self-regulatory and early decoding skills were the skills that predicted the child's math performance in the second wave of the study measured through the Applied Problems subtest of the WJ-III, whereas the child's self-regulatory and vocabulary skills were positive predictors of the child's math achievement in both waves. The variance in the percentage of error in the Number Line Estimation task was not explained by either the home numeracy variables or the control variables included in the analyses.

Even though it was expected that the proportion of *higher order* math talk would be a positive predictor of the child's early math skills, the proportion with which families engaged in complex math was not significantly related to any of the math outcomes analyzed. It was also expected that the frequency of math talk involving *number games* would be related to the child's ability to understand numerical magnitudes in the second wave of the study; however, the low frequency with which these exchanges occurred during the recorded times did not allow for analyses beyond describing their occurrence.

In brief, the results of this study support the hypothesis that the ways in which families talk about math at home relate to their children's math skills. However, not all types of math talk were equally important for children's numerical abilities. The use of more sophisticated mathematical concepts in the mother-child conversations, such as fractions, seems to be a key piece in promoting early math skills. Other types of math talk and the math-related practices did not play a significant role in explaining preschoolers' math abilities in this study. Nevertheless, there were other crucial skills related to the child's early math performance, such as decoding skills, vocabulary, and self-regulation. All these factors together helped to explain a significant amount of variance in children's math skills.

CHAPTER VI: DISCUSSION

This study examined parent and child conversations about math in the home setting. It revealed interesting differences in the types of exchanges in which mothers and their preschool-aged children engage in a naturalistic and uncontrived setting. These differences were found to be related to the mother's educational background and some types of conversations predicted the children's early math skills across time. There were three primary findings. First, there was a wide range of *math talk*, as measured by the amount, type, and length of conversations about math used in the home environment. Second, families with different educational levels engaged in specific aspects of math talk at different rates, and the emphasis of these conversations varied between simplistic math talk focused on number operations and more complex fractional exchanges. Third, math talk that focused on fractional values as well as the child's vocabulary and self-regulatory skills were positive predictors of children's early math skills over time.

Math Talk in Naturalistic Settings

Previous studies that examined math conversations with preschoolers found that the amount and types of number talk with young preschoolers vary widely across families with different educational and socioeconomic backgrounds (Levine et al., 2011; Levine et al., 2010). Based on this research, it was expected that families would differ not only in the number of times that they engage in conversations about math, but also in the type and complexity of these exchanges. However, a unique aspect of this study was the ability to examine these exchanges with an unobtrusive digital recorder. The results found that *number talk* was indeed discussed in the home, but talk about many other aspects of mathematics were also discussed though they all varied in terms of their frequency, length, and type. The families in this study recorded their conversations for an extended period (up to 16 hours) so that their coded math talk is representative of their daily conversations during meal times. They were not instructed to focus on math, nor did they have the presence of a researcher in their homes during the recordings. On the contrary, even though families sometimes expressed awareness of their conversations being recorded, they continued with their daily routines with little acknowledgment of the recordings. In this context, the findings of this study highlight that families of preschool-aged children do engage in math talk in many different ways, and that those ways were similar across the meal times. The most common exchanges, about *naming numbers*, illustrate that 4-and 5-year-olds are exposed to a great deal of informal mathematics at home; they listen to and engage in conversations involving numbers to refer to cardinal values or units of measures and to name digits. But families also used *ordinal numbers* and referred to numbers in the context of *time* frequently during the recorded times, exemplifying that different facets are involved in the socialization of math in the home environment. These results are consistent with research showing that children have already been exposed to math in many ways in informal contexts at the time they start schooling (Ginsburg & Russell, 1981; Song & Ginsburg, 1987). Yet this study helps to understand some of the ways in which families engage their children in informal talk about mathematics from an early age in naturalistic contexts. These findings also provide a better picture of the differences in how these processes occur. Specifically, families varied greatly in the number of times that they talked about math or used math words in their regular conversations. For example, on average, children in this study were engaged in as few as 2 interactions about math during one hour to as many as 21. Similarly, some children heard an average of only 4 utterances involving math, while others heard more than 100 during an hour of recording. Thus, even though all children in this sample were socialized about math and exposed to informal mathematics at home, the number and length of these experiences create different home environments for children in these families.

This is consistent with the research in the area of home numeracy, suggesting that it is possible that some families do not know how to engage in math conversations with their children or they do not see such conversations as crucial agents to promote these skills at home (Cannon & Ginsburg, 2008). It could be that these parent-reported beliefs might not only relate to the low frequency of their math-related practices at home (Blevins-Knabe et al., 2000) but also reflect the ways in which parents talk with their children about using numbers or math. Even though this study did not look at the relation between beliefs about early math development and math talk, it would be interesting to explore some possible explanations for or consequences of the differences in frequency and length of engagement in math talk among families. One avenue could be looking at the relation between the families' knowledge and understanding about specific ways to support math development at home and their math talk (Cannon & Ginsburg, 2008). The current study did, however, provide other interesting elements that help to clarify how those differences are conveyed.

In addition to the large variability in the number of times and length of families' math talk, mother-child dyads also varied considerably in the types and complexity of math talk in which they engaged. For example, most of the families in this study were involved in few to no exchanges about *money*, *dates*, *estimating*, *comparing attributes*, *equality*, *grouping and sharing*, *measuring*, or *recognizing written numerals*. These exchanges were uncommon in the context of meal times and the time right before or after meals. Because of the research in the area of early literacy development showing that families use more sophisticated language (i.e., vocabulary) at meal times (Tabors et al., 2001), it could be hypothesized that families would also engage in complex math talk at those times. However, most of the families in this study used other types of math talk while having breakfast or dinner, and only 6% of the interactions were coded as higher order or "sophisticated" math talk.

Most of the families used numbers and references to time units frequently, but they did not engage in conversations about *measurement* or *grouping*. Thus, despite the fact that children were exposed to informal math at home in diverse ways, only a few of them were engaged in more sophisticated math topics during the recorded times. The results of this study provide an explanation for this variability in the types of math talk with regards to the links between math talk and educational level of the families. In fact, and as discussed more in detail in the next section, the educational level of the families appears to be a key piece in understanding the variations in math talk in the home. For example, more educated mothers talked more and had longer conversations about *fractions* (more sophisticated math) than mothers with lower educational levels. Conversely, mothers with less education engaged in a higher proportion of *counting* (less sophisticated) exchanges with their children. A possible interpretation is that for families with lower education it is easier to refer to numbers in an often-used context (i.e., counting) rather than using complex fractional values with their children (Saxe et al., 1987). Thus, the ways in which families with different educational levels talk about math with their children provide them with different learning contexts, which helps explain the different extents to which children learn mathematics before starting school.

Contrary to what was hypothesized, families in this study did not talk about the *purpose of math*. Even though there were a few instances that could have been used by mothers to explain some aspects of mathematics (e.g., a child asked her mother, “What does the sign + mean?”), mothers did not engage with their child in these types of sophisticated exchanges during the recorded times. One possible explanation for this lack of *purpose of math* conversations may be the fact that the children in this study were not attending school at the time of the first wave, and mothers may believe that math explanations are things that children learn in school. However, there is no evidence to support this claim besides the studies that show that mothers do not see math learning as important for their preschoolers (Cannon & Ginsburg, 2008; LeFevre, Polyzoi, et al., 2010; LeFevre et al., 2009; Skwarchuk, 2009). It might also be the case that families engage in these types of conversations in other contexts or places, such as when they are in the car for extended periods of time or when they are involved in activities with older siblings, but again, these suppositions need further study.

Math Talk in Families with Different Educational Levels

The naturalistic conversations between mothers and preschoolers in this study also provided a very interesting means for observing how families with different educational levels talk about math at home. It was expected that families would vary in their math talk in that more educated families would engage in topics other than *number operation* and *counting* and would have more complex math talk than families with less education. As hypothesized, interesting differences in math talk between families were found, although families did not differ in the total amount of math talk. First, families whose mothers had attained more education not only had a higher rate of conversations involving *fractional* values, but also used a larger number of utterances involving *fractions*. Although this was not a common type of math talk, it was more frequent among families with higher levels of education, so that their children were exposed to these concepts more often and for more time than their counterparts. This suggests that children who come from families with more educated mothers are exposed to numbers not only in the context of naming a group of objects or talking about time, but also in more complex ways. Therefore, children who come from families with lower education seem to be receiving less rich input in terms of math concepts than their peers from families with higher levels of education. These results mirror those from the field of home literacy that show that mothers with higher educational levels talk more to their children and use a richer and more complex vocabulary, than mothers from lower socioeconomic status, who talk less to their children and use a poorer vocabulary (Hart & Risley, 1995; Hoff-Ginsberg, 1991, 1998; Hoff, 2003). Importantly, the findings of this study suggest that mothers with a higher educational attainment might not only be talking with their children in a more complex way, but also using more complex math concepts.

Additional support for this claim comes from the finding showing that lower educated families indeed had a higher proportion of *counting* exchanges than families with higher education. In other words, when mothers with less education spent time talking about math, they focused on counting with their children at a higher rate than their counterparts with higher education. Although *counting* is a way to informally expose children to numbers from an early age, the results of this study also show that the higher the number of utterances involved in *counting* math talk, the lower the child's math achievement a year later. This suggests that being exposed to this type of input (i.e., *counting*) might not be developmentally appropriate or as beneficial as other types of math talk, such as *fractions*, which were positively related to the child's mathematical understanding. Thus, although all families in this study talk about math at a similar rate when looking at the total number of exchanges, families from lower educated backgrounds are not providing their child with a math input similar to that of higher educated families. This difference might have important implications for children's development of early math skills over the period of a year.

Surprisingly, higher educated families were the ones who engaged in more *naming numbers* exchanges. It was expected that families with lower educational levels would talk more about number operations, and the *naming numbers* code could have captured some of that. When coding for this type of math talk, however, it was clear that this category also gathered *number talk* in a more general way, as it included not only naming digits but also cardinal values (e.g., these are *three* balloons) and units of measures not coded as *time* (e.g., it is 30 degrees outside), among others. Therefore, despite the fact that families with higher education engaged in more *naming numbers* interactions, since *naming numbers* was the most common category, this might be an indication that families whose mother has a bachelor's degree or more expose their children to more talk involving numbers in general (Levine et al., 2011; Levine et al., 2010). This is consistent with prior research that shows that number talk about small sets of objects is related to the socioeconomic status of the families, in the sense that families from a higher socioeconomic status produce a higher amount of number talk involving small sets of objects than families from a lower socioeconomic background (Gunderson & Levine, 2011). Thus, although the interactions coded as *naming numbers* do not imply a higher complexity of math talk, children from more educated families in this study seem to be exposed to more number talk in general, by receiving more input in which cardinal values and digits are used, than their counterparts from lower educational backgrounds. To better understand which specific aspects of this *naming numbers* category explain the higher prominence of *naming numbers* math talk in more educated families compared to families with less education, future research could look at whether families who vary in their educational level talk about these different aspects (i.e., cardinal values involving small sets of objects, cardinal values involving large sets, units of measure, etc.) in dissimilar ways and where the differences related to the educational background of the families lie.

Interestingly, however, when adding all the math talk codes together, there are no significant differences between families with different educational levels in terms of the number of exchanges and length of total math conversations. This suggests that all families provide similar input, and that the differences between families from different educational backgrounds are found primarily in the types of exchanges that are more prominent in each group.

Finally, it is important to note that the fact that there were no other differences between families with different educational levels that reached statistical significance might be related to the lack of power due to the sample size of this study. There were several other interesting mean differences between families that had moderate effect sizes, suggesting that there might also be other nuances in the ways in which families with different educational levels convey math at home.

Math Talk and Children's Early Math Skills

How families talk about math in naturalistic contexts as well as how families with different educational levels vary in their math talk are very crucial aspects in understanding the ways in which children acquire informal mathematics at home. The results of this study provide some insight into whether these conversations involving math at home matter for children's early math skills both when they are attending preschool and a year later. In particular, the results found that math talk involving fractional values predicts children's math knowledge, after taking into account the child's cognitive and academic skills. However, they also show that not all math talk types were equally important, that not all early math outcomes were predicted by math talk, and that there are other important skills to take into consideration when predicting children's math achievement over time.

As mentioned previously, the families in this study engaged in different types of math talk, and their conversations varied in length and complexity. The results from the correlation and regression analyses showed that only some aspects of math talk were related to the math skills that children exhibit before they enter school and a year later. Interestingly, math talk involving *fractions* played a crucial role in explaining the child's formal and informal mathematical knowledge a year after the recordings. Families where these exchanges happened more often had children who performed better in tasks involving number facts, number-comparison, calculation, and understanding of concepts (i.e., TEMA-3). This is a very interesting finding considering the recent research showing that elementary school students' knowledge of fractions is one of the unique predictors of their algebra and math achievement in high school (Siegler et al., 2012). Even though Siegler and colleagues' study looked at elementary school students, it is important to highlight the possibility that some of those children might have been receiving input involving fractions at an even earlier age at home. It would be interesting to explore whether children's early math skills, which are predicted by conversations involving fractions, are related to students' knowledge of fractions later in school, and what the role of instruction is in this picture.

Other types of math talk, such as *naming numbers* and *counting*, were also related to the child's math outcomes at the bivariate level. Specifically, families who engaged in more *naming numbers* conversations had children with higher math achievement, measured at the first wave of the study. In other words, being exposed to more number talk was correlated with children's quantitative reasoning and math knowledge, as expected. When controlling for amount of language that families produced during the recording, this relation ceases to be significant, suggesting the role of general language in predicting a child's ability to solve a math problem. In addition, the length of the conversations about *counting* was negatively correlated with children's math achievement a year after the recordings. As suggested earlier in this chapter, a possible explanation may be that mothers who spend time counting with their children are exposing them to a type of math content that might not be beneficial in that counting is a skill that most of the children at this age have already mastered (Engel, Claessens, & Finch, 2012). Since the lower educated families in this study had a higher proportion of conversations involving *counting*, the children in these families might not benefit as much from the input they are receiving as do their counterparts from higher educated families. Again, this finding might relate to the mothers' lack of understanding and knowledge about what mathematics their children are able to do at this age and how they can support this learning (Cannon & Ginsburg, 2008).

However, math talk was not the only important factor associated with early math skills; the self-reported practices mothers engaged in with their children at home were also correlated with these skills. Families who report engaging in math-related activities, such as simple math problems, math workbooks, or puzzles, were more likely to have children with better early math skills. Thus, socialization of math at home takes different shapes depending on how each family approaches this phenomenon. Involving children at home in math activities from an early age is one example of such socialization, as is using math in conversation.

In contrast to the findings regarding general math knowledge and math achievement, children's understanding of numerical magnitudes (as indexed by the Number Line Estimation task) was not explained by the model proposed in this study. Though there were some interesting relations between children's knowledge of the number system and both maternal education and the reported frequency of home numeracy activities, these variables did not account for children's accuracy in estimating the place of a number on a line. One possibility could be that this task was too difficult for some children in this group, as children are not expected to transition from a logarithmic to a linear function understanding until kindergarten or first grade (Booth & Siegler, 2006). However, this study only included numbers from 1 to 19 to avoid the difficulty issue, and the distribution of the scores for this variable was not skewed. Thus, it could be that other family-related factors that were not explored in depth in this study may also account for the model's failure to explain children's knowledge of the number system. For example, research shows that children's exposure to board games relates to their understanding of numerical magnitudes (Ramani & Siegler, 2008), but the conversations coded in this study did not include many exchanges involving games. This finding might be related to the segments used for this study, as all of them were meal times, and families could be engaging in board games at other times during the day (e.g., after dinner) or during the weekend. These are open questions that would benefit from future research that looks at math talk as occurring in naturalistic settings.

As discussed earlier, complex math talk, as measured by the proportion of total math talk that consisted of higher order math talk, was infrequent in this study and not related to early math skills. However, distinguishing between only two types of exchanges (i.e., basic skills math talk and higher order math talk) might not capture the nuances of the conversations that families sustained. It could be that there are degrees in terms of complexity of math talk with regards to content, length, and vocabulary involved in the conversations. These are all very interesting possibilities to explore in subsequent studies. Nevertheless, this study did show that talking about complex topics, such as fractions, is related to children's math achievement. This finding, therefore, points to the conclusion that the complexity of the conversations is also captured by the type of math talk.

Finally, the findings regarding how math talk and math-related practices are related to early math skills need to be examined in terms of the differences in the outcomes assessed in this study. Children's early math skills were measured using three different assessments: the Applied Problems subtest of the WJ-III, the TEMA-3, and the Number Line Estimation task. Even though these three measures provide information about each child's math knowledge, performance, and achievement, they rely on different types of questions and emphasize specific math-related abilities. Both the TEMA-3 and the Applied Problems subtest of the WJ-III assess the child's math knowledge through the use of problems presented orally and visually. The TEMA-3 test, however, includes more questions targeting informal and formal mathematics for young children than the Applied Problems subtest of the WJ-III. Thus, the findings about the predictive role of the number of utterances involving fractions on early math skills, as assessed by the TEMA-3 but not the Applied Problems subtest, could be related to this focus on early informal and formal mathematics, specifically on numbering and calculation skills. In addition, the language comprehension component of the Applied-Problems subtest might explain why early decoding and vocabulary skills were positive predictors of the child's early math skills when using this measure, as children need to construct mental models vial language comprehension to answer the questions (Schrank, 2006). As a final point, the Number Line Estimation task assesses the estimation abilities of children, in that it requires translation between numerical and spatial representations (Berteletti et al., 2010) but does not involve other aspects of mathematical knowledge assessed in the Applied Problems subtest of the TEMA-3. Thus, even though being able to provide a linear representation of numbers is related to math achievement (Siegler & Booth, 2004), this ability seems to be linked to other numerical tasks that the other assessments of this study may have failed to capture. These mathematical aspects, however, were not predicted by math talk, suggesting that the types of conversations that mothers and preschoolers have at home are more related to math knowledge and performance as assessed by calculation, solving problem, and numbering questions, as included in the Applied Problems and the TEMA-3 tests.

Children's Self-Regulation and Early Math Skills

One of the interesting findings of this study was the role of self-regulation in explaining the variance in children's early math skills. Although this skill was included in the analyses as a control variable, because of prior research showing its links to children's performance in mathematics in elementary school (Bull, Espy, & Wiebe, 2008; Mazzocco & Kover, 2007), it is interesting to find that it was one of the strongest predictors of the child's early numerical understanding and math performance. Recent research, in fact, has highlighted the role of executive function in predicting early math skills, even after taking into account the role of socioeconomic status and language proficiency (Clark, Sheffield, Wiebe, & Espy, 2012). The current study adds to this growing body of research showing that executive function skills are perhaps just as crucial in promoting children's readiness for school as early math exposure.

To explain why executive functions might play a crucial role in the development of early math skills, some researchers have argued that working memory and its executive function components are involved when children engage in mathematical problems, such as solving simple-digit and multi-digit calculations, counting, and so on (Noël, 2009). In particular, when children have better working memory capacities, they engage in more mature mathematical strategies to solve a problem, such as retrieving information from the long-term memory for solving addition problems (Noël, Seron, and Trovarelli, 2004, as cited in Noël, 2009). Moreover, in addition to better working memory, improved attention and enhanced inhibitory control in preschoolers have also been shown to be related to better math performance when children attend school (McClelland et al., 2007). Thus, it seems that being able to perform mathematical operations requires the child to self-monitor his or her behavior while keeping in mind and retrieving pieces of relevant information from the long-term working memory. This suggests the presence of an overreaching meta-cognitive skill informing these math tasks. The question of how families enhance these self-regulatory skills along with math skills is also critical to understanding the roles that families play in promoting children's academic skills from an early age. Consequently, considering the research linking parenting and executive function (Davis-Kean, Shah, Worzalla, & Sexton, 2013), it would be interesting to explore not only how families socialize math at home but also the ways in which executive functioning is conveyed through conversations in naturalistic settings.

Limitations of the Sample of the Study

The larger study that provided the sample for this study required families to agree to record three whole days of their lives during a week. This was a major commitment for families, as both mother and child needed to wear the LENA device for a long period of time. Families also agreed to receive the researchers in their homes and complete several questionnaires and assessments. Thus, those who signed up to be part of the study were not randomly selected and in fact tended to belong to a very specific group: highly educated families. Even though there were numerable attempts to diversify the sample during the recruitment process, including multiple recruitment efforts at Head Start centers, the vast majority of the mothers had a bachelor's degree, and approximately a third of the total had an advanced degree. This selection effect in the sample created a non-continuous distribution in this variable and could only be examined as a grouping variable instead of as a continuous variable. This could explain why this sample lacked some of the expected differences between families with varied educational levels. Furthermore, some of the hypothesized differences between families with lower and higher educational levels in terms of math talk may be found at the bottom of the distribution (i.e., between families with a high school diploma versus families with more education) and not at the top of it, as in this sample.

Another limitation involves the sex distribution of the children in this study, which was not even, as two thirds of the sample were boys. Again, efforts were put into diversifying the sample, but mothers of boys were still more likely to participate. This unbalanced sample in terms of sex could help explain the lack of differences in early math skills between boys and girls, though the data coming from this study do not fully account for this issue. Therefore, the results of this study do not represent the ways in which all families talk about math at home, but how mothers and children with characteristics similar to the ones in this study interact with math at home.

The small sample size is likely the reason several relations in this study did not reach statistical significance, yet this study was conservative in its approach to predicting children's early math skills. For example, several measures of children's skills and demographic variables were incorporated into the equations in order to evaluate whether math talk and math-related practices would explain the variance in the children's math outcomes. Many studies in the area of home numeracy or number talk do not control for as many variables as this study did. Thus, there is a possibility that some of the relations between math-related practices and math talk and corresponding early math skills could be found in a study with a larger sample. In fact, when looking at the standardized coefficients in the regressions of this study, many of them remain moderate in size, despite losing statistical significance.

Even though participation in this study involved difficult tasks, 87.5% of the families who were part of the first wave nevertheless agreed to participating in the second wave, a year after the recordings. Although the second wave did not include recordings, families were still interested in being part of this research and allowed the research team to enter their homes. Thus, the attrition rate was low, considering the nature of the study. Another strength of the study is that, despite the small sample size, four hours of recordings were analyzed, whereas similar prior research has only looked at shorter periods of time (Tudge & Doucet, 2004). Moreover, and regardless of the power issues, the present study did find interesting statistically significant effects, such as the length of math talk about fractions being a crucial piece in understanding children's math skills.

Using Voice-recorders to Study Math Talk

This study employed a very innovative source of data collection. The naturalistic conversations of each family were recorded using a digital voice recorder during three days. Prior research interested in capturing naturalistic interactions at home has either observed the mother-child interactions (i.e., by using online coding or field notes) (Tudge & Doucet, 2004) or videotaped their ordinary activities (Levine et al., 2010), but both of these types of approaches require the researcher to be in the home for the entire length of the recording, which would not have allowed for the richness of data gathered in the current study. Nevertheless, using this voice-recording technology was not without challenges, as described earlier in this chapter. Asking families to record their conversations posed many obstacles for recruitment. Analyzing conversational data also required transcribing long stretches of talk and invariably led to coding issues. Furthermore, due to time constraints decisions made about the specific times to sample the mother-child conversation reduced the amount of coded math talk. Even though only 4 of the up to 48 hours recorded by each family were selected for this study, those hours provided a rich sample of conversations between mothers and children in their regular routines during meal times.

Thus one of the strengths of this study was analyzing the conversations that families had in their natural contexts without prompting any emphasis on math-related activities or math talk at home for extended periods of time. One of questions not addressed by prior research was whether the described math-related conversations and exchanges are a representative picture of what families do at home or, on the contrary, whether they are a description of what families do when complying with researchers' petitions and goals even when does not represent what they would normally do. This might even pose the question of whether parents of preschoolers are actually doing math in non-laboratory situations. Therefore, the methodology used in this study helps to understand how families talk about math when they are not prompted to do so, showing the ways in which children are exposed to informal mathematics in everyday situations at home before entering school. It also allows avoiding the biases of using self-reports as the lone data collection tool, since the categories of periodicity used by parents to estimate frequencies of specific activities do not always concur with their actual frequencies. For example, if a mother is asked, "How many times do you play number games with your child in a typical week?," and the answer options are “once a week”, “twice a week”, etc., it may be difficult for her to figure out which option captures her behavior in a more reliable way if she plays with her child twice on Saturday. Self-reports are also affected by social desirability and recall, as parents are often aware of the things that are supposed to be important for children. The current study, therefore, provides a very comprehensive approach to observing how families socialize math at home in that recordings were used in addition to more traditional maternal self-reports, offering a big picture of what happens in naturalistic contexts.

What is less clear from this study, however, is the direction of the relations between math-related practices and math talk and children’s early math skills. Due to the correlational nature of the study, it is possible that parents who use more math talk may have children who are more interested in numbers and therefore have a better understanding and knowledge of mathematics. Experimental research in which children are randomly assigned to groups in which they receive different amounts and types of math talk and then the relations between math talk and children’s outcomes are analyzed, could provide insights with regards to the direction of the relations found in this study. Also, the results of this study do not provide information that explains why parents engage in different amounts and types of math talk with their preschoolers. Follow-up studies that explore the predictors of math talk at home would illuminate these issues.

Even given these limitations, the methodology used in this study provided an interesting avenue to explore how families from different educational levels engage in math at home, as well as how those math-related conversations predict their children’s early math skills over time. One of the main motivations for using this technique was to gather conversational input from mothers and preschoolers in order to explore and understand the kinds of family processes that promote children’s readiness for school and early math skills in a way that is not possible via other methods. The goal was to access what families actually do in their natural contexts in order to explore the different ways in which they socialize their children in math, and how these processes predict children's early math skills over time. Indeed, the use of the LENA technology allowed for the collection of rich data on families during an extended period of time, which provided a substantial corpus of conversations happening in the home over a week. In the end, only a few hours of these data were analyzed to answer this study's research questions, but there are many other analyses and ways to explore how families socialize math at home that can be performed by looking at their exchanges during the three days of recordings. Thus, although this technique provided extremely rich information about the family dynamics at home that could be used to answer very different and interesting questions, there were also many challenges inherent in working with such a large amount of data. Selecting the time frames, their duration, and the days needed to transcribe and code the data were not easy decisions to make. It would have been ideal to analyze more hours and different time frames; however, there were limited resources in terms of time and researchers needed to transcribe and analyze the data. Nevertheless, despite these limitations, gathering and analyzing data on parent-child conversations in everyday contexts for an extended period of time using the LENA technology seems to be a valuable way to improve understanding of the ways in which families interact in the domain of math with their preschool-aged children in the context of their ordinary activities.

General Implications

The results of this study illustrate the frequency, length, and types of math talk that occur in the homes of preschoolers. They also provide a rich description of the nature of the parent-child interactions in the home that support children's early mathematics learning in families with different educational levels. This description, in turn, improves the understanding of how families interact in the domain of math with their preschool-aged children in naturalistic contexts, as such interactions are related to children's early performance in math and to the achievement gap in school readiness. Moreover, this understanding provides some insight for parents, caregivers, practitioners, and policy makers on how to foster children's achievement in math by taking family environment into account.

First, by knowing the type of math-related input that children are exposed to at home, teachers might be better equipped to support children's numerical development in school. For example, children from families with a higher educational level in this study were exposed to more math talk about *fractions*. This does not necessarily mean that these children have a better understanding of *fractions* specifically, but the findings from this study do suggest that these types of conversations are important for children's early math skills. Thus, something about this type of input seems to be directly related to their performance. If kindergarten teachers are aware that the children in their classrooms come from families with different backgrounds not only in terms of culture, socio-economic status, ethnicity, etc., but also in terms of the math input that they receive at home, they might be able to better bridge the gap in their math input.

However, research shows that mathematics is not a prominent domain on which kindergarten teachers focus (Engel et al., 2012). They do not spend an equal amount of time teaching mathematics as they spend on other domains such as reading. Also, when they do teach math, they concentrate on aspects that many children have already mastered when entering kindergarten (i.e., counting and recognizing shapes) (Engel et al., 2012). Moreover, a recent study, conducted using a nationally representative data set, evaluated the math content that children are exposed to in kindergarten and found that exposure to basic mathematics content, such as counting or shapes recognition, is negatively associated with math achievement in kindergarten (Engel et al., 2012). Thus teachers are engaging children in low amounts of math in general and, when they do expose them to the topic, they concentrate on aspects their students have already mastered and that therefore are not beneficial. The current study found that length of math talk at home that focused on counting was negatively related to the children's math outcomes and that lower educated families engaged in a higher proportion of counting exchanges than higher educated families. One possibility for understanding these findings could be that children of this age already know how to count and, much as was seen in the study by Engel and colleagues mentioned above, being exposed to more *counting* by their parents does not help them develop math knowledge or other math skills. If teachers also spend more time on activities involving basic mathematics content, this mismatch between what children know and what they need to know keeps perpetuating. Therefore, as is the case with reading, the instructional strategies on which kindergarten teachers should focus on need to consider the skill level of the student (Connor, Morrison, Fishman, Schatschneider, & Underwood, 2007). Consequently, teachers should take into account both the input that the child receives at home (i.e., math talk and math-related practices) and the child's skill level (e.g., knowledge of counting) when designing instructional strategies to be beneficial for students. This means that teachers need to emphasize different skills and domains depending on the type of input that the child has received at home as well as their initial level of skill. For example, Connor and colleagues (2007) designed an individualized intervention for reading that is targeted to the characteristics of each child. Trying a similar approach in the area of mathematics would be a way to avoid the reported mismatch between children's abilities and instruction, in that it would provide a way of incorporating the input that children receive from their parents at home. An intervention at this level could be crucial for children who are not exposed to a richer math environment and math talk, namely those coming from families with lower educational backgrounds.

Additionally, research has shown that early number development is highly malleable (Codding, Chan-Iannetta, George, Ferreira, & Volpe, 2011; Starkey, Klein, & Wakeley, 2004). Interventions can help children who start kindergarten with lower math skills avoid continuing to perform behind their peers with better skills at school entry. In addition to aligning instruction to the skills and input that students have received, families can also be targeted and given tools to improve math performance. In general, economically disadvantaged parents, whose children lag behind in aspects of everyday mathematics, have shown eagerness for an explanation about how to foster their children's early skills in math (Ford, Evans, & McDougall, 2003; Starkey & Klein, 2000). Accordingly, the results of this study suggest some avenues through which parents can introduce math in the home and foster their preschoolers' readiness for school. Talking about math in their ordinary activities and spending time on other math concepts besides number operations seem to be important for children's development of math skills. Even though most parents are aware of the importance of reading to young children and the benefits of literacy activities at home, this same awareness is not paralleled in their approach to incorporating mathematics in home activities. One issue might be that parents do not know how to engage in these types of math talk and could need some examples and guidance, but they could also not be aware that using more complex math talk (i.e., fractional values) in their common conversations with preschoolers seems to be more fruitful than emphasizing number operations. Thus, efforts should be placed on getting parents involved in math talk at home and promoting effective shared math activities before children begin formal schooling, especially in families with lower educational backgrounds.

Directions for Future Research

The current study considered the ways in which families socialize math at home by looking at mother-child math talk. As this study was a pioneer in the use of the LENA device as a method of gathering information about math talk, studying mothers seemed a reasonable option, as they are often the main caregiver. However, it would be interesting to investigate how not only mothers but also fathers socialize math at home. Research with younger children that focused on the ways parents talk to toddlers, for example, has found that parents engage in different degrees of cognitively demanding questions with their children (Rowe, Coker, & Pan, 2004). Rowe and colleagues describe that children talked more, used more diverse vocabulary, and produced longer utterances when talking with fathers, compared to mothers (Rowe et al., 2004). 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 specificities of their input with their preschoolers. 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 illuminate the nuances of how families socialize math at home and its relation to the development of early math skills. Children who are the oldest siblings could be receiving input dissimilar to that received by younger siblings. Differences in amounts of time spent on math could also depend on the number of children in the home, and families may even focus more or less on math depending on whether one of the children has school-related math homework. Again, these are all possibilities to explore in future research to better understand reasons behind the differences in the input that preschoolers receive in the arena of math.

Although this study suggests that conversations involving more complex math topics, such as fractions, could be related to children's math outcomes over time, there are additional issues to explore with regards to the complexity of math talk. This study was not able to capture many complex interactions between mothers and children in the domain of math for several reasons. One explanation is the nature of the selected segments themselves, as families could not be expected to spend much time on in-depth conversations about math while eating or preparing dinner. It could also be that they need more "free time" to engage in more explanations about math. Studies in the field of reminiscing, for example, show that when both parents and children discuss an event or activity together, children are more likely to remember it later (Boland, Haden, & Ornstein, 2003; Haden, Ornstein, Eckerman, & Didow, 2001). Something similar could happen in the area of math, as parents who engage in joint discussions that include elaboration about math concepts with their children may promote better mathematical understanding. Less clear, however, is which contexts promote these types of sophisticated exchanges. The activities explored in the current study (mealtimes) did not seem to foster complex math talk at a higher rate. Analyzing other times of the day, such as the hour after dinner but before bedtime, or a time during the weekend, would provide helpful information about whether this low rate of complex math talk is representative of the complexity of math input that children receive in general or just of the input received during mealtimes. Also, going beyond the context of the home and listening to conversations that families have while in the car could provide insight about the ways in which families socialize math. Moreover, coding for nuances in complexity, and not only whether the conversation was *higher order*, could also provide a more characteristic portrait of the nature of math talk at home. An enhanced understanding of when these complex interactions occur could guide interventions that promote complex or advanced exchanges about math, which could lead to improvement in children's math skills.

Another relevant follow-up study could pursue a more detailed analysis of the subtypes of *naming numbers* math talk. This was the most common category in the current study, and all families engaged in exchanges of this type. However, the nuances of these conversations are not entirely clear. For example, looking at the use of *cardinal values* versus *units of measure* in naturalistic settings and how each use relates to specific early math skills would be a relevant question to answer (Levine et al., 2010). Also, analyzing whether the distinctions between specific types of *naming numbers* math talk relate to family educational level would also provide a more comprehensive picture of math talk at home.

Moreover, looking at the input that families provide to their children at home alongside the input that they receive in ordinary conversations with peers and teachers in preschool is another way to expand upon the issues raised by this study. Research has shown, in fact, that children are exposed to different amounts of math talk in their preschool classrooms (Klibanoff, Levine, Huttenlocher, Vasilyeva, & Hedges, 2006). Thus, children's early math skills could also be related to a combination of the types of math talk that they hear at home and the ones that they hear in other contexts, especially those contexts in which they spend many hours during the day. Future research should try to account for these diverse sources of math input, as they might help to explain differences in early math skills. Analyzing different sources of math talk as well as how this talk relates to teacher instruction and children's skill levels are all logical steps to promote understanding of the development of early math skills, yet these issues need to be studied in diverse samples in order to better conceptualize the topic and provide parents and practitioners with more effective tools to help children succeed in school.

Finally, it would be interesting to explore alternative ways to involve more families in research using similar methodologies to explore math talk. Asking families to record their conversations at specific and targeted times of the day, based on the follow-up research suggested above, could provide a more representative and diverse sample of families. Since recording for several entire days was challenging for the families, another possibility would be to try to collect data not only at specific times during the day but also for only one or two days instead. Other areas of research have used a “moving lab” in which researchers provide the participants with the materials in their own contexts by bringing the lab to the places they frequent. Perhaps taking the LENA technology to selected neighborhoods and showing families how it works could promote a higher rate of participation among families with diverse educational backgrounds. These alternative ways to use the LENA device to study families in their naturalistic contexts to focus on how they promote math could all help to further explore the issues of math socialization in early childhood.

Conclusion

Despite the increasing evidence regarding the importance of early math skills for later achievement in school (Duncan et al., 2007), few efforts have been focused on promoting the development of these skills in the preschool period, compared to the emphasis from practitioners and policy makers on reading over the past decades. Similarly, though fostering academic and cognitive skills in young children through the stimulation and support they receive from their parents at home has been emphasized in many domains, less is known about the ways in which families promote early math skills at home. The current study indicates that all families involve their children in a variety of math exchanges, although there are differences among families with different levels of education. Children from higher educated families seem to have more opportunities to learn mathematics at home than do children from families with lower educational levels, and those opportunities relate to the development of math skills at an early age. Families who engage in complex math talk at home by going beyond basic mathematics content appear to more effectively promote children's math performance. Future research can build upon these findings to further disentangle the nature of math talk in families of preschoolers and kindergarteners, as well as the links between types of math-related exchanges and children's skills during the preschool and early school years.

TABLES

Table 2.1

Descriptive Statistics for Child and Family Sociodemographic Factors in Waves I and II

	Wave I (n=40)				Wave II (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	.45-9.04	4.19	2.65	27	.49-12.93
Categorical Variables	N	Percent			N	Percent		
Child ethnicity								
African American	8	20%			6	17.1%		
European 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%		
Child living parents								
Living with mother only	32	80%			27	77.1%		
Living with both parents	8	20%			8	22.9%		
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 on 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 education								
High school	1	2.5%			1	2.9%		
Some college (including community college)	14	35%			10	28.6%		
Associate's Degree	0	0%			1	2.9%		
Bachelor's degree	12	30%			10	28.6%		
Master's degree/other advanced degree	13	32.5%			13	37.1%		
Maternal employment								
No employment	20	50%			17	48.6%		
Part-time	10	25%			8	22.9%		
Full-time	10	25%			10	28.6%		

Table 2.2

Amount of Time Recorded per Family for Each Day and Time Frame Included in the Study

Family	Day 1						Day 2						Total available times
	Breakfast			Dinner			Breakfast			Dinner			
	Total Minutes	Time available[1]	Recorded 1 hour[1]	Total Minutes	Time available[1]	Recorded 1hour[1]	Total Minutes	Time available[1]	Recorded 1 hour[1]	Total Minutes	Time available[1]	Recorded 1 hour[1]	
1	60	1	1	60	1	1	0	0	0	60	1	1	3
2	38	1	0	60	1	1	36	1	0	60	1	1	4
3	40	1	0	60	1	1	60	1	1	60	1	1	4
4	60	1	1	60	1	1	60	1	1	60	1	1	4
5	0	0	0	60	1	1	35	1	0	60	1	1	3
6	60	1	1	60	1	1	0	0	0	60	1	1	3
7	60[2]	1	1	60	1	1	30	1	0	60	1	1	4
8	60	1	1	60	1	1	60	1	1	60	1	1	4
9	46	1	0	60	1	1	49	1	0	60	1	1	4
10	60	1	1	60	1	1	50	1	0	0	0	0	3
11	60	1	1	60	1	1	58	1	0	60	1	1	4
12	60	1	1	60	1	1	60	1	1	60	1	1	4
13	28	1	0	0	0	0	41	1	0	0	0	0	2
14	60	1	1	60	1	1	60	1	1	60	1	1	4
15	60	1	1	0	0	0	60	1	1	60	1	1	3
16	60	1	1	60	1	1	60	1	1	60	1	1	4
17	35	1	0	0	0	0	0	0	0	60	1	1	2
18	60	1	1	60	1	1	60	1	1	60	1	1	4
19	60	1	1	60	1	1	60	1	1	53	1	0	4
20	60	1	1	60	1	1	60	1	1	60	1	1	4
21	57	1	0	60	1	1	60	1	1	60	1	1	4
22	60	1	1	0	0	0	59	1	0	0	0	0	2
23	60	1	1	60	1	1	60	1	1	60	1	1	4
24	0	0	0	52[2]	1	0	54	1	0	52	1	0	3
25	60	1	1	60	1	1	0	0	0	0	0	0	2
26	60	1	1	0	0	0	60	1	1	0	0	0	2
27	45	1	0	0	0	0	60	1	1	60	1	1	3
28	60	1	1	60	1	1	60	1	1	60	1	1	4
29	0	0	0	60[2]	1	1	0	0	0	60	1	1	2
30	60	1	1	0	0	0	0	0	0	60	1	1	2
31	60	1	1	56[2]	1	0	0	0	0	0	0	0	2
32	60	1	1	60	1	1	60	1	1	0	0	0	3
33	53[2]	1	0	60	1	1	0	0	0	60[2]	1	1	3
34	60	1	1	60	1	1	22	1	0	60	1	1	4
35	0	0	0	60	1	1	13	1	0	60[2]	1	1	3

36	60	1	1	60	1	1	60	1	1	60	1	1	4
37	51	1	0	60	1	1	60	1	1	60	1	1	4
38	60	1	1	60	1	1	60	1	1	60	1	1	4
39	0	0	0	0	0	0	60	1	1	0	0	0	1
40	60	1	1	60	1	1	60	1	1	60	1	1	4
Totals		35	26		32	30		32	21		32	30	164
Means	48.83			47.70			42.68			47.63			

[1] Yes=1; no=2.

[2] Family did not record these minutes in a consecutive way, and there was a break in the recorded time frame. The criterion used to add non-consecutive times (i.e., minutes that were not directly following the selected times) was if the recorded times occurred within the range of an hour either earlier or later than the initial selected time. Only one family did not record additional minutes in one time frame within the consecutive hour before or after, so this criterion was extended to an hour and a half for this one family.

Table 3.1

Frequency of Different Types of Math Talk across Days and Time Frames

	Day 1								Day 2							
	Breakfast				Dinner				Breakfast				Dinner			
Type of math talk	*M*	*SD*	Min	Max	*M*	*SD*	Min	Max	*M*	*SD*	Min	Max	*M*	*SD*	Min	Max
Naming numbers	4.43	3.00	1	12	3.09	2.72	0	14	3.41	3.42	0	17	3.81	4.05	0	17
Ordinal numbers	1.40	1.42	0	6	1.13	1.66	0	8	1.34	1.31	0	5	.81	.97	0	3
Adding and subtracting	.17	.57	0	3	.19	.59	0	3	.09	.39	0	2	.03	.18	0	1
Counting	.63	1.11	0	6	.63	1.13	0	4	.56	.72	0	2	.91	1.40	0	5
Monetary exchange	.06	.24	0	1	0	0	0	0	0	0	0	0	.03	.18	0	1
Dates	.09	.28	0	1	0	0	0	0	.06	.25	0	1	.03	.18	0	1
Estimating	0	0	0	0	.03	.18	0	1	.03	.18	0	1	0	0	0	0
Fractions	.46	.74	0	3	.28	.52	0	2	.38	.55	0	2	.44	.91	0	4
Comparing attributes	.11	.32	0	1	.09	.30	0	1	0	0	0	0	.03	.18	0	1
Noting equality	.06	.24	0	1	0	0	0	0	0	0	0	0	.03	.18	0	1
Grouping and sharing	.09	.37	0	2	.03	.18	0	1	.03	.18	0	1	.06	.25	0	1
Measuring	.03	.17	0	1	.06	.25	0	1	0	0	0	0	.06	.25	0	1
Naming shapes	.23	.55	0	2	.06	.25	0	1	.06	.25	0	1	.09	.30	0	1
Number books and games	0	0	0	0	.09	.39	0	2	.09	.39	0	2	.06	.25	0	1
Printing or recognizing numerals	.03	.17	0	1	.06	.35	0	2	0	0	0	0	.03	.18	0	1
Time	1.29	1.36	0	4	1.00	1.22	0	5	1.22	1.39	0	4	.91	.96	0	3
Purpose of math	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	9.06	5.63	1	25	6.75	5.69	1	24	7.25	4.78	0	21	7.34	6.36	0	24

Note. Day 1, breakfast, *n* = 35; day 1, dinner, *n* = 32; day 2, breakfast, *n* = 32; day 2, dinner, *n* = 32.

Table 3.2

Average Frequency and Average Proportion of Different Types of Math Talk

	Frequency of math talk				% of math talk	
Type of math talk	*M*	*SD*	Min	Max	*M*	*SD*
Naming numbers	3.75	2.11	1.00	9.50	48.09	12.38
Ordinal numbers	1.25	1.04	0	5.00	15.04	9.64
Adding and subtracting	.14	.31	0	1.50	1.69	3.61
Counting	.75	.78	0	3.67	9.75	7.37
Monetary exchange	.03	.09	0	.50	.32	1.13
Dates	.05	.12	0	.50	.58	1.5
Estimating	.02	.09	0	.50	.24	1.07
Fractions	.38	.48	0	2.25	4.59	5.42
Comparing attributes	.06	.14	0	.67	.78	1.98
Noting equality	.03	.09	0	.50	.24	0.93
Grouping and sharing	.05	.13	0	.50	.51	1.34
Measuring	.03	.09	0	.33	.43	1.24
Naming shapes	.12	.27	0	1.50	1.66	3.2
Number books and games	.07	.21	0	1.00	.97	2.8
Printing or recognizing numerals	.03	.12	0	.67	.36	1.39
Time	1.17	0.87	0	3.33	14.80	9.81
Purpose of math	0	0	0	0	0	0
Total	7.91	3.98	2.25	21.00		

Table 3.3

Average Amount of Talk and Proportion of Math Talk across Segments

	Total number of utterances				% of math talk	
Segment	*M*	*SD*	Min	Max	*M*	*SD*
Breakfast Day 1	627.89	251.47	225.00	1205.50	3.22	4.14
Dinner Day 1	553.39	225.04	201.50	1302.00	2.59	3.52
Breakfast Day 2	566.09	251.98	86.00	1293.00	2.58	2.22
Dinner Day 2	579.22	308.93	88.00	1637.00	2.63	2.23
Total	595.88	204.07	287.67	1172.50	2.89	1.82

Table 3.4

Average Number of Utterances and Average Proportion of Utterances for Different Types of Math Talk

	Number of utterances of math talk				% of utterances of math talk[1]	
Type of math talk	*M*	*SD*	Min	Max	*M*	*SD*
Naming numbers	8.30	7.84	1.33	48.33	47.21	18.19
Ordinal numbers	1.78	1.62	0	8.00	9.86	6.70
Adding and subtracting	.65	2.09	0	11.67	2.72	6.67
Counting	3.53	5.66	0	21.67	14.81	15.18
Monetary exchange	.04	.18	0	1.00	.33	1.55
Dates	.22	.66	0	3.50	1.81	6.69
Estimating	.03	.12	0	.50	.28	1.08
Fractions	.50	.74	0	3.75	3.14	4.73
Comparing attributes	.11	.34	0	2.00	.56	1.46
Noting equality	.03	.09	0	.50	.12	.45
Grouping and sharing	.10	.27	0	1.00	.58	1.78
Measuring	.07	.25	0	1.50	.40	1.30
Naming shapes	.25	.69	0	4.00	1.50	2.94
Number books and games	1.26	5.87	0	36.50	3.90	12.98
Printing or recognizing numerals	1.03	5.76	0	36.33	1.13	5.01
Time	1.80	1.48	0	5.75	11.64	10.02
Purpose of math	0.00	0.00	0	0	0	0
Total	19.70	19.85	3.75	119.67		

[1] Number of utterances of a specific type of math talk divided by the total number of utterances of math talk.

Table 3.5

Average Proportion of Complexity, Initiation, Dominance, and No Response of Math Talk

	%	
Complexity of math talk	*M*	*SD*
Basic skills	93.76	10.48
Higher order	6.24	10.48
Initiation of math talk		
Mother initiated	64.36	14.87
Child initiated	35.64	14.87
Dominance of math talk		
Dominated by mother	57.25	15.38
Dominated by child	27.38	14.94
Dominated by both	15.37	10.10
No response		
Yes	.87	2.73

Table 4.1

Average Frequency of Different Types of Math Talk in Families with Different Educational Backgrounds

	Low educational background (*n* = 15)				High educational background (*n* = 25)				
Type of math talk	*M*	*SD*	Min	Max	*M*	*SD*	Min	Max	*d*
Naming numbers**	2.66	.92	1.00	4.25	4.41	2.36	1.75	9.50	-.98
Ordinal numbers	1.19	1.02	0	3.00	1.29	1.08	0	5.00	-.10
Adding and subtracting	.15	.30	0	1.00	.13	.33	0	1.50	.06
Counting	.91	.65	0	2.25	.66	.85	0	3.67	.33
Monetary exchange	0	0	0	0	.04	.12	0	.50	-.47
Dates	.02	.06	0	.25	.06	.14	0	.50	-.37
Estimating	.05	.14	0	.50	.00	.00	0	0	.51
Fractions*	.19	.25	0	.67	.49	.56	0	2.25	-.69
Comparing attributes	.06	.12	0	.33	.06	.15	0	.67	0
Noting equality	0	0	0	0	.04	.12	0	.50	-.47
Grouping and sharing	.03	.13	0	.50	.06	.14	0	.50	-.22
Measuring	.04	.10	0	.33	.03	.08	0	.25	.11
Naming shapes	.07	.16	0	.50	.15	.32	0	1.50	-.32
Number books and games	.11	.27	0	1.00	.05	.16	0	.67	.27
Printing or recognizing numerals	.04	.17	0	.67	.02	.08	0	.33	.15
Time	1.18	.97	0	3.33	1.17	.83	0	3.00	.01
Purpose of math	0	0	0	0	0	0	0	0	
Total	6.71	2.62	2.25	11.25	8.64	4.51	2.75	21.00	-.52

Note. Low educational background: mothers with less than a bachelor degree; high educational background: mothers with a bachelor degree or a more advanced degree.
* $p < .05$. ** $p < .01$.

Table 4.2

Average Proportion of Different Types of Math Talk in Families with Different Educational Backgrounds

	% of math talk				
	Low education		High education		
Type of math talk	*M*	*SD*	*M*	*SD*	*d*
Naming numbers*	42.33	12.94	51.54	10.88	-.77
Ordinal numbers	16.45	12.85	14.19	7.26	.22
Adding and subtracting	1.98	3.82	1.52	3.54	.12
Counting*	13.51	6.75	7.49	6.90	.88
Monetary exchange†	0	0	.51	1.41	-.51
Dates	.24	.92	.79	1.75	-.39
Estimating	.64	1.71	0	0	.53
Fractions	2.80	4.24	5.66	5.83	-.56
Comparing attributes	1.17	2.78	.54	1.30	.29
Noting equality	0	0	.39	1.16	-.48
Grouping and sharing	.30	1.15	.63	1.46	-.25
Measuring	.38	1.02	.46	1.38	-.07
Naming shapes	1.49	3.30	1.77	3.21	-.09
Number books and games	1.71	3.87	.53	1.86	.39
Printing or recognizing numerals	.46	1.78	.30	1.13	.11
Time	16.55	12.57	13.75	7.81	.27
Purpose of math	0	0	0	0	

Note. Low educational: mothers with less than a bachelor degree (n = 15); high educational: mothers with a bachelor degree or a more advanced degree (n = 25).
† $p < .10$. * $p < .05$.

Table 4.3

Average Amount of Talk and Proportion of Math Talk across Segments in Families with Different Educational Backgrounds

	Total talk (in utterances)								
	Low educational background				High educational background				
Segment	*M*	*SD*	Min	Max	*M*	*SD*	Min	Max	*d*
Breakfast Day 1**	442.90	159.40	225.00	733.00	701.88	245.15	234.00	1205.50	-1.25
Dinner Day 1	581.64	307.39	201.50	1302.00	538.60	174.88	257.00	965.00	.17
Breakfast Day 2	471.00	202.62	86.00	687.00	615.90	265.16	264.00	1293.00	-.61
Dinner Day 2†	446.36	254.85	88.00	1125.00	648.81	317.28	340.00	1637.00	-.70
Total*	498.02	138.28	287.67	786.00	654.61	216.65	312.00	1172.50	-.86

	% math talk				
	Low educational background		High educational background		
Segment	*M*	*SD*	*M*	*SD*	*d*
Breakfast Day 1	2.63	2.21	3.46	4.72	-.23
Dinner Day 1	3.88	5.54	1.92	1.57	.48
Breakfast Day 2	2.46	2.13	2.65	2.32	-.09
Dinner Day 2	2.87	2.32	2.51	2.24	.16
Total	3.07	1.70	2.78	1.90	.16

Note. Low educational background: mothers with less than a bachelor degree (n = 15); high educational background: mothers with a bachelor degree or a more advanced degree (n = 25).
† $p < .10$. * $p < .05$. ** $p < .01$.

Table 4.4

Average Number of Utterances for Different Types of Math Talk in Families with Different Educational Backgrounds

Type of math talk	Low educational background				High educational background				*d*
	M	*SD*	Min	Max	*M*	*SD*	Min	Max	
Naming numbers	6.60	4.34	1.33	16.33	9.32	9.27	2.00	48.33	-.38
Ordinal numbers	1.71	1.42	0	4.00	1.82	1.76	0	8.00	-.07
Adding and subtracting	.98	3.00	0	11.67	.46	1.30	0	6.00	.22
Counting	4.09	5.00	0	19.33	3.19	6.10	0	21.67	.16
Monetary exchange	0	0	0	0	.07	.22	0	1.00	-.45
Dates	.05	.19	0	.75	.33	.81	0	3.50	-.48
Estimating†	.08	.18	0	.50	0	0	0	0	.63
Fractions*	.20	.32	0	1.00	.68	.87	0	3.75	-.73
Comparing attributes	.07	.16	0	.50	.13	.42	0	2.00	-.19
Noting equality	.00	.00	0	0	.04	.12	0	.50	-.47
Grouping and sharing	.05	.19	0	.75	.13	.30	0	1.00	-.32
Measuring	.12	.39	0	1.50	.04	.12	0	.50	.28
Naming shapes	.09	.19	0	.50	.34	.86	0	4.00	-.40
Number books and games	2.66	9.38	0	36.50	.43	1.67	0	8.00	.33
Printing or recognizing numerals	.24	.95	0	3.67	1.49	7.26	0	36.33	-.24
Time	1.38	1.12	0	3.75	2.06	1.62	0	5.75	-.49
Purpose of math	0	0	0	0	0	0	0	0	
Total	18.32	15.65	5.67	54.33	20.53	22.26	3.75	119.67	-.11

Note. Low educational background: mothers with less than a bachelor degree ($n = 15$); high educational background: mothers with a bachelor degree or a more advanced degree ($n = 25$).
† $p < .10$. * $p < .05$.

Table 4.5

Average Proportion of Utterances for Different Types of Math Talk in Families with Different Educational Backgrounds

	% number of utterances of math talk				
	Low education		High education		
Type of math talk	*M*	*SD*	*M*	*SD*	*d*
Naming numbers	45.05	20.89	48.51	16.69	-.18
Ordinal numbers	10.27	8.35	9.62	5.67	.09
Adding and subtracting	2.96	6.53	2.58	6.89	.06
Counting	19.63	12.84	11.92	15.97	.53
Monetary exchange	0	0	.53	1.95	-.38
Dates	.38	1.46	2.67	8.33	-.38
Estimating	.74	1.7	0	0	.62
Fractions*	1.09	2.18	4.37	5.42	-.79
Comparing attributes	.91	2.08	.35	.91	.35
Noting equality	0	0	.19	.57	-.47
Grouping and sharing	.19	.74	.82	2.16	-.39
Measuring	.42	1.47	.39	1.22	.02
Naming shapes	1.07	2.25	1.75	3.3	-.24
Number books and games	6.93	18.49	2.08	8.07	.34
Printing or recognizing numerals	.45	1.74	1.53	6.22	-.24
Time	9.92	9.79	12.68	10.21	-.28
Purpose of math	0	0	0	0	

Note. Low education: mothers with less than a bachelor degree (n = 15); high education: mothers with a bachelor degree or a more advanced degree (n = 25).
* $p < .05$.

Table 4.6

Average Proportion of Complexity, Initiation, Dominance, and No Response of Math Talk in Families with Different Educational Backgrounds

	% Low education		% High education		
Complexity of math talk	*M*	*SD*	*M*	*SD*	*d*
Basic skills	93.18	13.94	94.11	8.05	-.08
Higher order	6.82	13.94	5.89	8.05	.08
Initiation of math talk					
Mother initiated	64.73	16.56	64.14	14.1	.04
Child initiated	35.27	16.56	35.86	14.1	-.04
Dominance of math talk					
Dominated by mother	55.36	14.55	58.38	16.05	-.20
Dominated by child	30.07	18.45	25.77	12.53	.27
Dominated by both	14.56	12.05	15.86	8.98	-.12
No response					
Yes	1.96	4.10	0.21	1.05	.58

Note. Low education: mothers with less than a bachelor degree (n = 15); high education: mothers with a bachelor degree or a more advanced degree (n = 25).

Table 5.1

Correlations between Child's Early Math Skills and Maternal Reports of Math-related Practices

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Measures of Early Math Skills																	
1. WJ Applied Problems (wave I)																	
2. WJ Applied Problems (wave II)	.74 **																
3. Number Line (wave II)	-.36 *	-.47 **															
4. TEMA (wave II)	.58 **	.82 **	-.50 **														
Mother-child Math-related Practices																	
5. Workbooks or math problems	.21	.24	-.32 †	.30 †													
6. Connect number-pictures, mazes, puzzles	.15	.14	-.26	.25	.41 **												
7. Play number games	-.19	-.15	.06	-.02	.08	.46 **											
8. Play counting games	-.11	-.05	-.32 †	.06	.51 **	.41 **	.59 **										
9. Play board or card games	.10	.10	-.07	-.01	.06	.49 **	.32 *	.25									
10. Count objects	.01	-.01	-.18	.00	.39 *	.20	.28 †	.65 **	.33 *								
11. Sort things by size, color, or shape	-.24	-.04	-.05	-.01	.19	.37 *	.40 *	.50 **	.55 **	.52 **							
12. Talk about money when shopping	-.17	-.03	.07	-.20	.04	.10	.22	.24	.32 *	.33 *	.38 *						
13. Measure ingredients when cooking	-.08	-.11	-.04	-.13	.29 †	.20	.12	.07	.18	.23	.17	.12					
14. Play with calculators	-.47 **	-.25	.26	-.29	.02	.22	.22	.22	.14	.18	.33 *	.48 **	.27 †				
15. Use calendars and dates	.10	.27	-.18	.15	-.01	.25	.38 *	.05	.25	.11	.29 †	.35 *	.23	.13			
16. Child wears a watch	-.25	-.14	.09	-.21	-.05	-.26	-.11	-.15	-.18	-.20	.07	.26	.26	.30 †	.14		
17. Engage in identifying writing numbers	-.14	-.11	-.17	-.12	.44 **	.26	.20	.56 **	.35 *	.63 **	.53 **	.24	.34 *	.20	.06	-.09	
18. Engage in printing numbers	-.11	-.03	-.22	.05	.19	.48 **	.40 *	.53 **	.31 †	.31 †	.34 *	.18	.18	.32 *	.17	.04	.50 **

Note. WJ= Woodcock-Johnson III Tests of Achievement.
† $p < .10$. *$p < .05$. **$p < .01$.

Table 5.2

Correlations between Child's Early Math Skills and Frequency of Different Types of Math Talk

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Measures of Early Math Skills																			
1. WJ Applied Problems (wave I)																			
2. WJ Applied Problems (wave II)	.74 **																		
3. Number Line (wave II)	-.36 *	-.47 **																	
4. TEMA (wave II)	.58 **	.82 **	-.50 **																
Types of Math Talk																			
5. Naming numbers	.30 †	.26	-.05	.28															
6. Ordinal numbers	.08	.05	.13	.22	.56 **														
7. Adding and subtracting	-.11	.09	-.22	-.01	-.06	-.11													
8. Counting	-.11	-.20	.06	-.07	.14	.00	.08												
9. Cultural exchange	.21	-.08	.11	-.03	.08	.08	-.12	.22											
10. Dates	.10	.09	.01	.13	.25	.40 *	-.04	.10	-.11										
11. Fractions	.16	.25	-.18	.38 *	.51 **	.46 **	-.16	-.25	-.14	.14									
12. Comparing attributes	-.05	.06	-.16	.24	.16	-.03	-.03	.35 *	-.11	.29 †	.00								
13. Noting equality	.12	-.11	.16	.10	.26	.21	-.12	.26	.82 **	-.11	.14	-.11							
14. Grouping and sharing	.09	.06	-.10	.20	.27	.14	.37 *	.04	.02	-.16	.10	-.16	.15						
15. Measuring	-.17	-.30 †	.17	-.29	.04	-.06	.20	.07	-.10	.00	.07	-.03	-.10	.12					
16. Naming shapes	.23	.07	-.09	-.01	.43 **	.38 *	-.11	-.31 †	-.12	.42 **	.40 *	-.06	-.12	-.06	-.11				
17. Number books and games	-.16	-.17	.02	-.20	-.05	.07	-.10	.20	-.09	-.14	.09	-.04	-.09	.07	-.13	-.06			
18. Printing or recognizing numerals	.01	-.18	-.14	-.09	.07	-.08	.34 *	.35 *	-.07	.10	-.06	.23	-.07	-.10	.42 **	-.02	-.09		
19. Time	-.03	.02	.28	.11	.32 *	.41 **	.17	.23	.12	.19	.20	-.16	.18	.41 **	.10	.10	-.03	.01	
20. Total amount of math interactions	.18	.14	.03	.25	.89 **	.75 **	.06	.33 *	.12	.36 *	.52 **	.14	.31 †	.34 *	.08	.39 *	.06	.14	.60 **

Note. WJ= Woodcock-Johnson III Tests of Achievement.
†p < .10. *p < .05. **p < .01.

Table 5.3

Correlations between Child's Early Math Skills and Number of Utterances of Different Types of Math Talk

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Measures of Early Math Skills																				
1. WJ Applied Problems (wave I)																				
2. WJ Applied Problems (wave II)	.74 **																			
3. Number Line (wave II)	-.36 *	-.47 **																		
4. TEMA (wave II)	.58 **	.82 **	-.50 **																	
Types of Math Talk (# of utterances)																				
5. Naming numbers	.15	.16	-.25	.24																
6. Ordinal numbers	.07	.00	.16	.14	.53 **															
7. Adding and subtracting	-.18	-.08	-.13	-.06	.11	-.07														
8. Counting	-.11	-.30 †	.12	-.17	.51 **	.23	.35 *													
9. Cultural exchange	.14	-.11	-.06	.04	-.08	.00	-.08	.14												
10. Dates	.14	.15	.10	.18	.23	.19	-.07	.07	-.08											
11. Estimating	-.02	-.07	-.15	-.22	-.02	-.04	-.06	-.03	-.07	-.09										
12. Fractions	.10	.21	-.20	.47 **	.31 †	.40 *	-.11	-.08	-.06	-.01	-.19									
13. Comparing attributes	-.02	.06	-.18	.20	.75 **	.25	-.07	.40 *	-.08	.29 †	-.01	.17								
14. Noting equality	.12	-.11	.16	.10	.00	.18	-.08	.35 *	.69 **	-.09	-.07	.21	-.08							
15. Grouping and sharing	.05	.01	-.13	.22	.03	.12	.17	-.11	.45 **	-.13	-.11	.10	-.12	.28 †						
16. Measuring	-.01	-.16	.15	-.17	.06	.07	.13	.10	-.07	-.04	-.08	-.07	-.03	-.08	.32 *					
17. Naming shapes	.17	.11	-.01	.05	.15	.50 **	-.10	-.21	-.09	.10	.02	.33 *	.03	-.10	-.11	-.06				
18. Number books and games	-.22	-.17	.07	-.22	-.10	.09	-.06	.13	-.05	-.07	-.06	.00	-.06	-.06	-.07	-.06	-.07			
19. Printing or recognizing numerals	.05	.02	-.22	.13	.84 **	.31 †	.03	.56 **	-.04	.35 *	-.05	.18	.88 **	-.05	-.07	-.03	-.06	-.04		
20. Time	.21	.11	.02	.29	.25	.41 **	.07	.12	-.05	.00	-.22	.42 **	.05	.17	.28 †	.16	.30 †	-.17	.18	
21. Total amount of math utterances	.00	-.05	-.11	.07	.87 **	.54 **	.23	.75 **	-.03	.23	-.08	.25	.70 **	.10	.00	.07	.06	.26	.84 **	.28 †

Note. WJ= Woodcock-Johnson III Tests of Achievement.
† $p < .10$. *$p < .05$. **$p < .01$.

Table 5.4

Correlations between Child's Early Math Skills and Other Aspects of Math Talk

	1	2	3	4	5	6	7	8	9	10
Measures of Early Math Skills										
1. WJ Applied Problems (wave I)										
2. WJ Applied Problems (wave II)	.74 **									
3. Number Line (wave II)	-.36 *	-.47 **								
4. TEMA (wave II)	.58 **	.82 **	-.50 **							
Characteristics of Math Talk										
5. Mother-initiation	.13	.02	.12	.18						
6. Child-initiation	.20	.31 †	-.14	.28	.44 **					
7. Higher order	-.14	-.06	-.13	-.05	.22	.21				
8. Basic skills	.22	.15	.07	.27	.91 **	.70 **	.02			
9. Mother-dominance	.19	.09	.12	.25	.96 **	.43 **	.04	.93 **		
10. Child-dominance	.20	.24	-.08	.10	.25	.91 **	.16	.53 **	.24	
11. Equally dominated by mother and child	-.07	.00	-.11	.13	.55 **	.54 **	.63 **	.50 **	.36 *	.31 *

Note. WJ= Woodcock-Johnson III Tests of Achievement.
† $p < .10$. *$p < .05$. **$p < .01$.

Table 5.5

Correlations between Child's Early Math Skills and Control Variables

	1	2	3	4	5	6	7	8	9	10	11	12
Measures of Early Math Skills												
1. WJ Applied Problems (wave I)												
2. WJ Applied Problems (wave II)	.74 **											
3. Number Line (wave II)	-.36 *	-.47 **										
4. TEMA total score (wave II)	.58 **	.82 **	-.50 **									
Control Variables												
5. # of utterances	.27	.01	.04	.10								
6. Self-regulation (HTKS)	.57 **	.50 **	-.10	.46 **	.14							
7. Self-regulation (OP)	.23	.15	-.33 †	.11	-.07	.36 *						
8. WJ decoding skills (LWI)	.69 **	.57 **	-.56 **	.67 **	.12	.46 **	.17					
9. Vocabulary (PPVT)	.63 **	.39 *	-.26	.27	.39 *	.17	.04	.50 **				
10. Child's age (months)	.45 **	.43 *	-.18	.30	-.15	.37 *	.31 *	.44 **	.20			
11. Child's gender (1=boy)	.20	.10	-.08	.02	.23	.19	.00	.13	.14	-.11		
12. Child in kindergarten (1=yes)	.39 *	.50 **	-.22	.46 **	-.04	.13	.10	.32 †	.16	.48 **	-.18	
13. Maternal education (1=BD or more)	.54 **	.50 **	-.40 *	.51 **	.38 *	.43 **	-.02	.45 **	.55 **	.08	.12	.02

Note. WJ= Woodcock-Johnson III Tests of Achievement; PPVT= Peabody Picture Vocabulary Test; HTKS= Head-Toes-Knees-Shoulders; OP= Operation Span task.
† $p < .10$. *$p < .05$. **$p < .01$.

Table 5.6

Descriptive Statistics for Variables Included in Regression Analyses

	M	*SD*	Min	Max	*N*
Independent Variables (wave I)					
Frequency of naming numbers math talk	3.75	2.11	1	9.50	40
Length of counting math talk	3.53	5.66	0	21.67	40
Length of fractions math talk	.50	.74	0	3.75	40
Math-related activities at home	6.10	1.97	2	10	40
Counting games at home	3.49	1	2	5	39
Control Variables					
Total number of utterances	595.88	204.07	287.67	1172.50	40
Child's self-regulation (HTKS)	14.98	13.90	0	38	40
Child's decoding skills (WJ LWI)	11.05	6.33	1	38	40
Child's vocabulary (PPVT)	70.57	17.60	11	102	40
Child's age (in months)	53.75	5.47	46	69	40
Child in kindergarten(1= yes)	.60	.50	0	1	35
Maternal education (1=BD or more)	.63	.49	0	1	40
Outcome Variables					
WJ Applied Problems (wave I)	14.59	4.53	1	26	39
WJ Applied Problems (wave II)	20.85	4.81	12	32	34
Number Line (wave II)	18.76	9.46	3.95	38.33	34
TEMA (wave II)	30.21	13.02	8	65	33

Note. Math-related activities: math workbooks or simple math problems, or connect the number-pictures, mazes or puzzles; HTKS: Head-Toes-Knees-Shoulders; WJ LWI= Woodcock-Johnson III Tests of Achievement, Letter-Word Identification subtest; PPVT= Peabody Picture Vocabulary Test; BD= Bachelor's degree.
All control variables were measured at the first wave of the study, with the exception of whether the child was attending kindergarten or not, which corresponded to the second wave of the study.

Table 5.7

Hierarchical Multiple Regression Analysis Predicting the Child's Applied Problems Score in the First Wave of the Study (N = 38)

Block	1			2			3			4			5			6		
	B	*SE B*	β	*B*	*SE B*	β	*B*	*SE B*	β	*B*	*SE B*	β	*B*	*SE B*	β	*B*	*SE B*	β
Independent Variables																		
Frequency of naming numbers math talk	.72	.40	.34 †	.36	.52	.17	.21	.46	.10	-.11	.34	-.05	-.09	.34	-.04	-.11	.34	-.05
Length of counting math talk	-.12	.13	-.15	-.16	.14	-.20	.00	.13	.00	.01	.09	.01	.01	.09	.02	.01	.09	.02
Length of fractions math talk	-.66	1.20	-.10	-.79	1.21	-.12	-.54	1.06	-.08	.58	.84	.09	.59	.84	.09	.40	.89	.06
Math-related activities at home	.76	.45	.33	.81	.45	.36 †	.54	.41	.24	.13	.30	.06	.14	.30	.06	.21	.32	.09
Counting games at home	-1.55	.90	-.33 †	-1.62	.90	-.35 †	-1.23	.80	-.26	-.61	.58	-.13	-.48	.60	-.10	-.71	.67	-.15
Amount of Language																		
Total number of utterances				.01	.01	.25	.00	.01	.18	.00	.00	.03	.00	.00	.05	.00	.00	.05
Child's Self-regulation																		
HTKS							.16	.05	.50 **	.13	.04	.39 **	.12	.04	.37 **	.11	.05	.33 **
Child's Academic and Cognitive Skills																		
Child's decoding skills (WJ LWI)										.18	.10	.25 †	.15	.10	.22	.14	.11	.20
Child's vocabulary (PPVT)										.13	.04	.48 **	.13	.04	.47 **	.11	.04	.41 **
Child's Demographics																		
Child's age (in months)													.09	.10	.11	.10	.10	.12
Mother's Demographics																		
Maternal education (1=BD or more)																1.11	1.45	.12
F	1.78			1.68			3.32 *			8.83 ***			7.98 ***			7.20 ***		
Adjusted R^2	.10			.10			.31			.66			.65			.65		

† $p < .10$. * $p < .05$. ** $p < .01$. *** $p < .001$.

Table 5.8

Hierarchical Multiple Regression Analysis Predicting the Child's Applied Problems Score in the Second Wave of the Study (N = 33)

Block	1			2			3			4			5			6		
	B	*SE B*	β	*B*	*SE B*	β	*B*	*SE B*	β	*B*	*SE B*	β	*B*	*SE B*	β	*B*	*SE B*	β
Independent Variables																		
Frequency of naming numbers math talk	.44	.42	.21	.70	.58	.33	.55	.56	.26	.21	.49	.10	.13	.50	.06	-.02	.50	-.01
Length of counting math talk	-.33	.14	-.40 *	-.30	.15	-.36 †	-.15	.16	-.18	-.13	.14	-.16	-.12	.14	-.15	-.13	.14	-.15
Length of fractions math talk	.41	1.29	.06	.45	1.31	.07	.78	1.24	.12	1.38	1.23	.21	.96	1.26	.14	.24	1.32	.04
Math-related activities at home	1.02	.55	.43 †	.93	.57	.40	.77	.55	.33	.50	.47	.21	.20	.52	.08	.45	.53	.19
Counting games at home	-2.42	1.20	-.47 †	-2.24	1.24	-.43 †	-1.97	1.18	-.38	-1.74	1.00	-.33	-.58	1.28	-.11	-1.60	1.42	-.31
Amount of Language																		
Total number of utterances				.00	.01	-.18	-.01	.01	-.23	-.01	.01	-.33	-.01	.01	-.26	.00	.01	-.18
Child's Self-regulation																		
HTKS							.13	.07	.36 †	.11	.06	.31 †	.11	.07	.29	.07	.07	.19
Child's Academic and Cognitive Skills																		
Child's decoding skills (WJ LWI)										.26	.20	.25	.18	.21	.17	.21	.21	.20
Child's vocabulary (PPVT)										.10	.06	.35 †	.10	.06	.34 †	.03	.07	.11
Child's Demographics																		
Child's age (in months)													.06	.18	.06	.05	.18	.05
Child in kindergarten(1= yes)													2.49	2.12	.25	2.42	2.06	.25
Mother's Demographics																		
Maternal education (1=BD or more)																3.58	2.41	.34
F			2.36 †			1.99			2.46 †			3.94 **			3.43 **			3.53 **
Adjusted R^2			.18			.17			.25			.47			.47			.50

† $p < .10$. * $p < .05$. ** $p < .01$.

Table 5.9

Hierarchical Multiple Regression Analysis Predicting the Child's Number Line Estimation Task (Percentage of Error) in the Second Wave of the Study (N = 33)

Block	1			2			3			4			5			6		
	B	*SE B*	β	*B*	*SE B*	β	*B*	*SE B*	β	*B*	*SE B*	β	*B*	*SE B*	β	*B*	*SE B*	β
Independent Variables																		
Frequency of naming numbers math talk	.38	.91	.09	.16	1.27	.04	.18	1.31	.04	.65	1.19	.16	.67	1.30	.17	1.15	1.25	.28
Length of counting math talk	.07	.31	.04	.04	.33	.03	.02	.38	.01	.06	.34	.04	.05	.36	.03	.06	.34	.04
Length of fractions math talk	-1.85	2.77	-.14	-1.89	2.83	-.15	-1.94	2.91	-.15	-1.28	3.00	-.10	-1.10	3.25	-.09	1.17	3.28	.09
Math-related activities at home	-1.54	1.18	-.34	-1.47	1.24	-.33	-1.44	1.28	-.32	-.70	1.16	-.16	-.56	1.34	-.13	-1.36	1.33	-.30
Counting games at home	-.15	2.58	-.02	-.30	2.69	-.03	-.35	2.77	-.04	-.54	2.46	-.05	-1.08	3.29	-.11	2.12	3.53	.21
Amount of Language																		
Total number of utterances				.00	.01	.08	.00	.01	.08	.00	.01	.09	.00	.01	.07	.00	.01	-.06
Child's Self-regulation																		
HTKS							-.02	.16	-.03	.07	.15	.11	.08	.17	.12	.19	.17	.28
Child's Academic and Cognitive Skills																		
Child's decoding skills (WJ LWI)										-1.07	.50	-.52 *	-1.03	.54	-.50 †	-1.12	.51	-.55 *
Child's vocabulary (PPVT)										-.06	.14	-.10	-.06	.14	-.10	.15	.17	.28
Child's Demographics																		
Child's age (in months)													-.05	.47	-.03	-.02	.45	-.01
Child in kindergarten(1= yes)													-1.05	5.45	-.06	-.85	5.12	-.05
Mother's Demographics																		
Maternal education (1=BD or more)																-11.28	6.00	-.56 †
F			.89			.72			.60			1.55			1.16			1.50
Adjusted R^2			-.02			-.06			-.10			.14			.06			.17

† $p < .10$. * $p < .05$. ** $p < .01$.

Table 5.10

Hierarchical Multiple Regression Analysis Predicting the Child's TEMA-3 Score in the Second Wave of the Study (N = 32)

Block	1			2			3			4			5			6		
	B	*SE B*	β	*B*	*SE B*	β	*B*	*SE B*	β	*B*	*SE B*	β	*B*	*SE B*	β	*B*	*SE B*	β
Independent Variables																		
Frequency of naming numbers math talk	.11	1.08	.02	.69	1.49	.13	.26	1.39	.05	-.34	1.21	-.06	-.57	1.31	-.10	-1.03	1.26	-.19
Length of counting math talk	-.44	.37	-.20	-.36	.39	-.17	.06	.41	.03	.02	.35	.01	.04	.37	.02	.02	.35	.01
Length of fractions math talk	6.91	3.27	.39 *	7.01	3.32	.40 *	7.92	3.11	.45 *	7.51	3.07	.43 *	6.86	3.27	.39 †	4.69	3.33	.27
Math-related activities at home	2.88	1.39	.47 *	2.68	1.45	.44 †	2.24	1.36	.37	1.39	1.18	.23	.93	1.35	.15	1.69	1.35	.28
Counting games at home	-4.97	3.05	-.37	-4.58	3.16	-.34	-3.81	2.95	-.28	-3.53	2.51	-.26	-1.99	3.31	-.15	-5.07	3.58	-.37
Amount of Language																		
Total number of utterances				-.01	.02	-.15	-.01	.01	-.20	-.01	.01	-.23	-.01	.01	-.18	-.01	.01	-.09
Child's Self-regulation																		
HTKS							.37	.17	.39 *	.26	.15	.28 †	.28	.17	.30	.17	.17	.18
Child's Academic and Cognitive Skills																		
Child's decoding skills (WJ LWI)										1.16	.51	.42 *	1.07	.54	.39 †	1.17	.52	.42 *
Child's vocabulary (PPVT)										.10	.14	.13	.09	.14	.12	-.11	.18	-.15
Child's Demographics																		
Child's age (in months)													-.09	.48	-.04	-.12	.45	-.05
Child in kindergarten(1= yes)													4.45	5.49	.17	4.26	5.20	.17
Mother's Demographics																		
Maternal education (1=BD or more)																10.83	6.09	.39 †
F			2.78 *			2.31 †			3.01 *			4.52 **			3.53 **			3.86 **
Adjusted R^2			.23			.21			.32			.51			.48			.53

† $p < .10$. * $p < .05$. ** $p < .01$.

APPENDICES

APPENDIX A

Instructions for Transcribing Sound Files at the Utterance Level
(Adapted from Worzalla, 2012)

1. Check the Transcriptions Record spreadsheet to see which files need to be transcribed. Then mark your name for the family/time you are going to do (when you are done, write YES in the column "done"). This spreadsheet is located in: LENA Project\Transcriptions.
2. Open the Transcriber Program.
3. Open the audio file located in the Lena drive under a folder called "combined audio files." Right-click the (.wav) sound file you want to work with and choose "Open With."
4. Choose "transwin" (for the Transcriber program). If this doesn't work you may need to go to: Choose Default Program -> Transcriber -> transwin.exe.
5. Transcriber will open the sound file. There will be a small window that says "Shape info", which should go away within a minute or two (you can begin working in the meantime).
6. Go to Segmentation→ Edit Turn Attributes → Create speaker. Then, create speakers as needed (mother, child, father, sibling 1, etc.).
7. Start transcribing the conversations at the utterance level as you listen to the files. Here are some tips for this:
   - Play/Pause→ TAB
   - Rewind→ Alt Left
   - To change speakers→ Ctrl t (if there are more than two speakers, you'll need to move up and down)

- If you selected a speaker by mistake and need to change it → Ctrl Alt t
- To save the file→ Control s (make sure you save your file every few minutes). Save file to LENA Project\Transcriptions\ Family ID (e.g., 1004)\Day (e.g., 1). The name of the file should include be: Family ID_Day_Timeframe_Your name. For example, if Mane transcribed for the second day, for family 1012 during dinner time, save as: 1012_2_dinner_Mane. There will be up to 3 files per day per family.

Guidelines for defining Utterances

1. RULE OF THUMB: If a sentence ends with any punctuation mark (e.g. period, exclamation point, question mark NOT commas), start a new utterance.
   - "No! No!" Split this into TWO utterances:
   - "No!"
   - "No!"
2. Watch your grammar, punctuation marks, and spelling!! Every utterance should end with a punctuation mark!!
3. When one word is spoken by itself, it is considered a single utterance. The only case in which this does not apply is if the mother is going to continue into a longer sentence, but is interrupted.
   - Name (*"Grant!"*) – single utterance
   - Command (*"Wait!"*) – single utterance
   - "Grant, put your shoes on." – single utterance
4. If a sentence is interrupted for any reason, include it as two separate sentences. If a sentence starts off one way, but then changes to a new sentence halfway through, this should be two separate sentences.
   - *"Can you…Are you done with your waffle?"* should be:
     - "*Can you…"*
     - *"Are you done with your waffle*?"
5. Sentences that begin with a word and a comma will be one utterance unless there is a big pause between the word and the rest of the sentence.
   - *"Here, do you want a towel?"*

- *"Grant, I want you to…"*

6. Sounds that are substitutions for words are an utterance.
   - *"Hmmm?"*
   - *"Uh huh"*
7. If something does not sound clear or entirely audible, you should transcribe it as either XX for a single word or XXX when there is more than one word involved.
8. When one word is repeated many times in a row *without pauses in between the words*, this is still only one utterance.
   - *"No, no, no…"*
9. When there is counting, alphabet singing, spelling letters, or other series of words or numbers, these series are considered one utterance.
   - "One, two, three, four…"
   - "C-A-T spells 'cat'"
10. If a question comes before a statement, then there will be two utterances.
    - "Why?"
    - "Let me see."
11. If a question is immediately followed by another question, it will be two utterances.
    - "What?"
    - "What was that?"
12. When the mother says the name of the child at the start of a sentence, it is part of the same utterance.
    - "Avik, here's what we're going to do next."
13. Don't include *umm*, grunts, or any other sounds that have no significant meaning as separate utterances; include them in the original utterance.
14. If there is about a one-second pause or more, you should transcribe two separate utterances (three dots indicate a pause and you can end an utterance with that).
    - "The boy turned nine years old…(pause)…and he didn't want to come in for dinner." Should be transcribed as:
    - "The boy turned nine years old…"
    - "And he didn't want to come in for dinner."

APPENDIX B

Instructions for Coding Math Talk

The purpose of this coding is to record the ways in which families talk with their preschool-aged children about math (i.e., the ways in which families socialize math at home).

Two time frames (i.e., *breakfast, dinnertime*) from two different days will be coded and analyzed in terms of **math talk** by reading the transcripts of conversations during those times. The length of each time-frame will be about one hour, so that up to 4 hours per each family will be coded in total (up to two hours per day per two days).

The coding scheme that will be used in this study includes the following categories:

1. Naming numbers
2. Ordinal numbers
3. Adding/Subtracting
4. Counting
5. Monetary exchange
6. Dates
7. Estimating
8. Fractions/Percentages
9. Comparing attributes
10. Noting equality
11. Grouping, sharing, or distributing
12. Measuring
13. Naming shapes
14. Number books/Number games
15. Printing numbers/ Recognizing written numerals
16. Time
17. Purpose of math (see below for a description of these categories)

These categories are not exclusive since they attempt to represent the broad range of math-related activities in which children and mothers are engaged in their normal routines. Thus, if a math-related activity fits two categories, that activity will be coded within both categories (please highlight the description when this happens) (i.e., dual coding).

Tips for Coding Math Talk

Before Coding:

- How to find **time-frames** to code:

- Go to *LENA Project\MATH TALK Coding*.

- Go to *Math Coding Record*.xls. Find a day that has not yet been completed. Be sure to add your name to the document in the proper time slot so someone else does not code the same time as you. Different research assistants may code for different <u>days</u> of the same family. However, the two times for each day (Breakfast and Dinner) should all be completed by the same research assistant. Check the *Math Coding Record.xlsx* document to see which specific time the event you are coding (breakfast or dinner) occurred. You will do a one hour long time period.

- How to find **transcripts** to code:

  - Go to *LENA Project\Transcriptions\Exported word files*.
  - Then open the word file that corresponds to the family day and time that you will code. Before we have established reliability, please make sure to click SAVE AS before starting the coding. Do not click save, as this will replace the original transcript. You will need to save the file with your highlights in a personal folder in *LENA Project\MATH TALK Coding*. When reliability has been established, you will work on the original file.

- How to save files:

  - You will save your coding on a document called *Coding sheet.docx* (go to *LENA Project\MATH TALK Coding)*, but you need to click SAVE AS. <u>Do not click save</u>, as this will replace the blank coding sheet.
  - Save document to LENA Project\MATH TALK Coding as **FamilyID_Day_Time**. For example, if you coded for the second day, dinner time for family 1012 save as: 1012_2_2. There will be up to 2 files per day per family. For the timeframe, please keep in mind that breakfast=1, and dinner time=2, regardless of whether or not the family was recorded for all of these times.

<u>When coding, be sure to note the following:</u>

- The purpose of the coding is to record all math practices between the mother and child that take place during these times. Since we are only interested in Mother-Child interactions, <u>do not record</u> math practices or conversations that take place between the child and father or siblings, mother and siblings, child and siblings, etc. It is fine if others are present during the interactions, just be sure to <u>only include the parts involving the mother and child while coding</u>. There are some parts where the mother may be talking to all siblings such as “girls we have five more minutes”, and we will code for this. Also, do not code if the child or the mother are talking to themselves. The coding is based on strictly verbal interactions. So, only code what families actually say (i.e., do not code based on assumptions, inferences, or metaphors that don't intend to discuss math as a topic). If you are not sure if the mother is talking to the child or someone else, don't code it.

- In order to code, you will first have to read the transcript fully (coding while reading it). After reading the transcript, you will check that you have not missed any conversations by using the computer to search for the list of key words (please see the word document called *"Keyword List"*). If you find that you have missed any conversations about math, you will include them as a part of your coding as well. This list of words is just a guide, so it does not necessarily mean you should code for every word on that list. These words are also not only for the category they are under but may be applicable to any other category. For example, "how many" can lead you to a conversation about printing numbers. Use the list of keywords after you have already coded for math-talk as a form of checking to make sure you haven't missed anything. Moreover, when you find a word, be sure to read three utterances before and after the math word. However that does not mean you need to include these lines. We will start the coding at the first math word and finish the conversation at the last word about math, even though the whole conversation may have started earlier. Keep in mind that the conversation involves the mother and the child so you should start and end it when they are talking to each other.

-Each type of math talk will be recorded in the corresponding code category (Adding/Subtracting, Counting/Counting down, etc.). However, there might be cases in which a conversation includes two or more categories, so you will need to code it in all the corresponding categories. In this case, keep in mind that for each different category you should include only the part of the conversation that belongs to that category.

-Be sure that you are coding for Math Talk and Math Talk only. We will not include idioms and other colloquial phrases that include some math-words but don't intend to talk about math, such as "I'll throw in my two cents", or "a penny for your thoughts".

-Total number of utterances

- When coding, highlight utterances in yellow (i.e., sentences) that include <u>math talk</u> in the original transcript. If there is more than one category in the same conversation, you may dual code it using the green highlighter for this other category. Further, if there is a third category that fits the conversation, code this using the turquoise highlighter. In order to count the number of utterances, we will only count what was highlighted. You will also need to report the number of lines, which will include all the utterances involved in the conversation through the last highlight of the conversation (even though there are some utterances that don't include math in between). For example:

68 Child: Five. 69 Mother: Just five and then... And then we will get one for Allie. 70 Child: Ok, one for Allie 71 Mother: So how many is that now? Six plus one. 72 Child: Yeah. 73 Mother: Is? 74 Child: Six plus one. 75 Mother: Is? What's six and then what's after six? 76 Child: Seven. 77 Mother: Good job. 78 Child: Seven of them. 79 Mother: Seven of them. All right. 80 Child: Why did daddy not get one?

In this case, we would count the whole conversation when calculating the number of lines (lines 68-80), but we will include only the exact number of utterances that involved math. In this case, for example, 7 utterances were involved in "Naming Numbers" [lines 68-80 (utterances 7)] and 4 utterances involved "Adding and Subtracting" [lines 68-80 (utterances 4)]. When you are dual coding, be sure that you use the number of lines (such as 68-80) for the dual code as well as the overall topic of the conversation. For example: if a family is talking about dates from lines 1-15 and they also mention fractions ("whole weekend"), then we will still dual code under fractions in lines 1-15, except there will only be one utterance. In brief, when you are dual coding, you will have the same number of lines but a different number of utterances per code.

-Brief Description of the Math talk

- Please provide a brief description of the type of activity/interaction that was coded.
    - For example: Child asks mother what time it is, mother explains to child the time and at what times during the day other things will happen

-Initiation of Math Talk

- At end of the math talk description, record who initiated the conversation/interaction, mother (I/M) or child (I/C). This initiation is seen at the beginning of the interaction, by whoever first mentioned the math talk, either by asking a question or making a statement.

-Most math talk

- After deciding who initiated the conversation, decide who in the conversation spoke the <u>most</u> <u>math talk</u>, based on the number of utterances (i.e., most number of utterances). If the mother spoke two or more math utterances than the child, code (M). On the contrary, you should code (C) if the child was the person who spoke two or more utterances about math than the mother. If there are no differences in the number of utterances or if there is only one utterance of difference spoken by the mother compared to the ones spoken by the child, use the code (B) for both.
    - Whether it was the Child (C), Mother (M), or they Both (B) said math words.

-Math Talk Level

- The level of the math talk, either <u>higher order math talk</u> (H/O) or <u>basic skills math talk</u> (B/S) should also be recorded at the end of <u>each</u> conversation.
    - <u>Higher order math talk</u> includes any activity/conversation that involves an explicit explanation on anything about math. This can be more or less deep depending on the conversation. Some examples of higher order will be: “a mother explains that third follows second, and that the second shelf is shelf two”, “the mother explains reasons for a mathematical concept to her child”, or “the mother and child discuss why the child got something wrong on a math worksheet.” A deeper level of understanding is meant to be accomplished through higher order math talk in some cases. In other cases, when a conversation is explained a little more than just using math words, then we will consider this higher order math talk, as well.
    - <u>Basic skills math talk</u> includes activities that require yes/no responses or are either correct or incorrect, such as drawing and naming shapes. These often occur when families use implicit explanations not necessarily with the intention of talking about math. Although they are math related, they are not discussed in the way that higher order math talk is.

- No Response

- Sometimes, the mother or child will say something math-related, but no response will follow when an answer is expected (such as a question with no answer). In this case, still code the activity and who initiated it, but make a note at the end of the activity that there was no response (NR). Keep in mind that you will use this code only when there is no interaction. So, if the mother and the child are already talking and then one of them asks a question and the other person doesn’t respond to it, please don’t use the no response code. Since this was only present in a part of the dialog, there was still a conversation between them, so No Response does not apply in this case.

- <u>After coding both parts of a day, be sure to note the following</u>:

- Add the total of each type of math talk and whether it was initiated by the mother or the child at the bottom of each category.

- Also, add the total <u>number of utterances</u> spent in math talk per family that day.

- Finally, make note of how many interactions in the whole day were initiated by the mother (I/M), initiated by the child (I/C), higher order (H/O), basic skills (B/S), and who was the one who talked the most about math: Mother (M), Child (C), or Both (B).

-During coding, if there is ever a time where you are unsure about something or feel that it needs to be discussed further, mark it with an asterisk (*). Add the total number of flags at the end of each page, too. At the end of the document is a place to add notes and comments. Be sure to make notes about questions for discussion, as well as anything else that you feel needs to be further explained. Once you have discussed your questions with Mane and appropriate changes have been made, check the "questions resolved" section. This will make it clear that the coding is complete. More information is better, so do not omit something if you feel it might be helpful. Before finishing the coding be sure you have resolved all questions or issues.

Code Explanations and Examples

- **Naming numbers:** Describing the number of objects immediately, without counting. Objects can be physical objects (such as balls, animals, letters, etc.), actions (e.g., hugs, kisses, jumps) or abstract things (such as ideas, thoughts). However they need to refer to a specific number of these things. Ex: "I have three ideas" will be coded, but "I have an idea" will not be coded as it doesn't necessarily involve a description of one object. This code should be used only when they describe the number of objects (i.e., they say the number by its name in the context of describing a number of objects, or sing a song with the number in the context of describing objects). This code will also include instances where families mention a group of numbers, such as *dozen*.

  Naming numbers should only be coded if there is a use of numbers being spoken about in terms of the definition described above and these numbers **cannot be included in any of the other categories.** This means naming numbers might be in the same conversation as another category, but in a different sentence. If they are naming numbers in the same sentence as another category, we will not dual code for this.

  Keep in mind that the word *one* can be used numerically and non-numerically. Since some uses of *one* can be ambiguous with respect to their numerical content, we will consider strict criteria so that we will code for this category only when *one* is used to describe numerical objects, such as "you can only have one", "just one", "one per day", "one more", or "one at a time". This means that all the following uses of the word *one* <u>should not</u> be coded: deictics (e.g., "this one," "that one"), use of *one* as a direct object (e.g., "that's the pretty one," "do you want one?"), and some idioms (e.g., "one day," "one morning," "one of these days").

    - 6-10 (3) Mother asks child how many candy canes are in the kitchen and the child answers three (I/M) (B/S)(M)
    - 25-27 (2) Mother tells child that there are three balloons in the sky (I/M) (B/S)(B)

- **Ordinal numbers:** When ordinal numbers are used, such as: first, second, third, etc.
    - 99-103 (3) Mother tells the child that first goes the red square and then the blue triangle because of the way they are shaped (I/M) (H/O)(C)
    - 35-37 (2) Mother tells child she is first going to take away one cookie and then the rest of the stuff (I/M) (B/S)(C)
    - 12-13 (1) Child says he wants to feed his brother but first he has to wash his hands (I/C) (B/S)(B)

- **Adding/Subtracting:** Combining two or more numbers together, taking one or more numbers away from a larger number
  - Addition or subtraction worksheets, using objects to add or subtract, talking about how many more/less there would be if an amount was added/taken away.

Additive language or implied additive actions are included. Differences found or "take away" analogy is used.

        - 15-39 (20) Mother and child work on addition worksheets together, discuss answers child got wrong and how they should be changed (I/M) (H/O)(B)
        - 45-48 (2) Child says if there were two more crayons he would have six (I/C) (B/S)(C)
        - 76-78 (2) Mother tells child she is going to take away one cookie because he can only have two (I/M) (B/S)(M)

- **Counting**: Listing numbers in an increasing or decreasing order of regular intervals Ex: count, number sequences
    - Counting objects, counting out loud, and singing counting songs. Interactions where a "string" of numbers is used to determine an amount
        - 8-12 (2) Mother counts 1…2. (while telling child to go to his room) (I/M) (B/S)(B)
        - 10-12 (3) Child tells mother to jump then counts: 1,2,3! (I/C) (B/S)(C)
        - 142-156 (10) Mother and child count how many candies child has (I/C) (B/S)(B)

- **Monetary exchange**: Talking about the value of money or how it works, using or counting money.
    - If there is a situation where comparing money comes up such as, "What is more a dollar or a nickel?" this will be coded in this category.
    - Coding for this category should include TALK about money (either numerical or discussion).
    - Discussing how much something costs, playing store with money and a cash register, comparing amounts of different coins
        - 10-12 (3) Child says he is going to play "Comerica" with money (I/C) (B/S)(C)
        - 34-40 (2) Mother asks child how much various items cost while pretending they are grocery shopping (I/M) (B/S)(M)
        - 66-69 (3) Child asks mother why he can't have all the toys in the store and she says because it would be expensive and cost too much money (I/C) (B/S)(B)

- **Dates**: talking about the day, month, week, etc., with the idea of a <u>calendar</u> in mind. They refer to these concepts in the context of talking about:

- When an event occurred/is occurring in the past/future, naming days of the week or months of the year. This should be in relation to other dates. For example "This weekend we are going to Grandma's, but last weekend we went to the store".
- NOT just a mention of a word, but talk about the number of weeks in a month, or how many days until something.
- This category will not include seasons.
  - 39-47 (8) Child asks if he goes to preschool today, they talk about how it is Monday, and how dad works at home on Mondays (I/C) (H/O)(B)
  - 98-101 (3) Mother says that the dog's birthday is in January so they have to wait 3 months (I/M) (B/S)(M)

- **Estimating:** Guessing approximately how much or how many in terms of quantity. Involve guessing, predicting, or personal judgment of an <u>amount</u>. Therefore, if the mother (or child) uses the words "*how much*" in a non-numerical way (for example, how much do you think I love you? where the <u>answer is not a number</u>), we <u>will not code for this</u>.
  - Looking at objects and guessing how many there are, estimating how much money something will cost or how much of something will be needed.
    - 85-89 (3) Child says he thinks he saw about 20 birds on the way to school (I/C) (B/S)(C)
    - 96-104 (5) Mother says she will probably need somewhere around 2 more hours to finish her work (I/M) (B/S) (M)
    - 13-15 (2) Mother tells child to guess how many peanuts are in the jar (I/M) (B/S)(B)

- **Fractions/Percentages**: <u>Fractional values</u> are <u>**verbalized**</u>. We will NOT code for piece, slice or part. However, we WILL dual code for *half hour* in this category and in the time category. Use this code when fraction words are used in the context of things that can be split. For example, the "whole thing" should not be coded unless it refers to something that can easily be split in equal parts.
    - 87-90 (3) Child says the box is half empty because he ate half already and mother says if you eat the second half there will be none left (I/M) (H/O)(M)
    - 14-20 (2) Mother says child ran out of food because he dumped three quarters of it on the floor (I/M) (B/S)(M)

- **Comparing attributes:** Interactions where comparisons of <u>size</u>, <u>weight</u>, <u>length</u>, <u>width</u>, <u>numbers</u>, or <u>height</u> are being made. Talking about similarities or differences among items based on those attributes. Judging sizes or quantities of one item based on another. Only code for this when a direct comparison is made, not just the use of one of the comparing words. Comparing size (large, small, big, little, fat, tiny), weight (heavy, light, dense), length (short, long), width (wide, narrow, thick, thin), or height (tall, short).

In the case of comparing size, you should code conversations in which the family compares the size of two or more objects (for example, the mother says to the child: "this is a little ship"). If they use the word "little" to refer to other attributes but not size of the objects (for example, mother said she was going to put a *little bit* of lotion (not size) on the child, or she said she was going to be a *little late* for work), do not code for this.

- Comparing size
    - 15-18 (3) Child tells mother than 7 is more than 3, mother asks what about 6, child says 6 is smaller than 7 (I/C) (H/O) (C)
    - 23-34 (9) Mother asks child which animal is biggest? (I/M) (B/S)(M)
    - 55-57 (2) Child asks mother which sets of blocks is longest now (I/C) (B/S)(B)

- **Noting equality:** Sameness in terms of size, weight, length, width, height, or number verbalized.
    - Noting same number
        - 3-6 (3) Child asks mother to draw a line between the things that have the same number (I/C) (B/S)(C)
        - 15-20 (4) Child says that now the sets of blocks are the same height (I/C) (B/S) (N/R)(C)

- **Grouping, sharing, or distributing:** Putting objects in a group according to any of these attributes: shape, size, weight, length, width, or height, etc. This will not include days, weeks or months. Sharing involves distributing things or objects.
    - Organizing shapes and quantities. Mother and child speak of putting objects in a group according to some attribute (e.g., shape or size).
        - 78-80 (2) Child asks mother if she wants to separate all the triangles (I/C) (B/S)(C)
        - 56-67 (10) Child tells mother one for you, one for me (I/C) (B/S) (B)
        - 45-47 (3) Mother tells the child she will connect the brown blocks linearly (I/M) (B/S)(B)

- **Measuring**: Interactions where a unit or numerical measurement was taken for the purpose of determining or comparing size or weight. Using tools or other means to find how big, heavy, etc. something is.
    - Using cooking utensils, tape measures, scales
        - 103-130 (20) Child weighs himself then proceeds to weigh various items in the bathroom, mother and child discuss what is heavier (I/C) (H/O)(C)
        - 15-25 (9) While cooking, child is pouring milk, mother says to make sure he makes it one cup (I/M) (B/S)(B)

- **Naming shapes**: Identifying shapes by their name. Names of conventional geometric shapes are used. Use this category only when shapes are named. If the conversation consists of a deeper level, it should go in a different category. Also, don't code for the word "shape" but when they actually name the respective shapes.
  - Looking at shapes, drawing shapes, finding shapes in the environment
    - 35-39 (3) While playing with blocks, child says the star came out really easily (I/C) (B/S) (C)(NR)
    - 60-67 (5) Mother says she is going to draw a circle and a square and the child should draw a triangle (I/M) (B/S)(B)
    - 88-93 (4) Child says he can make a triangle with his hands, mother asks how he knows it's a triangle, child says it has 3 points (I/C)(H/O)(C)

- **Number books/Number games**: Reading books about numbers, playing games involving numbers, dice, timing, shapes, etc. This will include any book that has the purpose of promoting or using math. Books in which math words are used (for example, Charlie and the Chocolate Factory) but don't have the purpose of promoting math will be coded as any other regular conversation.
  - Playing board games, card games, matching games, etc.
    - 80-117 (35) Mother reads child a book about counting (I/M) (B/S)(M)
    - 55-90 (43) Mother and child play a memory game and talk about how to remember (I/C) (H/O)(B)

- **Printing numbers/Recognizing written numerals**
  - Writing and reading of numerals on paper and other forms of media, recognizing numbers when they are seen or making physical representations of them. Saying a number by its name.
    - 43-47 (3) Mother asks child if he knows what a number on a box is and child recognizes 7 and 9, and mother asks what is that together, and child says it makes 97 and mother explains that it is 79 (I/M) (H/O)(B)
    - 23-30 (7) Child asks mother what father's phone number is and she instructs him which numbers to dial (I/C) (B/S)(B)
    - 60-67 (6) Child says he can make a four with his legs and proceeds to do so (I/C) (B/S)(C)

- **Time**: Telling time or talking about when something happened or will happen. Should be numerical. So, this will not include "in a minute", "in a second", or "in a couple of minutes" with no specific number verbalized.
  - How many hours and minutes until bedtime.
  - Referring to a specific time (12:30)

        - 30-35 (3) Mother says child can watch TV for two more minutes (I/M) (B/S)(M)
        - 3-10 (8) Mother says they went to bed around 9:00 or 9:30 (I/M) (B/S)(M)

- **Purpose of math**: Talking about why math concepts are important
    - Discussing the use of numbers, why measuring things is important, reasons for telling time, etc.
        - 15-50 (35) Mother tells child that learning to count is important because then he will always be able to tell how many of something there are and if he needs more, such as with money or food (I/M) (H/O)(B)
        - 88-150 (63) Child says he wants to learn to add so he can do well in school and mother explains why adding is important to learn in school but is also used a lot outside of school, too (I/C) (H/O)(B)

APPENDIX C

Math Talk Coding Sheet

Family ID ___________ Coder ____________________________ Day (1 or 2) ____________ Time (1 or 2) ______________

Naming numbers (add number of utterances and brief description)	Ordinal numbers (add number of utterances and brief description)	Adding/Subtracting (add number of utterances and brief description)	Counting (add number of utterances and brief description)	Monetary exchange (add number of utterances and brief description)

Total #: _____	Total #: _____	Total #: _____	Total #: _____	Total #: _____
Utterances #:_____	Utterances #:_____	Utterances #:_____	Utterances #:_____	Utterances #:_____
(M/I:_____, C/I:____)	(M/I:_____, C/I:____)	(M/I:_____, C/I:____)	(M/I:_____, C/I:____)	(M/I:_____, C/I:____)
(H/O:_____, B/S_____)	(H/O:_____, B/S_____)	(H/O:_____, B/S_____)	(H/O:_____, B/S_____)	(H/O:_____, B/S_____)
(M:___, C:___, B:___)	(M:___, C:___, B:___)	(M:___, C:___, B:___)	(M:___, C:___, B:___)	(M:___, C:___, B:___)

Note: Initiated by mother (**M/I**) or initiated by child (**C/I**); Higher order math talk (**H/O**) or basic skills math talk (**B/S**); Talked the most about math: Mother (**M**), Child (**C**), or Both (**B**).**NR:** No response.

Flag for discussion (*) ____ Questions Resolved? _______

Dates (add number of utterances and brief description)	Estimating (add number of utterances and brief description)	Fractions/Percentages (add number of utterances and brief description)	Comparing attributes (add number of utterances and brief description)	Noting equality (add number of utterances and brief description)

Total #: _____	Total #: _____	Total #: _____	Total #: _____	Total #: _____
Utterances #:_____	Utterances #:_____	Utterances #:_____	Utterances #:_____	Utterances #:_____
(M/I:_____, C/I:____)	(M/I:_____, C/I:____)	(M/I:_____, C/I:____)	(M/I:_____, C/I:____)	(M/I:_____, C/I:____)
(H/O:_____, B/S_____)	(H/O:_____, B/S_____)	(H/O:_____, B/S_____)	(H/O:_____, B/S_____)	(H/O:_____, B/S_____)
(M:___, C:___, B:___)	(M:___, C:___, B:___)	(M:___, C:___, B:___)	(M:___, C:___, B:___)	(M:___, C:___, B:___)

Note: Initiated by mother (**M/I**) or initiated by child (**C/I**); Higher order math talk (**H/O**) or basic skills math talk (**B/S**); Talked the most about math: Mother (**M**), Child (**C**), or Both (**B**).**NR:** No response.

Flag for discussion (*) ____ Questions Resolved? _______

Grouping, sharing, or distributing (add number of utterances and brief description)	**Measuring (add number of utterances and brief description)**	**Naming shapes (add number of utterances and brief description)**	**Number books/Number games (add number of utterances and brief description)**	**Printing numbers/Recognizing written numerals (add number of utterances and brief description)**

Total #: _____	Total #: _____	Total #: _____	Total #: _____	Total #: _____
Utterances #:_____	Utterances #:_____	Utterances #:_____	Utterances #:_____	Utterances #:_____
(M/I:_____, C/I:____)	(M/I:_____, C/I:____)	(M/I:_____, C/I:____)	(M/I:_____, C/I:____)	(M/I:_____, C/I:____)
(H/O:_____, B/S_____)	(H/O:_____, B/S_____)	(H/O:_____, B/S_____)	(H/O:_____, B/S_____)	(H/O:_____, B/S_____)
(M:___, C:___, B:___)	(M:___, C:___, B:___)	(M:___, C:___, B:___)	(M:___, C:___, B:___)	(M:___, C:___, B:___)

Note: Initiated by mother (**M/I**) or initiated by child (**C/I**); Higher order math talk (**H/O**) or basic skills math talk (**B/S**); Talked the most about math: Mother (**M**), Child (**C**), or Both (**B**).**NR:** No response.

Flag for discussion (*) ____ Questions Resolved? _______

Time (add number of utterances and brief description)	Purpose of math (add number of utterances and brief description)

Total #: _____	Total #: _____
Utterances #:_____	Utterances #:_____
(M/I:_____, C/I:____)	(M/I:_____, C/I:____)
(H/O:_____, B/S_____)	(H/O:_____, B/S_____)
(M:___, C:___, B:___)	(M:___, C:___, B:___)

Total NR=

Note: Initiated by mother (**I/M**) or initiated by child (**I/C**); Higher order math talk (**H/O**) or basic skills math talk (**B/S**); Talked the most about math: Mother (**M**), Child (**C**), or Both (**B**).**NR:** No response.
Flag for discussion (*) ____ Questions Resolved? _______

NOTES AND QUESTIONS:

APPENDIX D

Keyword List

Naming numbers:
One
Two
Three
0-9

Ordinal numbers:
First
Second
Third

Adding/Subtracting:
Minus
Plus
Add

Counting:
Count

Monetary exchange:
Cost
Money

Dates:
Date
Month
Year

Estimating:
Guess
Estimate
About

Fractions/Percentages:
Half
Whole
Third
Fourth

Comparing attributes:
Large
Small
Big
Little
Short
Long

Noting equality:
Same
Identical

Grouping, sharing, or distributing:
Together
Distribute

Measuring:
Inches
Measure

Naming shapes:
Circle
Rectangle
Star
Triangle
Square

Printing numbers/Recognizing written numerals:
Book
Worksheet

Time:
Second
Minute
Hour

Purpose of math:
Explain
Learn
Reason

APPENDIX E

Today's Date: ____________________

A Week in the Life of Families

Background Questionnaire

CHILD INFORMATION

NAME: _______________________ ☐ Male ☐ Female

HOME ADDRESS Street _______________________ Apt. ______
City _______________________ State _______ Zip _______
Phone Number (___)__________

Race/Ethnicity: _______________ Native Language: _____________
School: ____________________ English Proficiency: ☐ None ☐ Fair ☐ Good ☐ Excellent
Teacher: ___________________
Date of Birth: _______________
Anticipated School District for Elementary School: ___________________

Who is completing this questionnaire?

☐ Mother ☐ Father ☐ Other Relative (specify) ____________
☐ Guardian ☐ Caregiver ☐ Other (specify) ___________________

FAMILY INFORMATION

Mother

NAME: _______________________

HOME ADDRESS (Same as child ☐)
Street_______________________ Apt. ______
City _______________________ State _______ Zip_______
Phone Number _____________

a. Age _______ b. Native Language _____________ c. Ethnicity/Race ___________

d. What is your occupation? (be as specific as possible) __________________________

e. Are you currently employed? □ Yes □ No

f. If "Yes" do you work □ part-time or □ full-time?

If part-time, please specify how many hours per week: _____________

g. What is your current yearly income? ______________________

h. Birthdate _____________

♦ What is the highest educational level you have attained? (Please check all that apply)

□ Some High School □ Graduated High School □ GED/Adult Education

□ Some College including Community College and Technical Training

□ Graduated Two-Year College (e.g., Associate's Degree, LPN) Degree Earned _____

□ Graduated Four-Year College (e.g., BA, BS) Degree Earned _____

□ Graduate School (e.g., MA, MS, MD, PhD, MSW, MBA) Degree Earned _____

♦ Name of the last school attended: ______________________

Father

NAME: _________________________

HOME ADDRESS (Same as child □)

Street_________________________ Apt. ______

City _________________________ State _______ Zip_______

Phone Number ______________

a. Age_______ b. Native Language______________ c. Ethnicity/Race___________

d. What is your occupation? (be as specific as possible) ____________________________

e. Are you currently employed? □ Yes □ No

f. If "Yes" do you work □ part-time or □ full-time?

g. What is your current yearly income? ______________________

h. Birthdate _____________

♦ What is the highest educational level you have attained? (Please check all that apply)

□ Some High School □ Graduated High School □ GED/Adult Education

□ Some College including Community College and Technical Training

☐ Graduated Two-Year College (e.g., Associate's Degree, LPN) Degree Earned _____

☐ Graduated Four-Year College (e.g., BA, BS) Degree Earned _____

☐ Graduate School (e.g., MA, MS, MD, PhD, MSW, MBA) Degree Earned _____

♦ Name of the last school attended: ____________________

OTHER FAMILY INFORMATION

1. Who has the child lived with for most of the past year? (check all that apply)
☐ Mother ☐ Father ☐ Both ☐ Guardian ☐ Other (specify) _______

2. Other children in the family:

Name	Sex	Age	Birthdate	Does she/he live at home?	Birthchild, Step-child, or Adopted
a. ____________________	____	____	_________	_________	__________
b. ____________________	____	____	_________	_________	__________
c. ____________________	____	____	_________	_________	__________
d. ____________________	____	____	_________	_________	__________

3. Other people living in the household: __________________________

4. What language (s) are spoken in the home? ___________

PRESCHOOL/CHILD CARE HISTORY

♦ Please list all forms of childcare and/or preschool experiences your child has had since birth:
(Please use the back of the survey if necessary)

a. Type __________________________
(e.g. small group home, relative, day care, preschool, etc.)

b. Dates attended (mm/yr) ___________ to ___________

c. Hours per week ______

----

a. Type __________________________

b. Dates attended (mm/yr) ___________ to ___________

c. Hours per week ______

----

a. Type __________________________

b. Dates attended (mm/yr) ___________ to ___________

c. Hours per week _____

----

a. Type ___________________________

b. Dates attended (mm/yr) ___________ to ___________

c. Hours per week _____

HEALTH AND OTHER INFORMATION

1. Is your child adopted? ☐ Yes ☐ No

2. Were there any significant problems during pregnancy? ☐ Yes ☐ No

a. If "Yes," please explain:

____

____

____

____

3. Was there anything unusual about your child's birth? ☐ Yes ☐ No

a. If "Yes," please check all that apply:

☐ Prematurity ☐ Low birth-weight ☐ Hypoxia ☐ Other _______________

4. Baby's birth weight: __________

5. Has your child had any of the following problems? (Please check all that apply)

☐ Hearing ☐ Speech ☐ Vision ☐ Convulsions/seizures

☐ Language ☐ Head injuries ☐ Frequent Ear infections ☐ Allergies

☐ Asthma ☐ Other (please specify) ________________________________

If any are checked, please give specifics ____

____

6. Is your child presently on any medications? ☐ Yes ☐ No

a. If "Yes," please describe:

____

____

7. To your knowledge, does your child have any emotional, social or other behavioral problems? ☐ Yes ☐ No

a. If "Yes," please specify ____
____

8. What is your child's height? __________ weight? ___________

9. How many glasses (4 oz) of each of the following beverages does your child consume per **day**? (check all beverages that apply)

		1-2	3-4	5-6	7 or more
a.	Milk	☐	☐	☐	☐
b.	Water	☐	☐	☐	☐
c.	Soda pop	☐	☐	☐	☐
d.	Fruit punch	☐	☐	☐	☐
e.	Fruit juice	☐	☐	☐	☐
f.	Other: _________	☐	☐	☐	☐

10. How many hours per **week** does your child spend participating in the following activities? (check all activities that apply)

	Less than 1	1-3	4-6	7-10	More than 10
a. Watching TV or playing computer/ video games	☐	☐	☐	☐	☐
b. Playing at home with toys (e.g. blocks, puzzles, cards) or crafts	☐	☐	☐	☐	☐
c. Playing outside with toys (e.g., tricycle, scooter, bicycle, wagon, etc.)	☐	☐	☐	☐	☐
d. Organized physical activity (e.g., gymboree, gymnastics, swimming, soccer)	☐	☐	☐	☐	☐
e. Organized music or art lessons	☐	☐	☐	☐	☐

f. Other organized activity (list all that apply)					
_________________	☐	☐	☐	☐	☐
_________________	☐	☐	☐	☐	☐
_________________	☐	☐	☐	☐	☐

11. My child asks permission before snacking between meals.

Not at all like my child	Slightly like my child	Somewhat like my child	A lot like my child	Very much like my child
1	*2*	*3*	*4*	*5*

12. What type of snacks is your child most likely to eat? (check three)

☐ Apple, oranges, banana, etc.
☐ Potato chips
☐ Popcorn
☐ Granola bars, breakfast bars, fruit snacks, etc.
☐ Cheese (or peanut butter) and crackers
☐ Ice cream
☐ Carrot sticks or other vegetables
☐ Whole grain cereal
☐ Sweet cereal
☐ Candy
☐ Other: ____________

13. How many times per **week** does your child have following food? (check all that apply)

		1-2	3-4	5-6	7 or more
a.	Fast food	☐	☐	☐	☐
b.	Frozen meals	☐	☐	☐	☐
c.	Pizza	☐	☐	☐	☐
d.	Chips	☐	☐	☐	☐
e.	Vegetables	☐	☐	☐	☐
f.	Fruits	☐	☐	☐	☐

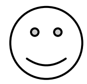
14. Are there any health concerns you would like to share with us about your child?

____

____

____

____

Thank you for providing this important information! 

Parent/guardian signature ____________________________________ Date ______________

APPENDIX F

FAMILY ID: ______________ DATE: _________________________________

The Week in the Life of Families Project

Parenting Questionnaire

1. I encourage my child to express his/her opinions.

Not at all like me	Slightly like me	Somewhat like me	A lot like me	Very much like me
1	2	3	4	5

2. How often do you read to your child?

Almost never	Every so often	1 to 3 times per week	4 to 6 times per week	Daily
1	2	3	4	5

3. How many hours per day does your child watch TV or videos?

Monday through Friday _____________ Saturday _____________ Sunday _____________

4. How important is it for your child to be honest?

Unimportant	Slightly important	Somewhat important	Fairly important	Very Important
1	2	3	4	5

5. How often do you read to yourself?

Almost never	Every so often	1 to 3 times per week	4 to 6 times per week	Daily
1	2	3	4	5

6. How often does your partner read to him/herself?

Almost never	Every so often	1 to 3 times per week	4 to 6 times per week	Daily
1	2	3	4	5

7. How often do you do math activities such as math workbooks or simple math problems with your child?

Almost never	Every so often	1 to 3 times per week	4 to 6 times per week	Daily
1	2	3	4	5

8. How critical is it for your child to obey you?

Not critical	Slightly critical	Somewhat critical	Fairly critical	Very critical
1	2	3	4	5

9. Approximately how many books does your child have? ________

10. I believe that it is as much my responsibility as the school's to help my child learn.

Not at all like me	Slightly like me	Somewhat like me	A lot like me	Very much like me
1	2	3	4	5

11. Suppose your child misbehaved and you felt he/she deserved a reprimand. Would you do it in public where someone else might hear?

Unlikely	Slightly likely	Somewhat likely	Fairly likely	Very likely
1	2	3	4	5

12. How important is it for your child to have good manners?

Unimportant	Slightly important	Somewhat important	Fairly important	Very Important
1	2	3	4	5

13. My child and I have warm, intimate moments together.

Not at all like us	Slightly like us	Somewhat like us	A lot like us	Very much like us
1	2	3	4	5

14. How many hours per day does your child use educational software on a computer?

Monday through Friday _____________ Saturday _____________ Sunday _____________

15. How many hours per day does your child play video or computer games?

Monday through Friday _____________ Saturday _____________ Sunday _____________

16. How often do you play number games such as "This Old Man" or "1, 2, Buckle My Shoe" with your child?

Almost never	Every so often	1 to 3 times per week	4 to 6 times per week	Daily
1	2	3	4	5

17. You pick your child up from school and the teacher mentions that your child has misbehaved. How likely are you to ignore it?

Unlikely	Slightly likely	Somewhat likely	Fairly likely	Very likely
1	2	3	4	5

18. I find it interesting and educational to spend time with my child.

Not at all like me	Slightly like me	Somewhat like me	A lot like me	Very much like me
1	2	3	4	5

19. I talk the problem over and reason with my child when he/she misbehaves.

Not at all like me	Slightly like me	Somewhat like me	A lot like me	Very much like me
1	2	3	4	5

20. How necessary is it for your child to have self-control?

Not necessary	Slightly necessary	Somewhat necessary	Fairly necessary	Very necessary
1	2	3	4	5

21. I typically ask my child how his/her day went.

Not at all like me	Slightly like me	Somewhat like me	A lot like me	Very much like me
1	2	3	4	5

22. Does anyone in your home have a library card? ___Yes ___No

If Yes, how often is it used? _____________

23. I encourage my child to be responsible (for example, putting away his/her toys, putting away his/her dishes after meals, etc.).

Not at all like me	Slightly like me	Somewhat like me	A lot like me	Very much like me
1	2	3	4	5

24. I am involved with my child's class (for example, volunteering in the classroom, going on field trips, etc.)

Not at all like me	Slightly like me	Somewhat like me	A lot like me	Very much like me
1	2	3	4	5

25. I encourage my child to talk to me about his/her feelings.

Not at all like me	Slightly like me	Somewhat like me	A lot like me	Very much like me
1	2	3	4	5

26. I never threaten to discipline my child unless I am sure I will carry it out.

Not at all like me	Slightly like me	Somewhat like me	A lot like me	Very much like me
1	2	3	4	5

27. It is important to me for my child to become a good student.

Not at all like me	Slightly like me	Somewhat like me	A lot like me	Very much like me
1	2	3	4	5

28. When a lot of time passes after my child misbehaves, I just let it go.

Not at all like me	Slightly like me	Somewhat like me	A lot like me	Very much like me
1	2	3	4	5

29. How frequently do you teach your child the names of letters of the alphabet?

Almost never	Every so often	1 to 3 times per week	4 to 6 times per week	Daily
1	2	3	4	5

30. How essential is it for your child to get along well with other children?

Not essential	Slightly essential	Somewhat essential	Fairly essential	Very essential
1	2	3	4	5

31. Does your family subscribe to newspapers/magazines? ___Yes ____No

If yes, Number of newspapers ___
Number of magazines ___
Number of child magazines ___

32. I yell or threaten punishment when my child misbehaves.

Not at all like me	Slightly like me	Somewhat like me	A lot like me	Very much like me
1	2	3	4	5

33. It is important to me for my child to be considerate of others.

Not at all like me	Slightly like me	Somewhat like me	A lot like me	Very much like me
1	2	3	4	5

34. I respect my child's opinion.

Not at all like me	Slightly like me	Somewhat like me	A lot like me	Very much like me
1	2	3	4	5

35. After arguing over toys, your child strikes a playmate. How likely are you to ignore it?

Unlikely	Slightly likely	Somewhat likely	Fairly likely	Very likely
1	2	3	4	5

36. I let my child know how ashamed and disappointed I am when he/she misbehaves.

Not at all like me	Slightly like me	Somewhat like me	A lot like me	Very much like me
1	2	3	4	5

37. Suppose your child misbehaved and you felt she/he deserved a reprimand. Would you do it when one of your child's friends could hear?

Unlikely	Slightly likely	Somewhat likely	Fairly likely	Very likely
1	2	3	4	5

38. How often do you math-related activities, such as connect-the-number pictures, mazes, and puzzles with your child?

Almost never	Every so often	1 to 3 times per week	4 to 6 times per week	Daily
1	2	3	4	5

39. I display my child's work and art in our home.

Not at all like me	Slightly like me	Somewhat like me	A lot like me	Very much like me
1	2	3	4	5

40. I encourage my child to explore and to question things.

Not at all like me	Slightly like me	Somewhat like me	A lot like me	Very much like me
1	2	3	4	5

41. How frequently do you teach your child letter sounds?

Almost never	Every so often	1 to 3 times per week	4 to 6 times per week	Daily
1	2	3	4	5

42. Suppose that you catch your child lying about something for the first time. How likely are you to ignore it?

Unlikely	Slightly likely	Somewhat likely	Fairly likely	Very likely
1	2	3	4	5

43. How frequently do you teach your child to read words?

Almost never	Every so often	1 to 3 times per week	4 to 6 times per week	Daily
1	2	3	4	5

44. Once I decide how to deal with a misbehavior, I follow through on it.

Not at all like me	Slightly like me	Somewhat like me	A lot like me	Very much like me
1	2	3	4	5

45. Who reads to your child at home? (Check all that apply)
You______________
Spouse ___________
Older sibling _________
Grandparent_____________
Other______________________

46. I have little or no difficulty sticking with rules for my child.

Not at all like me	Slightly like me	Somewhat like me	A lot like me	Very much like me
1	2	3	4	5

47. How frequently do you encourage your child to write?

Almost never	Every so often	1 to 3 times per week	4 to 6 times per week	Daily
1	2	3	4	5

48. How important it is for your child to be responsible?

Unimportant	Slightly important	Somewhat important	Fairly important	Very Important
1	2	3	4	5

49. Would you agree that if your child is successful academically, it is probably because . . .

	Strongly disagree	Disagree	Neither disagree or agree	Agree	Strongly agree
1. My child has a natural ability (i.e. he was born with this ability)	1	2	3	4	5
2. My child is well-liked by others	1	2	3	4	5
3. My child tries hard (i.e. works hard)	1	2	3	4	5
4. My child gets good teaching	1	2	3	4	5
5. The tasks are too easy for my child	1	2	3	4	5

50. If your child does NOT do well academically, it is probably because . . .

	Strongly disagree	Disagree	Neither disagree or agree	Agree	Strongly agree
1. My child lacks a natural ability (i.e. he was not born with this ability)	1	2	3	4	5
2. My child is not well-liked by others	1	2	3	4	5
3. My child does not try hard (i.e. does not work hard)	1	2	3	4	5
4. My child does not get good teaching	1	2	3	4	5
5. The tasks are too difficult for my child	1	2	3	4	5

51. How far in school do you expect your child to go? Would you say you expect him/her…

To receive less than a high school diploma	To graduate from high school	To attend two or more years of college	To finish a four-or five year college degree	To earn a master's degree or equivalent	To finish a PhD., MD, or other advanced degree
1	2	3	4	5	6

52. How often do you write or draw with your child at home?

Almost never	Every so often	1 to 3 times per week	4 to 6 times per week	Daily
1	2	3	4	5

53. How often do you take your child to the library?

Almost never	Every so often	1 to 3 times per week	4 to 6 times per week	Daily
1	2	3	4	5

54. How often do you play counting games at home with your child?

Almost never	Every so often	1 to 3 times per week	4 to 6 times per week	Daily
1	2	3	4	5

55. How often do you recite rhymes, jump rope chants, or songs with your child?

Almost never	Every so often	1 to 3 times per week	4 to 6 times per week	Daily
1	2	3	4	5

56. How often do you point out letters and words in the world around you (e.g., on signs, on food labels)?

Almost never	Every so often	1 to 3 times per week	4 to 6 times per week	Daily
1	2	3	4	5

57. How often do you invite your child to read (or pretend to read) to you?

Almost never	Every so often	1 to 3 times per week	4 to 6 times per week	Daily
1	2	3	4	5

58. How often do you play board games or card games with your child?

Almost never	Every so often	1 to 3 times per week	4 to 6 times per week	Daily
1	2	3	4	5

59. How often do you count objects with your child?

Almost never	Every so often	1 to 3 times per week	4 to 6 times per week	Daily
1	2	3	4	5

60. How often do you sort things by size, color, or shape with your child?

Almost never	Every so often	1 to 3 times per week	4 to 6 times per week	Daily
1	2	3	4	5

61. How often do you talk about money with your child when shopping (e.g. "which costs more?")?

Almost never	Every so often	1 to 3 times per week	4 to 6 times per week	Daily
1	2	3	4	5

62. How often do you measure ingredients with your child when cooking?

Almost never	Every so often	1 to 3 times per week	4 to 6 times per week	Daily
1	2	3	4	5

63. How often do you play with calculators with your child?

Almost never	Every so often	1 to 3 times per week	4 to 6 times per week	Daily
1	2	3	4	5

64. How often do you use calendars and dates with your child?

Almost never	Every so often	1 to 3 times per week	4 to 6 times per week	Daily
1	2	3	4	5

65. How often do you have your child wear a watch?

Almost never	Every so often	1 to 3 times per week	4 to 6 times per week	Daily
1	2	3	4	5

66. How often do you engage with your child in identifying written numbers?

Almost never	Every so often	1 to 3 times per week	4 to 6 times per week	Daily
1	2	3	4	5

67. How often do you engage with your child in printing numbers?

Almost never	Every so often	1 to 3 times per week	4 to 6 times per week	Daily
1	2	3	4	5

68. I find math activities enjoyable.

Not at all like me	Slightly like me	Somewhat like me	A lot like me	Very much like me
1	2	3	4	5

69. I find reading enjoyable.

Not at all like me	Slightly like me	Somewhat like me	A lot like me	Very much like me
1	2	3	4	5

70. I believe that literacy activities are more important than numeracy activities for young children.

Not at all like me	Slightly like me	Somewhat like me	A lot like me	Very much like me
1	2	3	4	5

71. I believe that it is important for caregivers to focus on math skills in young children.

Not at all like me	Slightly like me	Somewhat like me	A lot like me	Very much like me
1	2	3	4	5

72. Does your child have puzzles at home? ____Yes____No

If yes, roughly how many?_______

73. Do you have clocks in the house? _____Yes_____No

If yes, how many? _______

74. Do you have calendars in the house?_____Yes_____No

If yes, how many? _______

75. Do you have a scale in your home? ____Yes_____No

If yes, does your child weigh himself? ____

76. Do you have number magnets in your house? _____Yes_____No

77. Do you or your child have a piggy bank, coin box, or something similar?___Yes___No

78. Do you have a thermometer or a thermostat in your home? _____Yes____No

79. Does your family have calculators in the home?____Yes____No

80. Does your family have measuring tapes in the home? ____Yes_____No

81. Do you have tools or a tool set in your home? _____Yes_____No

82. Does your family have a computer?____Yes____No

83. Does your family have blocks that your child plays with? _____Yes_____No

84. Does your family have cookie cutters? ____Yes_____No

85. Do you have rulers or yard sticks in your house? ____Yes_____No

Thank you very much for completing this questionnaire!

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