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Mom, Dad, Help Please: The Home Environment's Influences on a Child's Math Ability

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Submitted to

Professor Kanaya Tomoe

By

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For

Senior Thesis

Spring 2017

April 24th, 2017

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Abstract

Recently, there has been a big surge of research and public interest in increasing the math capabilities and skills of American children. This paper serves as a literature review examining how the home environment, specifically parents, can help with that. This meta-analysis delves into the factors of maternal math talk, a parent's own math anxiety, and the relationship between a parent and child in the context of a parent's gender stereotypes and a parent's perception on his or her child's math abilities. Interventions, suggestions, and future implications are also discussed. This paper will hopefully bring needed awareness to parents about their roles in their child's math development, abilities, and achievement.

Keywords: math, parents, children, home, math anxiety, math talk, gender stereotypes

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Introduction

Although the classroom is usually viewed as the primary vehicle for advancing academic achievement, parents also play an important role in students' academic success (Eccles, 2007). Parent involvement has long been recognized as a positive factor in student academic and social growth (Christenson, Rounds, & Gorney, 1992; Hoover-Dempsey & Sandler, 1995; Jeynes, 2005). Current research suggests that parent involvement through its influence on student beliefs and behaviors may make an important contribution that leads to achievement (Walker & Hoover-Dempsey, 2006). When parents find significant ways to participate in schooling, they model for their children the importance of their education and help bring together the cultures of home and school.

For many families, stories and reading are a regular part of a child's home routine. Indeed, many teachers and the media promote parent involvement when it comes to reading and literacy development, especially with English language learners (Peercy, Martin-Beltran, & Daniel, 2013). Parents are motivated to read to their children because they believe this activity promotes children's school achievement and reading development, and literacy help seems to be viewed as natural and normal in the eyes of parents. Even though reading is important and vital to a student' education, there seems to be less attention and focus on supporting children's math learning at home. A widely held belief among parents is that children's math education is primarily the responsibility of schools and that their role in supporting their children's math learning is not as important as their role in supporting their children's reading (Cannon & Ginsburg, 2008).

Math has become more important in today's current education system as there has been a recent push in education reform with the introduction of Common Core due to the 2015 PISA results. The Organization for Economic Cooperation and Development (OECD) conducts global rankings on student performance in mathematics, reading, and science with a worldwide exam called the Program for International Student Assessment, or PISA. PISA is administered every three years and about 540,000 15-year old students from 72 different countries took the exam in 2015. When looking at a comparable sample of countries that participated in the PISA exam in both 2012 and 2015, the US ranking fell from 25th to 38th in math, underperforming at the OECD average (Jackson & Kiersz, 2016). Scores were relatively unchanged in reading and science compared to 2012 with a decrease of one point in each, and the US performed better than the OECD average in both subjects with US rankings of 24 and 25 respectively (Jackson & Kiersz, 2016). See Figure 1 for the average scores on the 2015 PISA by country in mathematics, reading, and science.

American students performing poorly in mathematical areas can be quite frightening as math is highly important to the development of children and for future success. Studies have shown that math achievement positively relates to future economic stability and wealth. Children with higher math scores tend to be in higher income brackets, own savings accounts, and are more financially stable (Elliot, Jung, & Friedline, 2010). Math has real world application as well as nearly every profession uses some form of math, and math is needed to perform many different daily tasks, such as telling time, reading an odometer, counting change, and making decisions in one's work life. An engaging and encouraging climate for children's early encounters with mathematics

develops their confidence in their ability to understand and use mathematics. These positive experiences help children to develop dispositions, such as curiosity, imagination, flexibility, inventiveness, and persistence, and contribute to their future success in and out of school (Clements & Conference Working Group, 2004). From their earliest encounters, children explore the abstractions of mathematics. Toddlers and young children develop the skills and concepts of pattern, sequence, seriation, spatial relationships, object permanence, sorting, comparing, classifying, and one-to-one correspondence (Davis & Keller, 2009). These are all important to the brain development of a child and to building a foundation of logical thinking. For example, an important mathematical concept that infants develop is pattern, which is an underlying theme of all mathematics and science. It is our ability to discover and recognize patterns that help us understand how our world works in logical and predictable ways. Experiences with observing and making sense of patterns are what helps young children develop a sense of order, logic, and reason.

With American students performing so poorly in mathematics and the importance of mathematics, there needs to be a push and focus on improving the mathematical abilities of children. This may start with educational reform and a new system of teaching, but parents and the home environment can help children as well; however, parent involvement with their child's math is more complicated than reading. Society tends to encourage parents to readily be available and help their children in terms of literacy by reading to them, especially at early ages, but there tends to be no such emphasis for parental math involvement. The schools and media focus on the needs of the parents to interact with their children relating to language and reading, leaving math

education to the responsibility of schools and not parents (Duursma, Augustyn, & Zuckerman, 2008). This ignores the fact that math input in the home is an important predictor of children's mathematical success (Levine, Suriyakham, Rowe, Huttenlocker, & Gunderson, 2011).

This paper is a comprehensive synthesis that outlines previous research conducted on the issues of the home environment and its influences on a child's math ability, perceptions, and math anxiety. Specifically, this paper examines the effects of maternal math talk, parent's math anxiety, and the relationship between parent and child. Chapter one specifically focuses on the aspects and influences maternal math talk has on a child when he or she is preschool-age or younger. Maternal math talk is the focus rather than paternal math talk because there has been significantly more research conducted on maternal math talk. Children develop math concepts and skills very early in life, and from the moment they are born, babies begin to form ideas about math through everyday experiences and through interactions involving the use of language with trusted adults (Greenberg, 2012). There tends to be more primary caregivers that are mothers for these children at younger ages because of stereotypical female roles of stay-at-home moms, an increase of stay-at-home moms, and the availability and longer length of maternal leave compared to paternal leave (Howard, Martin, Berlin, & Brooks-Gunn, 2011). Chapter two takes a closer look into a parent's math anxiety and how this may affect a child's own math achievements and math anxiety. Chapter three examines the relationship between parent and child by addressing the possible effects of a parent's perception on the child's math abilities, a parent's gender stereotypes, and parental-gender relationships. Chapter four offers some ideas and techniques that parents can utilize in the

home. Hopefully, this will help increase the math achievements, confidence, and abilities of children.

Chapter 1:

Maternal Math Talk

Math talk is the mathematical input that children hear from their primary caregivers at home. The home numeracy environments, particularly parent math talk, are predictive of children's early math development, and both formal and informal math learning activities have been linked to children's math knowledge. Before they even enter a formal school setting, children and their parents are involved in a variety of math-related exchanges, but the amount and type of math exchanges vary by the data collection methods. Studies that utilize experimental situations or structured observations show a wider range of math-related exchanges than studies using other methodologies, such as self-report questionnaires and interviews. For example, observations of parent-child interactions in the activities of cooking, reading, and playing with money highlight math interactions related to buying or selling goods as well as conceptual and procedural understandings of math. (Vandermaas-Peeler, Boomgarden, Finn, & Pittard, 2012; Vandermaas-Peeler, Nelson, Bumpass, & Sassine, 2009). Based off research that comes from self-report questionnaires, parents fail to recognize that some activities they participate in, such as the one described above, do include math. Instead, parents report a limited range of actions, mainly focusing on foundational skills, such as counting, naming numbers, and teaching numbers (Cannon & Ginsburg, 2008; Skwarchuk, 2009). This means that many parents view math talk and interactions as merely occurring when teaching their children foundational skills; however, observational studies show that other activities with different goals besides learning math also involve and influence a child's

math ability. These different methodologies and collection methods help show that there are two different types of maternal math talk: formal and informal.

Formal Maternal Math Talk

Formal maternal math talk is all activities in which mothers are actively trying to teach their children the fundamental math concepts and skills. Their goals are to increase the child's math abilities. These activities are the traditional and typical interactions that people imagine when they hear parents trying to teach their children math, such as counting, naming numbers, and using mathematical operations. Most of the research in activities with formal maternal math talk has been conducted in structured settings in order to identify what activities best increase a child's mathematical ability. The specific and best activities are suggested in Chapter 4: Interventions and Techniques.

Unsurprisingly, the math-related verbal input from formal maternal math talk that children receive at home before kindergarten is a positive predictor of early numerical knowledge and performance in early math tasks (Levine et al., 2010; Ramani, Rowe, Eason, & Leech, 2015). The amount of maternal math talk in counting numbers from 1 to 10 with children between 14 and 30 months has been found to be related to children's early mathematical understanding of the cardinal meaning of number words (Levine et al., 2010). Besides the amount of maternal math talk, the quality is also linked to early numerical knowledge. Ramani and colleagues (2015) found that advanced math talk and activities, such as math talk involving cardinality, ordinal relations, and arithmetic, is linked to preschoolers' understandings of numerical knowledge and comparison. Gunderson and Levine (2011) found that math talk involving large sets of objects and

grouping activities predicted children's cardinal number knowledge, increasing the child's knowledge as the amount of grouping activities increased.

In addition, Ramani et al. (2015) investigated parent and child talk about fractions and numbers during didactic and playful math activities as well as guided versus unguided play context. The study tested whether didactic instruction, guided play, or unguided play would increase a child's math ability when participating in an activity intended to promote understanding of fractions. Dyads in the more structured didactic instruction had greater proportions of and more diverse math talk than those in the playful math contexts. Within the playful math contexts, parents and children in the guided play also used a greater proportion of and more diverse math talk than dyads in the unguided play. All the children that participated in the activity intended to promote understanding of fractions did have an increase in fraction knowledge when compared to children who did not participate. Together, the results of these studies indicate that children who are exposed to formal maternal math talk and more advanced math talk at home have better mathematical knowledge and skills when entering the school system.

Informal Maternal Math Talk

Informal maternal math talk can be considered any activity in which the immediate goal is not increasing the child's mathematical knowledge and skill. Instead, math is informally and naturally used. Some examples of these activities would be asking the time, the use of numerical words, such as "you can go play after you finish all *three* carrots," questioning to pronouncing certain mathematical numbers, and air-writing numbers. Most of the research that has been conducted on informal maternal math talk and its effects have been managed in short term observations of free play, parental

reports, and naturalistic observations (Vandermaas Peeler et al., 2009, 2012; LeFevre et al., 2009; Tudge & Doucet, 2004).

One of the easiest ways to observe maternal math talk in the natural home setting would be during meal time. The mealtime context is advantageous for learning social and cultural rules as well as engaging in explanations and narratives that foster language and literacy skills (Snow, Perlmann, Gleason, & Hooshyar, 1990; Snow & Beals, 2006). These complex interactions between parent and child that occur during mealtimes caused many researchers to focus on observational studies of maternal math talk during this time.

Two studies conducted by Susperreguy and Davis-Kean (2015; 2016) examined the natural conversations and interactions a mother had with her child during meal times, specifically breakfast and dinner. For their studies, math talk included interactions and discussions about numbers, geometrical shapes, quantities, and other mathematical aspects. The different uses of math were coded into the following specific types of math talk: *naming numbers* (i.e., referring to a specific number of objects without counting), *ordinal numbers, adding/subtracting, counting, dates, naming geometrical shapes, number games or songs, number recognition and writing*, and *time* (Susperreguy & Davis-Kean, 2015, 2016). See figure 2 for the frequency and type of math talk that occurred during meal times, and see figure 3 for the coding of such math interactions.

The results of these studies reveal interesting differences in the amount of math talk that mothers and children produce in a naturalistic and uncontrived setting of shared mealtime. Even though all mothers socialized math through the language they used with their children, the quantity and quality of their math talk varied greatly. Depending on the race of the family and the particular mealtime, there were differences in the range of the

total amount of math talk per hour coded between and within families. Despite these differences, the analysis of the nature of these math discussions showed that on average, mothers and children engaged in specific types of maternal math talk at similar rates. The two most common types of maternal math talk were naming numbers (ranging from 37% to 47% of the input) and counting (ranging from 12% to 22%). The rest of the maternal math talk mainly consisted of dialogues that included references to time, ordinal numbers, or number games. There were only a few instances of math talk that included geometrical shapes, dates, and number operations, such as adding or subtracting. These results are consistent with other research showing that by the time they start schooling, children are exposed to math in many different ways through informal contexts (Ginsburg & Russel, 1981; Song & Ginsburg, 1987). As expected, the results of these studies also found that maternal math talk is related to children's math knowledge a year later. This means that a mother's input involving informal math talk played a role in the child's mathematical knowledge a year after its occurrence. Mothers who produced math talk occurrences more often had children who performed better in tasks involving number facts, number comparisons, calculations, and understandings of concepts.

Interestingly, most of the mothers in these studies had very few to no exchanges involving calculations or number comparisons with their children. This suggests that these interactions might be uncommon in maternal input in the context of mealtimes. The possible reason for this might be that mothers are not focused on adding or subtracting during mealtimes because these are not instructional or teaching times. Instead, mothers use numbers as a means of communicating information about the meals themselves. For example, they say "Do you want *two* slices of bread?" or "You need to eat *three* pieces of

broccoli before you leave the table" (Susperreguy & Davis-Kean, 2016). The conversations analyzed in these studies do not intend to represent a complete register of math interactions in the home, but rather the maternal math talk that occurs during these particular cultural settings and mealtimes.

Chapter 2:

Math Anxiety

Many people have a fear of math, termed *math anxiety*, and it tends to lead to decreased math achievement (Ashcraft 2002; Maloney & Beilock, 2012). Classroom and laboratory studies have revealed a great deal about the link between an individual's math anxiety and his or her math performance. Specifically for American children, studies show that as a child's math anxiety increases, his or her math performance tends to decrease (Lee, 2009). Some research has shown that one person's negative emotional responses toward math and one's math anxiety might relate to someone else's math achievement, attitudes, and anxiety. For example, having a math-anxious parent or teacher might affect a child's mathematical success and math anxiety (Beilock, Gunderson, Ramirez, & Levine, 2010; Maloney, Ramirez, Gunderson, Levine, & Beilock, 2015). Children may turn to their parents for math help, teachers may ask parents to work with their children on homework, or both may occur. Either way, a parent will most likely at one point interact with their child in regards to math, so the amount of math anxiety a parent may have can negatively affect a child's math ability and anxiety.

Research has shown if parents are math anxious, their help could backfire, negatively affecting their children's math learning and attitudes. This is somewhat counterintuitive given that parent involvement in homework is generally believed to have positive effects on children's academic achievements; however, this positive relationship of parental homework help and improved child achievement holds truer for verbal subject matter than for mathematics (Robinson & Harrison, 2014). Parents' help on math

homework is sometimes negatively linked with students' math achievement (Patall, Cooper, & Robinson, 2008; Robinson & Harris, 2014).

Most studies that researched a parents' math anxiety and its effects on their children focused on early elementary school aged children because math anxiety can occur as early as first grade, and its negative effects on academic achievement can be seen (Ramirez, Gunderson, Levine, & Beilock, 2013). In addition, those elementary students who start behind their peers in math skills tend to stay behind throughout schooling (Cross, Woods, Schweingruber, 2009; Duncan et al., 2007). In one study, Maloney et al. (2015) demonstrated that parents' math anxiety was linked to their children's math achievement and math anxiety by showing how intergenerational effects of low math achievement and high math anxiety unfolded. They demonstrated that parents' math anxiety is negatively related to their children's math learning across the school year, but only when parents frequently help their child with math homework. The negative impact of homework help by highly math-anxious parents was only specific to children's math achievement and not for children's reading achievement. They further showed that this effect persists even after controlling for parents' math knowledge and for school-level factors (i.e., teachers' math anxiety and math knowledge, and school-level SES). When parents have a poor relation with math, experience math anxiety, and frequently help their children with his or her homework, their children learn less math and tend to develop math anxiety.

A parents' math knowledge does not affect a child's math ability. One reason could be that the math children learn in early elementary school is relatively easy (e.g., adding and subtracting; working with basic shapes, time, and money), and most parents

are likely competent in these basic skills and concepts. Despite most parents being capable of doing this type of basic math that elementary school-aged children encounter, their competence does not prevent them from having feelings of anxiety when faced with their children's math homework. A case in point is that even reading aloud simple math problems can be anxiety inducing for highly math-anxious adults (Ashcraft & Ridley, 2005).

A parent's math anxiety negatively effects not only their children's current math achievement and attitudes toward math, but also their opinions on math and math skills later in life. Previous research has shown that individuals with high math anxiety often express a variety of poor attitudes about math. They tend to believe that math is not useful and have low math self-efficacy and low motivation to succeed in math (Hembree, 1990). Expressing these negative beliefs and attitudes toward math could be de-motivating to children, likely reducing the amount of effort they invest in math and reducing the amount of math they learn and remember. As a result of learning less math and starting to develop these same negative feelings toward math, these children may then begin to have and increase their math anxieties. In addition, children can sense when their parents experience math anxiety and discomfort during homework help, which leads them to believing that math should produce these feelings of unpleasantness in them when doing math. The fact that this relationship between a parent's math anxiety and their child's performance is present during the early elementary school grades is consistent with the possibility that the math homework help provided by math-anxious parents may play an important but negative role in children's early math achievement,

math anxiety, and in their long-term academic-achievement trajectories (Duncan et al., 2007).

Chapter 3:

Relationship between Parent and Child

Parents' relationship with their child and their own personal beliefs and attitudes affect and shape many aspects of the child's life, including academics, social values, moral values, worldly views, etc. Parsons, Adler, and Kaczala (1982) introduced the expectancy-value theory (EVT) of academic motivation, which points at parents as a major environmental influence on the development of children's self-perception of ability in different academic domains. EVT states that in domains commonly stereotyped as masculine or feminine (such as math, language, sports, and social abilities), parents' stereotypical beliefs about males and females influence their children's individual characteristics (e.g., temperament, personality traits, talents, gender, etc.). Parents' beliefs affect children's self-perception of ability, and this effect is mediated by children's subjective perception of parents' beliefs (Eccles, 2011; Wigifield & Eccles, 2000). How can a parent's belief about and the interactions with their child affect a child's math ability and attitudes?

As mentioned before, a recent study found that a female teacher's math anxiety impacted early elementary school girls', but not boys', math achievements and attitudes (Beilock et al., 2010). Girls whose teachers had higher math anxiety had lower math grades and learned less content at the end of the year compared to girls whose teachers had lower math anxiety. It seems that math-anxious teachers reinforced math gender stereotypes.

A great deal of research focuses on the transmission of math gender stereotypes from parents to children, and how these stereotypes influence children's achievement

outcomes. Casad, Hale, and Wachs (2015) examined the gender of parents in their transmission of their math gender stereotypes, math attitudes, and math anxiety. When both mothers' and daughters' math anxieties were low, daughters had more positive math outcomes compared to when mothers' and daughters' math anxieties were both high. For the cases when both mothers' and daughters' math anxieties were high, daughters had more negative math outcomes. For the father-son dyad, when both fathers and sons had lower math anxiety, math GPA was higher. Even when fathers' math anxiety was high, if the son had low math anxiety, GPA remained higher. A son's GPA was lower only when both father and son had high math anxiety. For the father-daughter dyad, fathers with lower math anxiety and daughters also low in anxiety had less math devaluing than daughters higher in anxiety. For the mother-son dyad, sons with lower math anxiety had more positive math attitudes than sons with higher math anxiety, and this relationship was strongest when mothers had high anxiety.

Tomasetto, Mirisola, Galdi, and Cadinu (2015) showed that both mothers' and fathers' evaluations of their child's math ability were related to children's own self-view. These results are consistent with previous findings that in the earliest elementary school grades, children mostly rely on their parents as interpreters of external feedbacks on their academic performance (Frome & Eccles, 1998). In line with a wealth of previous findings (e.g., Bouffard, Markovits, Vezeau, Boisvert, & Dumas, 1998), a child's self-view appears very early in the school track and is related to information provided by both parents. Also, the study found that a mothers' and fathers' math gender stereotypes negatively affected a daughters' self-perception of her math ability, but this did not affect sons. Girls' self-views varied as a function of the extent to which their parents endorsed

the belief that math is a masculine domain, meaning a girl's self-view and abilities were worsened when either the mother or father projected directly or indirectly the belief that math is for boys.

O'Bryan, Fishbein, and Ritchey (2004) also support the same-gender dyad model that mothers communicate math gender stereotypes to their daughters, which subsequently predicts daughters' academic and career choices, even several years later (Bleeker & Jacobs, 2004). For example, if mothers endorse the math gender stereotype that men are superior to women in math, they may communicate this belief (intentionally or unintentionally) to their daughters, who then may show less interest in math and choose other academic and career domains. Indeed, girls' and women's choices of academic and career trajectories is one explanation for the underrepresentation of women in STEM, rather than a lack of ability explanation (Wang & Degol, 2013).

Overall, a parent's relationship with their child and views towards math does affect their child's own self-beliefs, math anxiety, math achievement and abilities. For the most part, a mother's or father's idea on typical math gender stereotypes does negatively affect only daughters, but not sons. Also, a father's high math anxiety only negatively affects his son when the son has high math anxiety and always affects his daughter. When the father has a negative impact caused by his math anxiety, the child has lower math achievements and abilities. A mother's high math anxiety only affects her son if he too has high anxiety already and does so by negatively changing his attitudes. For daughters, a mother's high math anxiety will cause them to become more anxious, begin to hold negative attitudes about math, and have lower math achievements. No matter the gender of the parent, if they hold negative beliefs about their child's math abilities, their child

will develop negative beliefs about his or her own abilities, which will adversely impact the child's future math achievements and anxiety.

Possible explanations behind the negative effects associated with parental math anxieties and their ideas on their children's abilities and gender stereotypes are gender role socialization and strong parental relationships. During development, daughters may be more likely to pick up on their mother's math anxiety than their father's; sons will pick up their father's math anxiety more than their mother's. This may occur because gender role socialization most commonly occurs with same-gender caregivers (Bussey & Bandura, 1984). This would explain why the same-gender parents may influence their daughter or son more. For example, a mother's high anxiety greatly, negatively affects daughters more than sons. Of course, there are children who strongly identify with other-gender parents and may more quickly adopt their beliefs, values, and attitudes (e.g., daddy's girl or mama's boy; Gniewosz and Noack, 2012). This could explain why different gendered parents and children can still affect one another.

Chapter 4:

Interventions and Techniques

Knowing what factors in the home environment can affect and influence a child's math ability is important and a good first step to improving math proficiency, but this information is pointless unless there are interventions and techniques that can be implemented. All of these techniques suggested here have been successful for some parents, but other parents using these strategies may get different results as each child, parent, and home environment is unique.

Maternal Math Talk

The easiest way for mothers to be more involved and increase their child's math abilities would be to simply incorporate maternal math talk. Previous studies have shown that utilizing informal or formal math talk will greatly increase the child's conceptual understandings of math. With formal and more advanced math talk, mothers will be able to specialize and focus on particular concepts, such as fractions and counting. When using formal maternal math talk with younger kids, around the age of preschoolers and younger, it is more crucial to focus on activities that are within their intellectual capacity; however, parents should be aware that educators with higher academic expectations for children report that they are involved in more learning activities outcomes than colleagues with lower expectations (LeFevre, 2009). Some activities are, but not limited to, grouping activities, nominal counting, comparing activities, identifying coins, counting money, and printing and reading numbers.

One key component of mathematics for early childhood that children should develop is numeracy. Numeracy has been defined as a proficiency which is developed

mainly in mathematics, is more than a basic ability to do arithmetic, and involves developing confidence and competence with numbers. It requires understanding of the number system, a repertoire of mathematical techniques, and an inclination and ability to solve quantitative or spatial problems. Numeracy also contains ways in which data are gathered by counting and measuring, and presented in graphs, diagrams, charts and tables'' (National Numeracy Strategy, 2009). Many educators believe that developing a strong foundation for numeracy is essential to later math achievement. Skwarchuk (2009) found that parents who focused on complex outcomes, such as printing numbers, playing with money, comparing, etc. had children with higher math scores, while those who focused on basic outcomes, such as operations, had children with lower math scores. Thus, early exposure to activities with a direct, complex mathematical focus (going beyond counting) may be key to enhancing numeracy, and thus, leading to better math academic achievement. It is best as the preschool age and younger to simply start a foundation of understanding the cardinality of numbers and helping increasing numeracy through using complex, formal activities and maternal math talk.

When working with children of the elementary school age, mothers can begin to incorporate more advanced math talk that is designed for specific concepts. The goals with these activities are to focus on increasing the child's numerical knowledge, comparison skills, number facts, and calculation. There are a variety of different forms and ways a mother can incorporate formal math talk when working with elementary and preschool aged children. Mothers can work one-on-one with their children utilizing worksheets and programs specifically designed to work on certain math concepts. There is also the choice of having the child work individually through guided or unguided play

with the difference being that guided play comes with more instructions and specificity. Interestingly, Ramani's et al. study (2015) showed that there is only a slight, statistically non-significant increase in the improvement of a child's fractional math ability between guided and unguided play. There was no difference between guided and dyad play. This implies that the there is no real difference in improving a child's math ability when it comes to which method of formal maternal math talk one uses. When choosing between dyadic, guided, or unguided play, mothers should not worry as long as they still incorporate some form of formal maternal math talk.

Most forms of informal maternal math talk will occur when the child is preschool aged and younger. As expected, the amount of informal maternal math talk directly predicts the child's improvements in tasks involving number facts, number comparison, calculation, and understanding of concepts. Interestingly, Ramani et al. (2015) found that the frequency of engaging in number-related activities using informal maternal math talk predicted children's foundational numerical knowledge, such as counting and identifying numbers. On the other hand, the quality of the caregiver–child interaction in terms of the math talk used while engaging in number activities predicted children's advanced numerical knowledge, such as cardinality. Parents can incorporate more and higher qualities of informal maternal math talk by playing board games, card games, and computer games that are related to children's foundational numerical knowledge; however, the nature of these games can differ greatly. Some informal number activities, such as number board games or card games, may be better at promoting numerical knowledge than other games, such as those involving letters or colors. Also, increasing the frequency of maternal informal math talk about shape and spatial features of objects,

such as using words like circle, tall, edge and corner, can help increase a child's special thinking, which is an important component to mathematical success (Pruden, Levine, & Huttenlocher, 2011; Verdine, Irwin, Golinkoff, & Hirsh-Pasek, 2014). When it comes to the informal maternal math talk, parents can increase their preschool aged or younger children's foundational numerical knowledge through increased frequency of informal maternal math talk and can increase advanced numerical knowledge by using higher quality versions of informal maternal math talk.

Consequently, efforts should be placed on providing parents with some instruction as to how to get their children involved in math talk at home. Families can be targeted and given tools to improve their children's math performance. Cannon and Ginsburg (2008) suggest that parents use their daily activities to think about math with their children. Talking about math during mealtimes could be used as an opportunity to engage parents and young children in math as a means of promoting early math skills. Indeed, mealtimes offer a scenario to encourage children to not only use math words, but also engage in cognitively stimulating conversations around math, ask questions about math concepts, and participate in problem-solving activities that involve math (Ginsburg et al., 1981). Some examples of informal maternal math talk would be asking the time, the use of numerical words, such as "you can go play after you finish all three carrots," questioning to what certain words say and how you would air-write or spell them. An example of asking for calculations would be "You have seven peas. If you eat two, how much will you have now?"

Giving examples and guidance to parents on how to talk about math while preparing meals, setting the table, serving the food, and clearing the table could be a

fruitful avenue for engaging preschoolers in math. This can be done, for example, by discussing specific examples in meetings or parent–teacher conferences or by sending home newsletters with detailed discussions of how to use conversations during mealtimes to engage in math talk. Parents can encourage their children's math skills in everyday situations (Cannon & Ginsburg, 2008) when they are provided with knowledge of specific activities and guidance on how to talk about math and how to capitalize on what their children are doing or saying during mealtimes (Vandermaas-Peeler et al., 2012). These enrichment activities include taking classes, using a computer, playing with blocks/Legos, helping with meals, etc. (Sonnenschein & Galindo, 2015).

In both the formal and informal settings, mothers who produced math talk occurrences more often had children who performed better in tasks involving number facts, number comparison, calculation, and understanding of concepts; however, it would be interesting to investigate how not only mothers, but also fathers talk about math at home. Research with toddlers, for example, has found that mothers and fathers engage in different degrees of cognitively demanding questions with their children described the fact that fathers produce more "why" questions than mothers and that children talked more, used more diverse vocabulary, and produced longer utterances when talking with fathers compared to mothers (Rowe, Coker, & Pan, 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 conclusive evidence to date regarding fathers' math talk and the quantity and quality of math words that they produce with their preschoolers. Moreover, differences in math talk could also depend on the number of

children in the home or on whether one of the children has school-related math homework.

In conclusion, math talk is highly beneficial to children when it comes to increasing their math knowledge and abilities. With younger children, there is no difference between informal and formal maternal math talk; however, as a child gets older (past the preschool years), parents should utilize more formal methods. This is almost natural to occur as informal maternal math talk occurs more during mealtime and playtime settings and are more about building foundational concepts, such as cardinality, in nature compared to building math skills, such as mathematical operations. When a mother is utilizing formal math talk, it does not matter when deciding between guided, didactic, or unguided play for children under the pre-school years, but mothers should utilize more complex activities and maternal math talk that are designed to increase numeracy and foundational concepts. As a child gets older, the more guided and didactic play the better. Although with older children, parents should be aware that helping or interacting with their child through math may negatively affect his or her performance, anxiety, and perceptions about math depending on which parent helps.

Specific examples of formal math talk would be questions and activities designed to increase the child's skills and abilities, such as computation questions. On the other hand, informal talk would be natural and mainly increasing the child's math concepts, such as saying numbers to describe groups of items. For practice and more information about utilizing maternal math talk, the school system needs to give examples, tools, and tips to parents as well as raise parental awareness of opportunities to support and encourage mathematics in activities at home.

Math Anxiety

A consistent message that parents receive from teachers and schools is that their involvement in their children's academics is an important factor predicting their children's school success; however, in the absence of positive math attitudes, parents' homework involvement, though well-intentioned, may backfire. It may negatively affect children's math growth across the school year and, in turn, children's math anxiety. Parents who suffer from math anxiety may have good intentions, but their homework help may backfire, decreasing children's math learning and increasing children's math anxiety across the school year.

Research showing the importance of parents' math attitudes in their children's mathematical achievement suggests that many parents need support to effectively help their children succeed in math. The fact that parents' math anxiety negatively affected children only when they frequently helped them with math homework points to the need for interventions focused on both decreasing parents' math anxiety and scaffolding their skills in homework help (Maloney et al., 2015; Ramirez et al., 2013). While a conservative interpretation of these data would be that parents who are anxious about math simply should not help their children with math homework, another approach is to provide parents with tools to successfully help their children with math homework or to lower the parents' own math anxieties. Schools and teachers providing parents with ways to help reduce math anxiety would be most helpful as some children may have both of their parents experiencing math anxiety, while other children may only be able to receive homework help from the parent that has math anxiety.

If both parents experience math anxiety, then it is still better to have the parents help with homework and perform math related activities rather than no homework help at all. Fortunately, adults' math anxiety can be changed, so parents who experience math anxiety, but still want to help their children with math homework, may use a variety of techniques to reduce their math anxiety. Studies have shown that taking curricular math classes and counseling interventions, such as therapy groups, can help reduce one's math anxiety (Hendel & Davis, 1978). Also, individuals can choose to receive counseling from therapists utilizing the acceptance and commitment theory (ACT) and systematic desensitization (Zettle, 2013). Both types of counseling require the participant to face and recognize their anxiety, take steps to try and relax, and develop and utilize a coping method. ACT and systematic desensitization were both administered individually to parents in Zettle's study, but other studies have shown that systematic desensitization could be effective in group settings (Suinn, Edie, & Spinelli, 1970), and is the most common behavioral treatment mode (Hembree, 1990).

A quick way to lower math anxiety without having to spend money for classes or therapy could be writing about one's worries and anxiety before helping and working with children on math. Park, Ramirez, and Beilock (2014) demonstrated the benefits of expressive writing by having highly test anxious high school students write about their worries prior to an upcoming final exam, which boosted their scores from B– to B+ (even after considering grades across the school year). One possibility for the effectiveness of expressive writing could be that it helps individuals distance themselves from the immediate source of stress.

Overall, parents who wish to decrease their math anxiety in order to best help their children with math homework have a variety of ways to do so. Individuals can choose to participate in curricular math classes, expressive writing, and counseling interventions, such as ACT and systematic desensitization. If decreasing parents' math anxiety can also translate into more effective homework help, then this help could increase math achievement and decrease math anxiety in their children (Vukovic, Roberts, & Wright, 2013). .

Another way to reduce a parent's math anxiety and still increase a child's math achievement while having that parent-child interaction would be the use of an app called Bedtime Math, which is available for free on iTunes and Android. In Berkowitz's et al. study (2015), they had children and their parents read topical math passages and answer corresponding math questions, delivered by the app several times per week over the course of the school year. The study found that the more times parents and their children used the app, ranging from 0 to 6 times per week, the higher the children's math achievement improved by the end of the school year. More importantly, when math anxious parents and their children interact about math story problems—even as little as once a week—children show increased math achievement by the end of the school year. This significant increase may occur because the math app provides parents with math anxiety an opportunity to talk to their child about math in engaging and effective ways, supporting the kind of math conversations they most likely would not otherwise have. By providing an engaging way for math anxious parents to share math with their children, the math app may help cut the link between parents' high math anxiety and children's low math achievement. Also, the math app is great for improving many different aspects

of math as its questions covered topics such as counting fluency, geometry, arithmetic, fractions, and probability.

Overall, this math app called Bedtime Math could be the key for math anxious parents. The app may give parents, especially high math-anxious parents or even parents with less skill or interest in engaging in math, more and better ways to talk to their children about math not only during app usage, but also in other everyday interactions. Given the increasing prominence of tablet-style devices and internet access (Zickuhr, 2013), this intervention has the potential to be a low-cost, high-benefit method to ensure that parents' uneasiness with math does not translate into their children's low math achievement (Maoney et al., 2015). Using this math app enhances the likelihood that children will succeed in math, which is essential for academic success and for the robustness of the science, technology, engineering, and math in the United States.

Parents may have inadequate math-helping skills or rigidly use instructional strategies that conflict with those that teachers use in the classroom, which could confuse children and negatively affect their math learning. Teachers can provide parents with tools, teaching strategies, and general information that might better prepare and equip parents with the resources to teach and work with their child from home. These might include structured activities that allow parents to interact with their children around math in positive ways, which could be delivered in the form of math books, computer and traditional board games, or internet apps. Parents' homework help could also be facilitated by providing tip sheets with general guidelines for math-homework help and through video models of effective math-homework help (Robinson & Harris, 2014). With support, parents with higher math anxiety may be less anxious while helping their

children with math and be more equipped to positively affect their children's math achievement and math attitudes (Frenkel, 2013).

Relationship between Parent and Child

A parent's relationship with their child and beliefs about math can affect their child's self-perception, math achievement, and beliefs. Now, there are a variety of ways that these characteristics of a parent and child relationship can affect mediate and moderate a child's math achievement, making it complex to create interventions and techniques to help children in regards to parent and child interactions. For the most part, sons tend to be protected from the negative effects a parent may have on them. A son is hardly ever statistically affected by his mother's or father's self-perceptions, and gender stereotypes in regards to math do not affect him. Only when the parent has high math anxiety and the son has high math anxiety as well will a boy's mathematical achievements decrease. In this case, the interventions and techniques discussed to help decrease a parent's math anxiety would be helpful in decreasing the negative effects of this math anxiety.

For young girls, gender stereotypes and a parent's math anxiety and perception of their child can all negatively impact the child. First, both moms' and dads' gender stereotypes and perceptions that boys are better in math worsen a girl's self-perceptions and math achievement. Also, if the daughter has high math anxiety, it does not seem to matter if the mother or father has high or low math anxiety as well as the child will perform lower than a girl who has lo math anxiety; although, if either parent has high math anxiety, than the daughter will perform worse than another female who has high math anxiety but parents with low math anxiety. The easiest way to have a child not

experience these negative effects possibly caused by a parent would be to not have that parent-child interaction in the first place. For example, a parent with high expectation and perceptions of their daughter's math ability should interact with the child in regards to math over a parent with low expectations and perceptions; however, this is not always possible due to familial circumstances. The best course of action would be to lower math anxiety, as already discussed, and change the perceptions, expectations, and gender stereotypes that a parent may have. One way to do so would be to have parents lower their math gender stereotypes and change their perceptions. There has been few research and interventions created in doing both things, but one study has attempted to change math gender stereotypes and stereotype threats in middle school girls. Zhao, Zhang, Alterman, Zhang, & Yu (2016) designed a three-month intervention program based on the Identity Threat Model to reduce math-gender stereotypes. Math gender stereotypes were significantly reduced, and math scores were improved. Hopefully, this intervention program can be broadened and modified to help parents' reduce their own gender stereotypes and not impose these beliefs onto their children.

Another study suggests that by telling daughters of stereotype threats and gender-stereotypes, girls will perform better and have lower math anxiety (Johns, Schmader, & Martens, 2005). For these women, attributing anxiety to gender stereotypes was associated improved performance in the teaching-intervention condition. This explanation and introduced awareness of gender stereotypes and stereotype threat may be more difficult to implement and help girls as some may be too young to understand and comprehend these concepts. Also, other studies and research have suggested that explaining stereotype threat does not actually help math performance or achievement

(Huguet & Régner, 2009), and in fact, Johns' et al. study (2005) shows that attributing anxiety to gender stereotypes lowered performance in math test conditions. For now, there does not seem to be much proven research on certain interventions and techniques that can help parents reduce their math gender stereotypes and perceptions of their child's abilities. The best parents can do is to continue to try and change their own personal beliefs of math and not impose these perceptions onto their children.

Chapter 5:

Conclusion

This paper attempts to address the many factors and ways parents can affect their child's mathematical achievement and education, both positively and negatively; however, it only scratches the surface as to the myriad of home factors that can affect a child's mathematical performance. Specifically, this paper examined the effects of maternal math talk, math anxiety, and the relationship between parent and child. The lack of research on some of these topics and interventions for parents shows that there needs to be more awareness and concern for mathematical achievement.

Parents have received a strong and consistent message that reading to children is important, and there is good reason to encourage parents to involve children in literacy activities; however, the picture is less clear concerning the promotion of numeracy skills development. Parents are exposed to prevailing societal viewpoints about providing high quality learning opportunities. The cause of these suggestions originates from research on the importance of early enrichment, early intervention benefits, suggestions to improve the home learning environment based on cross-cultural research, and societal pressures to ensure that young people are prepared for school entry. Parents have a personal bias toward language arts activities, and they report spending more time on literacy than numeracy outcomes. As the parents in Canon and Ginsburg's study (2008) have suggested, language skills may indeed be more critical for children's current and future success in life. For example, some parents discussed the vital role of language in children's developing academic skills (e.g., language skills can help children achieve more in school than mathematics skills), while other parents suggested that children who

possess good language skills can better communicate with others about their thoughts, feelings, and experiences. Most likely, many educators and researchers would agree that the same cannot be said for children who possess good mathematics skills. Why do parents not see children's mathematics abilities and interests as strongly as they do those of language? Tudge and Doucet (2004) argued that “because reading is so visually apparent and speaking so audible, it may lend itself more readily to direct observations than does mathematics.”

Due to all these misconceptions, greater efforts might need to be taken for parents to become more aware of mathematics learning. More awareness must be raised for the many different ways parents can help with child’s math and the pay offs of doing so. These attempts to help parents support children's mathematics learning might have to place equal attention on informing parents about the content and process of children's mathematics learning as well as helping parents overcome their own anxieties and insecurities surrounding this subject matter.

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Appendix A

Figure 1. 2015 PISA Average Scores

This figure shows the 2015 PISA average scores from each country that participated. The scale ranges from 0-1000. Source: OE C, PISA 2015

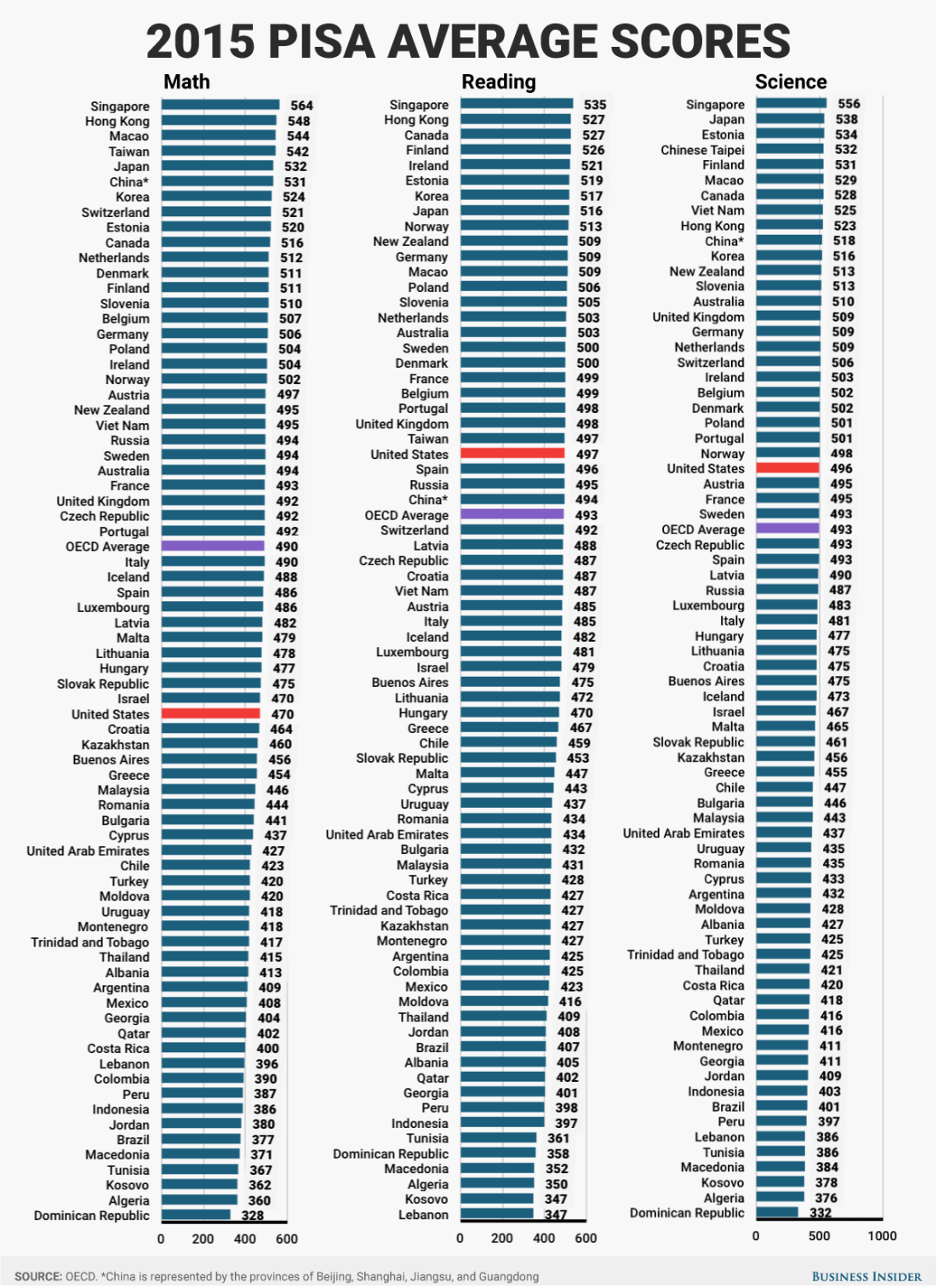

Figure 2. Proportions of types of math talks across mealtimes

This figure shows the percent of types of maternal math talk that occur naturally during certain mealtimes throughout the day.

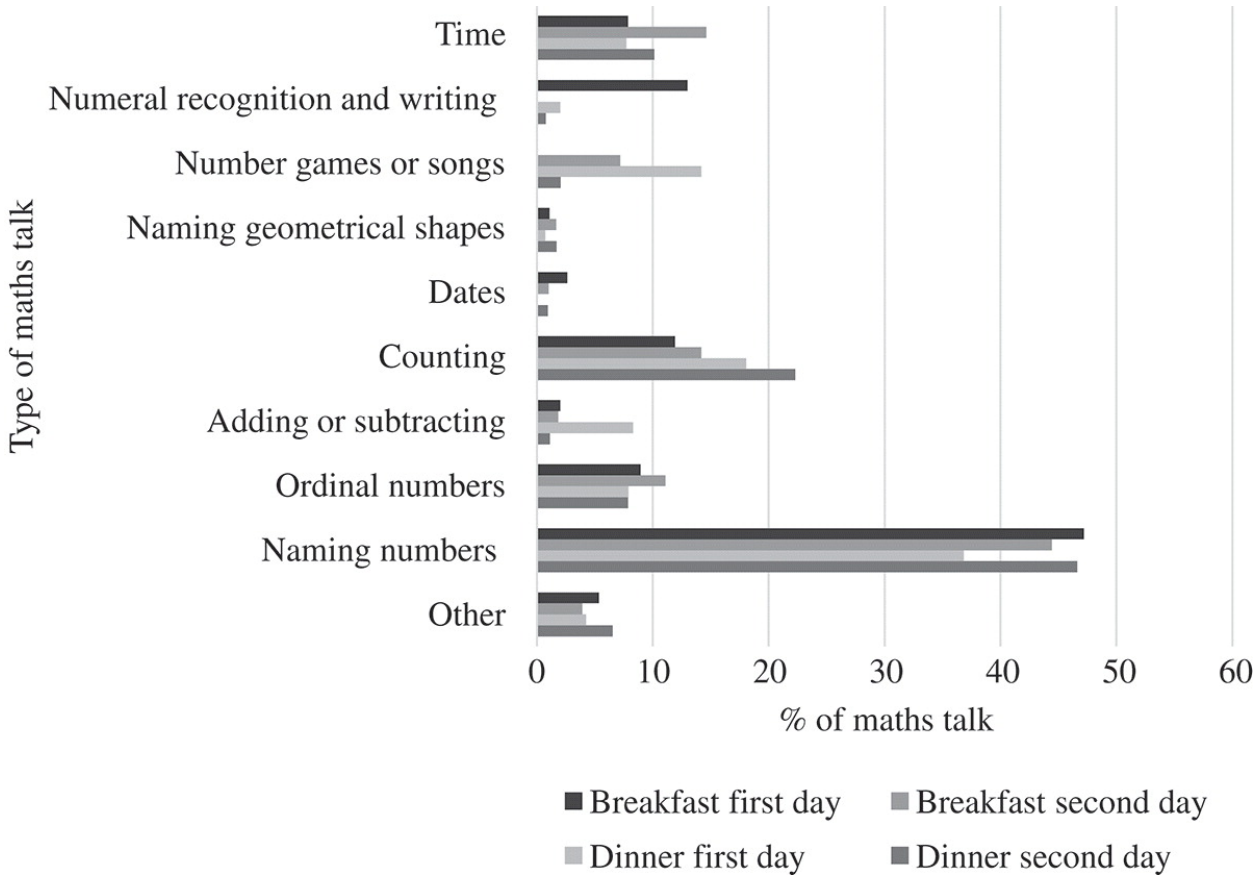

Figure 3. Math talk coding categories

Descriptions and examples of the categories and types of math talk that were coded

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