The Impact of Information, Context, and Child Gender on Parents' Early Numeracy Input

By

Ashli-Ann Douglas

Thesis

Submitted to the Faculty of the

Graduate School of Vanderbilt University

in partial fulfillment of the requirements

for the degree of

MASTER OF SCIENCE

in

PSYCHOLOGY

August 31, 2019

Nashville, Tennessee

Approved:

Bethany Rittle-Johnson, PhD

Lisa Fazio, PhD

Acknowledgements

This thesis would not have been possible without the contribution and support of several individuals and organizations. I thank Dr. Bethany Rittle-Johnson, Dr. Lisa Fazio, and Dr. Erica Zippert for their guidance. I am grateful for the research assistants who contributed to data collection and coding, namely Addison Armstrong, Kayla Folz, Kristin Williams, and Olivia Rastatter. I am also grateful for the staff at the many organizations who facilitated participant recruitment and/ data collection, namely the Adventure Science Center, Vanderbilt University Child Care Centers, Ross Early Learning Center, Holly Street Day Care, Hull Jackson Montessori School, Glen Leven Day School, and Susan Gray School. I am also very appreciative of all the participating parents and children, and for the financial support provided by the Heising Simons' Foundation.

TABLE OF CONTENTS

Page

LIST OF TABLES

Table Page

LIST OF FIGURES

Figure Page

Introduction

Children's early numeracy varies at school entry and is important to their later academic success and socioeconomic attainment (Duncan et al., 2007; Jordan, Kaplan, Ramineni, & Locuniak, 2009; National Research Council, 2009; Ritchie & Bates, 2013). Early numeracy refers to conceptual and procedural knowledge of numbers which children may acquire before they begin formal schooling (Jordan et al., 2009; National Mathematics Advisory Panel, 2008; National Research Council, 2009). It includes proficiency in counting, determining the value of small quantities, identifying numerals, comparing the magnitudes of numbers, and solving simple arithmetic problems (Jordan et al., 2009; National Mathematics Advisory Panel, 2008). Children's early numeracy uniquely predicts their long term academic achievement (Jordan et al., 2009; National Research Council, 2009; Fyfe, Rittle-Johnson, & Farran, 2019). For instance, preschoolers' numeracy uniquely predicts their math skills three to seven years later (Fyfe et al., 2019; Xenidou-Dervou, Molenaar, Ansari, van der Schoot, & van Lieshout, 2017). In addition, children's early numeracy is correlated with their socioeconomic status (SES) as adults, even after controlling for their SES at birth and other factors like their childhood intelligence (Ritchie & Bates, 2013). Thus, it is important that children's early numeracy is supported.

The goal of the current study was to examine whether parents' support of their children's early numeracy may be promoted in a simple and generalizable way. In the introduction, I first review research on parents' support of early numeracy and highlight the need for parents' support to be more frequent. Next, I discuss experimental studies in which parents' numeracy and other academic support was promoted. Lastly, I discuss a limitation of the previous experimental studies which motivates the current study.

Parents' Support of Early Numeracy

There is increasing research examining the home environment as an important source of the variability in children's numeracy at school entry. Specifically, studies have shown that frequent parent-child engagement in number activities, such as comparing the magnitudes of numbers, practicing simple sums, and playing number games, relates to children's early numeracy (Dearing et al., 2012; Lefevre et al., 2009; Ramani, Rowe, Eason & Leech, 2015; Skwarchuk, Sowinski, & LeFevre, 2014; Zippert & Ramani, 2017). Furthermore, there is some evidence that parent-child engagement in number activities improves children's numeracy (Cheung & McBride, 2017). In particular, frequent parent-child engagement with a number board game or workbook (8 times during a month) resulted in the 3- to 5- year old children having improved early numeracy skills (i.e. rote counting and arithmetic). However, children whose parents were not asked to engage them in either number activity did not have improved number skills after a month. This suggests that promoting parents' number input may be an effective way to improve children's early numeracy. In addition to examining parents' reports about parent-child engagement in number activities, studies have explored the importance of parents' input about numeracy concepts (i.e. observed talk) for their children's early numeracy development. Preschoolers whose parents provide numeracy input frequently tend to have better number skills than preschoolers whose parents provide numeracy input infrequently (Casey et al., 2016; Elliott, Braham, & Libertus, 2017; Gunderson & Levine, 2011; Ramani et al., 2015; Susperreguy & Davis-Kean, 2016). Thus parents can support the development of their children's early numeracy skills.

Some research suggests that parents' early numeracy input needs to be promoted. While parents report engaging their preschoolers in number activities relatively often (a few times per

month to a few times per week; Lefevre et al., 2009; Ramani et al., 2015; del Río, Susperreguy, Strasser, & Salinas, 2017; Skwarchuk et al., 2014; Zippert & Ramani, 2017), they report rarely engaging in activities that emphasize more advanced early numeracy skills like magnitude comparison and arithmetic (Ramani et al., 2015; Vandermaas-Peeler, Boomgarden, Finn, & Pittard, 2012). Similarly, very little of parents' observed number talk with their 3- to 5- year old children is about more advanced early numeracy concepts like arithmetic and magnitude comparison (Ramani et al., 2015). Importantly, frequent parent input that emphasizes more advanced early numeracy uniquely predicts children's early numeracy while input that emphasizes other early numeracy concepts like counting does not predict children's early numeracy (Skwarchuk et al., 2014; Thompson, Napoli & Purpura, 2017). Thus, previous research suggests that parents need to provide their children with more input on more advanced early numeracy concepts.

Indeed while parents emphasize more foundational early numeracy concepts (e.g. rote counting and counting objects, numeral identification, and cardinality), preschool children are developing more advanced numeracy, and this more advanced knowledge is predictive of later math achievement (Duncan et al., 2007). For example, preschool children's knowledge about the relative size (magnitude) of numbers is predictive of their future math achievement up to 5 years later (DeSmedt, Noël, Gilmore & Ansari, 2013; Rittle-Johnson, Fyfe, Hofer, & Farran, 2017; Siegler, 2016; Xenidou-Dervou et al., 2017. In contrast, at the end of preschool, children's basic counting knowledge is no longer predictive of their fifth-grade math achievement when more advanced numeracy in preschool is also considered (Rittle-Johnson et al., 2017). Thus, there is an important question of whether researchers can promote frequent parent number input about

more advanced early number concepts (i.e. magnitude comparison and arithmetic) and whether this will improve children's early numeracy.

Promoting Parents' Academic Input

Parents might benefit from guidance on how to support their children's early numeracy, particularly more advanced early numeracy. A lack of knowledge about how to best provide number input about concepts like magnitude comparison and arithmetic may be related to how infrequently some parents provide such number input (Cannon & Ginsburg, 2008; Skwarchuk, 2009). Indeed, over 74% of parents of preschoolers reported that they did not know what math concepts and skills their children should be learning or how they could effectively support their children's numeracy development (Cannon & Ginsburg, 2008). Fortunately, previous research has indicated that the frequency and nature of parents' academic input are malleable.

Researchers have examined the malleability of parents' academic input in the domains of numeracy, space (a core component of math; Mix & Cheng, 2012), and literacy. They have improved parents' academic input in those domains by giving them context-specific directives (e.g. Blom-Hoffman, O'Neil-Pirozzi, Volpe, Cutting, & Bissinger, 2007; Ferrara, Hirsh-Pasek, Newcombe, Golinkoff, & Lam, 2011; Huebner & Meltzoff, 2005; Vandermaas-Peeler, Ferretti, & Loving, 2011; Vandermaas-Peeler et al., 2012). In particular, researchers have informed parents of things to do with their children in the context of specific activities and have examined whether parents are willing and able to implement those things with their children in the same context. Providing parents with context-specific directives leads to improvements in their academic input in those specific contexts and the directives are associated with improvements in

their children's academic skills (Blom-Hoffman et al., 2007; Cheung & McBride, 2017; Huebner & Meltzoff, 2005; Leyva, Davis & Skorb, 2018; Starkey & Klein, 2000).

For instance, Vandermaas-Peeler et al. (2012) informed some parents (numeracy intervention group) of specific ways to explore different number concepts with their children while engaging in a parent-child cooking activity (e.g., by asking their children to count the steps in their recipe). Parents in the numeracy group provided input about most of the number concepts for which the researchers provided context-specific directives (i.e. counting, shapes, and arithmetic) significantly more often than parents in the control group who did not receive instructions to explore number concepts. Likewise, Vandermaas-Peeler et al. (2011) provided some parents (numeracy intervention group) with a list of specific number activities that they could engage their children in while they played a board game together. Parents could, for example, have their child count as they moved their token along the board and compare the number of game pieces that they collected throughout the game. Immediately after receiving the information, parents in the numeracy intervention group talked about number concepts for which they received context-specific directives more often than parents in the control group who did not receive directives. Similarly, researchers found that parents who received context-specific directives about playing with blocks with their preschoolers discussed those spatial concepts, more frequently than other parents while playing with blocks (Ferrara et al., 2011). Likewise, researchers have effectively promoted dialogic reading (a strategy that has been shown to improve children's language and literacy skills) among parents by informing parents of how to implement dialogic reading with their children (Blom-Hoffman et al., 2007; Huebner & Meltzoff, 2005). Note that none of these studies evaluated whether parents generalized the directives and increased their academic input in other contexts.

In addition to providing parents with context-specific directives, informing them of the importance of the related academic concepts and of their academic input seems to improve their academic input. Niklas and colleagues (2016) found that informing parents about the importance of them giving their children number input, examples of ways to do so, and context-specific directives on engaging their children in a numeric game increased parents' reported number input. The researchers did not measure parents' belief about the importance of numeracy for their children, so the effect of the information on parents' belief is unknown. Similarly, researchers have informed parents about the importance of engaging their children in dialogic reading in addition to providing parents with context-specific directives on engaging in dialogic reading (Blom-Hoffman et al., 2007; Huebner & Meltzoff, 2005). Neither study isolated whether including information on importance impacted parent support or measured parents' belief about the importance of dialogic reading. Thus, there is a gap in the literature about how researchers impact parents' beliefs about the importance of academic concepts for their children and how that impact relates to parents' academic input. This is important in light of correlational evidence that parents' beliefs about the importance of numeracy for their children are related to the numeracy input that they provide them (e.g. Missall, Hojnoski, Caskie, & Repasky, 2015; Musun-Miller & Blevins-Knabe, 1998; Sonnenschein et al., 2012).

While providing parents with context-specific directives has effectively improved their use of those activities and strategies, it is not a practical approach as it includes researchers informing parents of specific ways to engage their children in specific activities, with little evidence that parents generalize these directives to new contexts. Only one previous study has examined the effectiveness of providing parents with non-contextual directives on their early academic input. Borrielo and Liben (2017) informed a group of parents about spatial thinking,

including its importance to their preschool children's later academic success and non-contextual examples of how parents can provide input about early spatial concepts (e.g., by talking about how the orientation of jigsaw puzzle pieces determine whether they fit together). Immediately following this, parents and their children played with spatial toys for a second and third time (the spatial toys were not mentioned in the non-contextual directives that the researchers provided). The parents who received the information provided input about spatial concepts more frequently than parents of similar-aged children who did not receive any information. Parents were not asked to report their academic beliefs. Thus, while the study shows that providing parents with non-contextual directives effectively improves their spatial input, little is known about whether the effect generalizes to different academic concepts in different domains or the effect of the directives on parents' beliefs about the importance of the academic concepts.

The goal of the current study is to explore whether parents can generalize directives about a core early math concept to a new context and whether their beliefs about the importance of the concept are impacted.

Current Study

The current study examined the effects of providing parents with non-contextual directives on parent early academic support as well as on parents' beliefs about the importance of the target academic concepts for their children. Specifically, it examined whether parents' numeracy support could be promoted by informing parents about the importance of magnitude comparison for children's math development and examples of ways they may incorporate it into informal activities with their children. It examined whether parents would generalize information about magnitude comparison to an informal activity that does not require magnitude comparison in addition to one that requires it.

The study focused on promoting parents' input about magnitude comparison given that parents discuss it infrequently with their children, even though it is an important early number concept (Ramani et al., 2015). Magnitude comparison refers to an understanding of the relative size of numbers and is a critical component of children's numeracy development (Siegler, 2016; Vanbinst, Ansari, Ghesquière & De Smedt, 2016). For example, children's early magnitude comparison knowledge is predictive of their future arithmetic development and mathematical achievement (Xenidou-Dervou et al., 2017).

Parents and their children were asked to play two card games together, listen to information about magnitude comparison, and then play the same card games again. The study focused on increasing parents' magnitude comparison input during informal activities because there is some evidence that parents prefer to engage their young children in informal math activities rather than formal ones (Cannon & Ginsburg, 2008). Playing cards might be a particularly good context for parent-child engagement in number talk for a number of reasons. First, they have both symbolic and nonsymbolic numbers on them. This provides children with opportunities to improve their numerical representations (Ramani & Siegler, 2008) and parents with opportunities to scaffold children's symbolic number knowledge as needed. Secondly, card games usually require some attention to numbers and so may elicit parent-child number talk. Thirdly, playing cards are common and so parents likely have them at home or can acquire them inexpensively.

One of the card games that parents were asked to play is *Top It*, also known as *War*, as it seems to provide a rich context for magnitude comparison exploration (Douglas, Zippert & Rittle-Johnson, *2019;* Scalise, Daubert & Ramani, 2019). Frequent *Top It* play with an experimenter (four fifteen minute sessions over 3 weeks) has been shown to improve children's

symbolic magnitude comparison skills (Scalise et al., 2019). In addition, parents of preschoolers who chose to play *Top It* provide input about magnitude comparison significantly more often than parents who played other card games (Douglas et al., 2019). Furthermore, the type of card game that the parent-child dyads played uniquely predicted parents' magnitude comparison input even after controlling for children's magnitude comparison exploration. In addition to playing *Top It* in the current study, parent-child dyads were asked to choose and play a different card game. Thus, the current study examined whether receiving information about magnitude comparison would improve parents' magnitude comparison talk during a game that is less related to magnitude comparison than *Top It.* This would provide evidence of the generalizability of providing parents with such information.

The study also examined the effect of non-contextual directives on parents' belief about the importance of magnitude comparison for their children to test whether parents' beliefs are malleable. Previous research indicates that parents' belief about the importance of math is related to the math input that they provide their three- to six- year old children (Missall et al., 2015; Musun-Miller & Blevins-Knabe, 1998; Sonnenschein et al., 2012). In addition, some interventions on parents' academic input have included information that might have changed parents' belief about the importance of the related academic concepts (e.g. Niklas et al., 2016). Thus, parents were asked to report on their belief about the importance of magnitude comparison for their children before and after receiving information on magnitude comparison.

The current study tested two main hypotheses. First, I hypothesized that parents would provide input about magnitude comparison more frequently after they receive non-contextual directives about magnitude comparison than before they received the directives. This finding would offer supporting evidence of the generalizability of providing parents with non-contextual

directives to improve their academic input. This finding would also indicate that parents' number input may be promoted in multiple number activities since parents were asked to engage in a card game that elicits magnitude comparison as well as a different card game. Secondly, I hypothesized that parents would rate magnitude comparison knowledge as more important for their child one week after they received non-contextual directives about magnitude comparison than they did before they received the information. This would confirm that researchers can improve parents' belief about the importance of specific academic concepts.

Methods

Participants

Seventy-one parents and their three- to five-year old children were recruited to engage in a twenty minute, videotaped parent-child interaction at a children's museum, children's schools or at a research lab. Nine parent-child dyads were dropped from the study because they did not complete at least three-quarters of the study. An additional 2 dyads were dropped from the study because the children did not meet the age criteria. Thus, the final sample was 60 parent-child dyads. A power analysis conducted with an alpha of .05 demonstrated that the study had 80% power to detect a medium effect (d=.4) of providing information to a sample of 52 parent-child dyads. Thus, the current sample (n = 60) allowed for a detection of the effects of an experimental manipulation that has a medium, although not a small, effect.

Participating children were 4.43 years old on average (SD= .64). Twenty one percent of children were 3 years old, 59% were 4 years old, and 21% were 5 years old. Most (69%) of the children attended preschool the previous year and did not receive Special Education Services at school (95%). Parents identified over half of the children (53%) as boys and as White (77%).

Ten percent of children were identified as Black, 8% were Biracial or Multiracial, and 5% were Asian or Pacific Islander. Eighty-five percent of parents reported that their child only heard English at home, 3% reported that their child heard English and another language at home, and 8% reported that their child heard a language other than English at home. Other home languages reported were Spanish, Italian, French, and Russian.

Seventy-five percent of the participating parents were mothers. Most participating parents (76% of mothers and 80% of fathers) had at least a Bachelor's degree. Most parents (83%) identified as White while 12% identified as Black and 5% identified as Asian or Pacific Islander. One parent also identified as Hispanic.

Procedure

After giving informed consent, parents first completed two brief questionnaires on their numeracy-related beliefs about their children and their demographics. The experimenter then provided parent-child dyads with a deck of modified playing cards (see Appendix B) and asked them to play two card games. The dyads were asked to play the card game *Top It* which is more commonly known as *War* for five minutes and a different card game of their choice for four minutes in a counterbalanced order. The experimenter read and provided written instructions on how *Top It* is played immediately before the parent-child dyads played the game (see Appendix B). If families had difficulty thinking of a second card game (n=5), the experimenter informed dyads that they could make up a card game or play *Go Fish* or *Match*. Next, the experimenter informed parents about the important link between children's early magnitude comparison knowledge and their later math achievement. The experimenter also gave parents examples of ways they could provide input about magnitude comparison while they engage their children in

various informal activities other than card games. The experimenter provided the information orally and via a written summary (see Appendix C).

Immediately following this, parent-child dyads played *Top It* again for about 5 minutes. Next, dyads played the other card game that they previously chose and played for about four minutes. Finally, the experimenter asked parents to complete 3 brief electronic surveys 5 to 9 days after the play session. Parents received an email with a link to the surveys 5 days after the play session. They received a reminder to complete the surveys 7 and 9 days after the play session as needed. The surveys asked parents to report on their numeracy-related beliefs about their child, the frequency of parent-child engagement in number activities at home, and their math anxiety. Parents who completed the follow-up survey could choose to receive a gift card valued at $5 or $20 depending on whether they had to travel to a location to participate in the study.

Materials

Parent surveys.

Parents' child-specific numeracy beliefs. Parents reported their numeracy-related beliefs about their child immediately before and after the play session by responding to 20 items that were adapted from previous surveys (LeFevre et al., 2009; Zippert & Rittle-Johnson, 2018; see Appendix A). Specifically, parents reported how important they thought their child's ability to compare magnitudes was and how useful they thought magnitude comparison would be for their child's future using 2 items. Parents also rated their child's innate, current, and anticipated magnitude comparison skills using 3 items. These ratings were averaged to create a composite measure of parents' beliefs about their child's magnitude comparison skills. The survey included

distractor items to mask its focus on parents' beliefs about magnitude comparison. Thus, parents also reported on their beliefs about their children's counting, number identification, patterning, and literacy skills.

Parent-child number engagement at home. The survey (see Appendix D) provided descriptive information on the frequency of parents' input about magnitude comparison and other numeracy concepts as well as parent-child engagement with playing cards at home. Parents reported how frequently they engaged their child in magnitude comparison activities at home using two sets of items.

First, they reported how frequently they typically engage in magnitude comparison activities using 2 items. Both items were on a 6-point Likert-type scale, where 0 = never, 1= once a month or less, 2 = 2- to 3-times a month, 3 = 1- to 2-times a week, 4 = 3- to 4-times a week, 5 = daily. The items were averaged to create a composite measure of parent-child typical engagement in magnitude comparison at home. Parents also reported how often they play *Top It* and other card games at home. They also reported the frequency of parent-child engagement in other numeracy and literacy activities at home. These additional items served as distractors items.

Secondly, parents reported how frequently they engaged their children in magnitude comparison activities in the week following the play session using 2 items on a 6-point Likert-type scale, where 0 = never, 1= once, 2 = 2- to 3-times, 3 = 4- to 6-times, 5 = daily. A composite score was created by averaging parents' responses to both items. Parents also responded to similar distractor questions as previously described. Most of the survey items were adapted from previously used instruments (Dearing et al., 2012; LeFevre et al., 2009; Rittle-Johnson et al., 2015; Zippert & Rittle-Johnson, 2018).

Parent rating of their math anxiety. Parents rated their math anxiety by completing six items from the Gulick Math Anxiety Scale. Specifically, they rated the level of math anxiety that they feel during 6 situations on a 5-point Likert scale (from 1 to 5, "low anxiety" to "high anxiety") after reading a brief prompt (see appendix D). The 6 items were averaged to create a composite. The Gulick Math Anxiety Scale includes 8 items, although 2 were not used in the current study because they pertain to respondents' level of anxiety about situations while they were students (Gulick, 2012).

Demographic information. Parents provided demographic information regarding their child and themselves immediately before the play session (see Appendix A). Specifically, they reported their gender and race/ethnicity, and the educational attainment of the child's parents. They also reported their child's gender, race/ ethnicity and age, whether their child receives special education services at school, and the language(s) to which their child is exposed at home.

Playing cards. The deck of playing cards that parent-child dyads used during the videotaped play session was modified so that the cards had dots instead of the suits of regular playing cards. In addition, the number of dots on each card corresponded exactly with the numeral on the card unlike regular cards which have additional suit motifs under the numerals. Finally, the modified deck included cards with the number one and did not include any face cards.

Video Coding

Each parent-child play session was divided into ten-second intervals. Parents' magnitude comparison talk was coded using the coding scheme displayed in Appendix E. The coding scheme was developed to capture parents' explicit input about symbolic magnitude comparison

(henceforth referred to as symbolic magnitude comparison) as well as other possible occurrences of magnitude comparison input (henceforth referred to as nonsymbolic magnitude comparison). The frequencies of the codes during each round of card game was divided by the duration of the round (i.e. the number of ten-second intervals) to account for variability in the duration of time parent-child dyads spent playing.

Reliability. Twenty percent of the play session videos were double coded by a graduate student who served as the master coder and an undergraduate research assistant. A kappa coefficient was calculated for the coders since previous research indicates that they are appropriate for coding schemes with mutually exclusive codes (Cohen, 1960). Agreement between the coders was moderate as indicated by a kappa of 0.76.

Analysis Plan

Preliminary Analyses

Bivariate correlations and independent sample t-tests were conducted to determine which theoretically interesting variables (i.e. parent belief about child's magnitude comparison skills, parent math anxiety, child gender, child age, and order of games before parents received the information) needed to be included as covariates in the main analysis on the effect of the information on parents' magnitude comparison input.

Main Analyses

First, a two-way repeated measures Analysis of Covariance (ANCOVA) with time (before versus after receiving non-contextual directives) and game (*Top It* versus other card game) as within-subject factors, controlling for a covariate identified in the preliminary analyses,

was conducted. The ANCOVA was used to test the first hypothesis (parents would provide magnitude comparison input more frequently after receiving non-contextual directives than before) and to examine whether the type of card game in which parent-child dyads were engaged moderated the effect. Next, a paired sample t-test was conducted to examine to test the second hypothesis (parents would rate magnitude comparison as more important one week after receiving non-contextual directives than immediately before).

Exploratory Analyses

The frequencies of parents' magnitude comparison input at home in general and their magnitude comparison input after the play session were explored. Additionally, bivariate correlations were used to examine the relations among parents' beliefs about the importance of magnitude comparison for their child, their observed magnitude input before receiving related information, and the frequency of their reported magnitude comparison input at home.

Results

Descriptive Statistics

Parents provided their preschoolers with input about magnitude comparison fairly often (*M* = 25% of 10-second intervals, *SD* = 8.76%*)* while engaging them in play with cards. Most of parents' magnitude comparison input was about nonsymbolic quantities (*M* = 65% of intervals during which they discussed magnitude comparison, *SD* = 20.66%*).*

Descriptive statistics on parents' child-centered beliefs about magnitude comparison and other early academic skills (distractors) are presented in Table 1. Parents reported believing that

magnitude comparison was important for their children and that their children were good at comparing magnitudes. They reported having some math anxiety (M = 1.79, SD = .80).

Table 1

Parents' Ratings of their Child-specific Beliefs about Academic Concepts

Academic Concept	*M(SD)*	
	Before Information	**After Information**
Importance[a]		
Magnitude Comparison	6.50(.63)	6.55(.65)
Value	6.27(.89)	6.45(.84)
Utility	6.69(.59)	6.65(.63)
Counting and Numeral Identification	6.58(.78)	6.62(.62)
Value	6.44(.95)	6.51(.79)
Utility	6.72(.72)	6.73(.57)
Patterning	6.37(.89)	6.49(.76)
Value	6.12(1.19)	6.35(.95)
Utility	6.63(.82)	6.63(.67)
Literacy	6.63(.78)	6.71(.55)
Value	6.45(.95)	6.59(.76)
Utility	6.80(.72)	6.84(.47)
Ability		
Magnitude Comparison	5.19(1.09)	5.46(1.17)
Current[b]	4.73(1.59)	5.27(1.35)
Future (next school year)[c]	5.85(1.15)	5.92(1.22)
Innate [d]	4.93(1.13)	5.20(1.24)
Counting and Numeral Identification	5.49(1.10)	5.78(1.10)
Current[b]	5.20(1.57)	5.78(1.21)
Future (next school year)[c]	6.04(1.10)	6.08(1.06)
Innate[d]	5.25(1.13)	5.49(1.24)
Patterning	5.42(1.1)	5.56(.90)
Current[b]	5.23(1.33)	5.51(1.08)
Future (next school year)[c]	5.92(1.24)	5.92(1.17)
Innate [d]	5.08(1.20)	5.27(1.08)
Literacy	4.85(1.23)	5.07(1.18)
Current[b]	4.18(1.70)	4.76(1.38)
Future (next school year)[c]	5.60(1.27)	5.57(1.21)
Innate [d]	4.76(1.23)	4.90(1.28)

Notes. [a]1(not at all important) – 7(very important) [b]1(not good at all) - 7(Very good) [c]1(Not at all well) - 7(Very well) [d]1(Much less than other children) - 7(Much more than other children)

Preliminary Analyses

Consider relations among parents' initial input about magnitude comparison (i.e. before receiving information about magnitude comparison), parent factors, and child factors. The frequency of parents' initial magnitude comparison input was not related to their beliefs about how good their child's magnitude comparison skills were, their ratings of their own math anxiety or their child's age (see Table 2). The frequency of parents' overall and symbolic magnitude comparison input before receiving information did not differ by their child's gender, $t_{\text{overall}}(57) = 1.57$, $p = .12$, $d = .44$; $t_{\text{symbolic}}(57) = .68$, $p = .50$, $d = .13$. However, the frequency of parents' non-symbolic magnitude comparison input before receiving information did differ by their child's gender. Specifically, parents of girls provided significantly more input about nonsymbolic magnitude comparison before receiving information (M = 18% of intervals, SD = 9%) than parents of boys (M = 13% of intervals, SD = 7%), $t(57) = 2.30$, $p < .05$, $d = .62$. Additionally, as expected, parents' magnitude comparison input prior to receiving related information did not differ significantly based on the order in which they initially played the two card games, $t_{overall}(57) = .63$, $p = .53$, $d = .11$; $t_{symbolic}(57) = .52$, $p = .61$, $d = .13$; $t_{nonsymbolic}(57) = 1.10$, $p = .28$, $d = .35$. Thus, only child gender was controlled for during further analyses with parents' magnitude comparison input.

Main Analyses

A two-way repeated measures ANCOVA was used to examine whether parents' input about magnitude comparison differed across time (before and after they received information about magnitude comparison) and between games, controlling for child gender.

Parents did not provide magnitude comparison input more often after receiving information about magnitude comparison, $F(1, 53) = 2.71$, $p = .11$, $\eta_p^2 = .05$. However, there was a main effect of game on parents' magnitude comparison input, $F(1, 53) = 33.08$, $p < .001$, $\eta_p^2 = .39$. Specifically, post hoc pairwise comparisons with a Bonferroni correction indicated that parents provided magnitude comparison input significantly more often while playing *Top It* than while playing a different card game (see Table 3). In addition, there was a marginally significant interaction effect of time and child gender, $F(1, 53) = 4.09$, $p = .05$, $\eta_p^2 = .07$, but no two-way interaction between game and child gender, $F(1, 53) = .24$, $p = .62$, $\eta_p^2 = .01$, or time and game, $F(1, 53) = .06$, $p = .81$, $\eta_p^2 = .00$. The analysis did not reveal a significant three-way interaction effect of time, game, and child gender on parents' magnitude comparison input, $F(1, 53) = .06$, $p = .81$, $\eta_p^2 = .00$.

Table 2

Correlations Among Parents' Initial Magnitude Comparison Input and Beliefs, Parents' Math Anxiety, and Children's Age

Variable	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1. Overall magnitude comparison	-						
2. Symbolic magnitude comparison	.47*	-					
3. Non-symbolic magnitude comparison	.68*	-.34*	-				
4. Belief about magnitude comparison importance	.02	.08	-.05	-			
5. Belief about child magnitude comparison ability	-.13	-.23	.05	.02	-		
6. Belief about own math anxiety	.17	.27	-.06	.09	.06	-	
7. Child Age	.03	-.20	.19	-.18	.51*	.16	-

Note. * $p < .05$

Table 3

Frequency of Parents' Magnitude Comparison Input by Game

Magnitude Comparison	***M(SE)***	
	Top It	**Other Card Game**
Overall	.43(.02)*	.03(.01)
Symbolic	.27(.02)*	.02(.01)
Non-symbolic	.16(.02)*	.02(.00)

Note. * $p < .05$

Additional analyses were conducted to explore the time by gender interaction (see Figure 1). First, univariate analyses were used to compare the overall magnitude comparison input of parents of girls versus parents of boys at each time point. The frequency of the magnitude comparison input provided by parents who engaged in the play session with their daughter before receiving information did not differ significantly (M = 27% of intervals, SD = 9%) from the frequency of the input provided by parents who engaged in the play session with their son (M = 23% of intervals, SD = 9%), $F(1, 58) = 2.46$, $p = .12$, $\eta_p^2 = .04$. However, parents who engaged in the play session with their daughter provided significantly more magnitude comparison input after receiving information (M = 33% of intervals, SD = 18%) than parents who played with their son (M = 23% of intervals, SD = 9%), $F(1, 58) = 8.62$, $p < .01$, $\eta_p^2 = .13$. Second, paired sample t-tests were used to examine change in the magnitude comparison input provided by parents of girls and to examine change in the magnitude comparison input provided by parents of boys. The results suggest that there was a marginally significant effect of the information on the magnitude comparison input provided by parents of girls, $t(26) = 2.05$, $p = .05$, $d = .37$. However, there was no effect of the information on the magnitude comparison input provided by parents of boys, $t(31) = .22$, $p = .83$, $d = .00$.

Next, parents' symbolic and non-symbolic magnitude comparison input were analyzed separately. Parents did not provide significantly more input about symbolic magnitude comparison after receiving information about magnitude comparison, $F(1, 53) = .28$, $p = .60$, $\eta_p^2 = .04$. However, there was a main effect of game on the frequency of parents' symbolic magnitude comparison input, $F(1, 53) = 14.02$, $p < .001$, $\eta_p^2 = .22$. Specifically, parents provided their preschoolers with input about symbolic magnitude comparison significantly more often while playing *Top It* than while playing a different card game (see Table 3). There were no significant interaction effects of time and child gender, $F(1, 53) = 2.72$, $p = .11$, $\eta_p^2 = .05$, game and child gender, $F(1, 53) = .54$, $p = .47$, $\eta_p^2 = .01$, or time and game, $F(1, 53) = .04$, $p = .85$, $\eta_p^2 = .00$, nor was there a three-way interaction effect of time, game, and child gender, $F(1, 53) = .11$, $p = .74$, $\eta_p^2 = .00$.

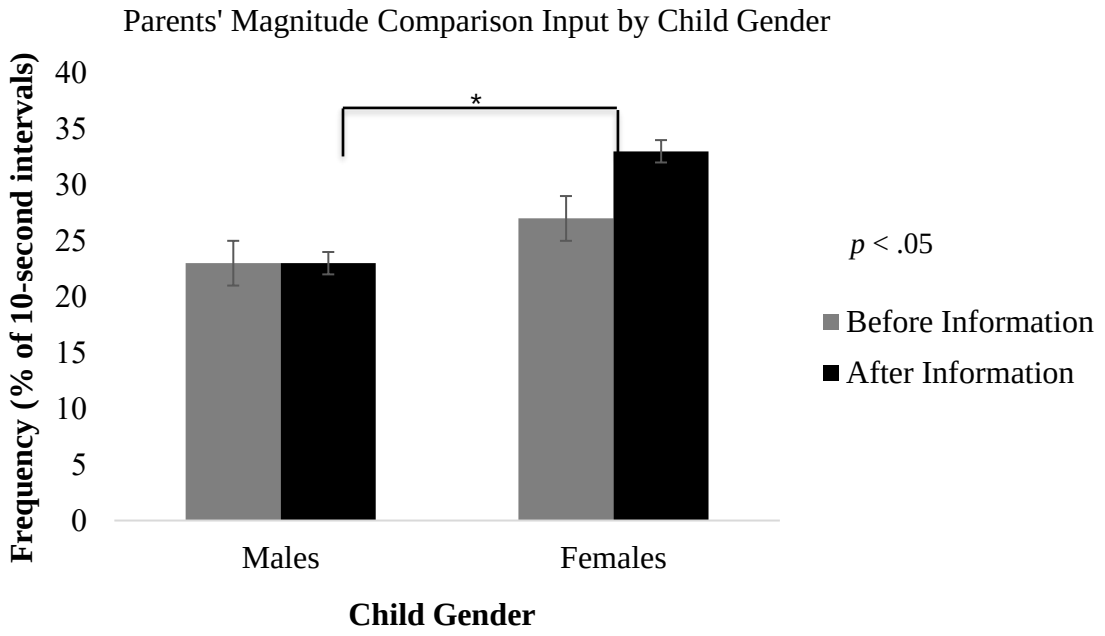

Figure 1. Parents' magnitude comparison input by child gender. Error bars reflect standard errors.

A similar pattern of results was found for parents' input about nonsymbolic magnitude comparison. Parents did not provide significantly more input about nonsymbolic magnitude comparison after receiving information about magnitude comparison, $F(1, 53) = .28$, $p = .60$, $\eta_p^2 = .01$. However, there was a main effect of game on the frequency of parents' nonsymbolic magnitude comparison input, $F(1, 53) = 13.72$, $p < .01$, $\eta_p^2 = .21$. Specifically, parents provided their preschoolers with input about nonsymbolic magnitude comparison significantly more often while playing *Top It* than while playing a different card game, (see Table 3). There were no significant interaction effects of time and child gender, $F(1, 53) = .64$, $p = .43$, $\eta_p^2 = .01$, game and child gender, $F(1, 53) = 1.66$, $p = .20$, $\eta_p^2 = .03$, time and game, $F(1, 53) = .02$, $p = .88$, $\eta_p^2 = .00$, or time, game, and child gender, $F(1, 53) = .02$, $p = .89$, $\eta_p^2 = .00$, on parents' nonsymbolic magnitude comparison.

A paired sample t-test was used to test whether parents rated their child's magnitude comparison skills as more important one week after receiving related information (including about the importance of their child's early magnitude comparison skills to their later math ability). Parents rated magnitude comparison as more important for their child after receiving related information, $t(46) = 2.20$, $p < .05$, $d = .32$. Importantly, parents did not rate distractor concepts as significantly more important for their child after receiving information about the importance of magnitude comparison, $t_{\text{othernumberconcepts}}(46) = .36$, $p = .72$, $d = .05$; $t_{\text{patterning}}(46) = 1.73$, $p = .09$, $d = .25$; and $t_{\text{literacy}}(46) = .93$, $p = .36$, $d = .14$.

Exploratory Analyses

The frequency of parents' magnitude comparison input at home was explored. Specifically, the frequency of the magnitude comparison input that parents generally provided at

home and the frequency of the magnitude comparison input that they provided during the week after the play session were explored to provide a sense of whether the information provided during the play session influenced parents' magnitude comparison input at home. Note that the response scale differed at the two points, so the numeric values cannot be compared directly across time points. Additionally, the frequency of the magnitude comparison input that parents generally provided at home was correlated with their initial belief about the importance of magnitude comparison for their child and with the frequency of the magnitude comparison input that they provided before receiving information during the play session.

First, consider descriptive statistics on the frequency of parent-child play at home, including those focused on supporting children's magnitude comparison at both times (see Table 4). Parents reported generally providing symbolic magnitude comparison input once per week. Interestingly, they reported providing symbolic magnitude comparison input more often after engaging in the play session (i.e. 2- to 3- times during the week after the play session). Additionally, parents reported generally providing nonsymbolic magnitude comparison input 2- to 3- times per week on average and reported the same frequency during the week after the play session. Lastly, parents reported generally engaging their preschooler in the card game *War* once per month or less on average but reported engaging their preschooler in *War* once during the week after the play session. Similarly, parents reported generally engaging their preschooler in card games 2- to 3- times per month but reported engaging in card games once after the play session.

Next, consider relations between parents' general frequency of providing magnitude comparison input at home and their belief about the importance of magnitude comparison before receiving information. Parents' general magnitude comparison input at home (average of the

frequency of the symbolic and nonsymbolic magnitude comparison input that they generally provide at homes) was not related to their beliefs about the importance of magnitude comparison for their child, $r(47) = .21$, $p = .16$. Likewise, parents' initial magnitude comparison input during the play session was not significantly related to their beliefs about the importance of magnitude comparison for their child, $r(59) = .02$, $p = .89$. However, there was a marginal, negative relation between the frequency of parents' initial magnitude comparison input during the play session and the frequency of their reported magnitude comparison input at home, $r(45) = -.28$, $p = .06$.

Table 4

Descriptive Statistics on the Frequency of Parent-Child Play at Home

Home Activity Types and Items	***Frequency M(SD)***	
	***General*[a]**	***Week After the Play Session*[b]**
Magnitude Comparison Composite	3.20(1.44)	1.97(1.31)
Compare quantities (e.g., when serving food for dinner or sharing toys)	3.46(1.79)	2.02(1.39)
Compare written numbers (e.g., "5 is bigger than 4")	2.93(1.56)	1.92(1.44)
Cards Composite	1.26(1.17)	1.19(1.42)
Play the card game “Top It” which is also known as “War”	.57(1.00)	.76(.92)
Play the card game that you and your child chose to play with our cards last week	1.35(1.59)	.71(1.13)
Play card games that involve numbers	1.83(1.59)	.87(1.09)
Other Number Composite	3.84(1.08)	2.08(.97)
Count items	4.91(1.26)	2.87(1.26)
Count out loud without objects	4.87(1.20)	2.74(1.36)
Read books that show and talk about numbers	3.54(1.35)	1.74(1.39)
Talk about written numbers (e.g., "That's a 7")	4.37(1.46)	2.63(1.18)
Add simple sums or talk about number facts (e.g., 2+2=4)	3.39(1.84)	1.83(1.42)
Play board games that involve counting (e.g. Chutes & Ladders)	2.11(1.55)	.58(1.07)
Pattern Composite	1.97(1.27)	.92(.99)
Make or copy patterns with objects or sounds (e.g. putting blocks in a red-green-red-green pattern; clap-clap-snap pattern)	2.15(1.43)	.77(1.12)
Figure out what comes next in a pattern	2.10(1.39)	1.17(1.17)
Describe patterns in words	2.26(1.59)	1.15(1.27)
Copy a pattern by making the same kind of pattern, but with different materials (e.g., use circles and squares to make the same kind of pattern as in a red-blue pattern)	1.24(1.34)	.77(1.12)

Notes. [a]Rated on a 6-point scale where 0 = never, 1 = once a month or less, 2 = 2- to 3- times a month, 3 = once a week, 4 = 2- to 3- times a week, 5 = 4- to 6- times a week, 6 = daily. [b]Rated on a 4-point scale where 0 = never, 1 = once, 2 = 2- to 3- times, 3 = 4- to 6- times, 4 = daily.

Discussion

The current study continues efforts to identify effective ways of promoting parents' early numeracy input. Specifically, it aimed to improve parents' input about an important early numeracy concept and their belief about the importance of their children's related skills by providing parents with information about the concept in a brief session. Though the study's main hypotheses were only partially supported, it offers insightful findings on the malleability of parents' talk and beliefs as well as the relations between the two.

Promoting Parent Magnitude Comparison Input

First, parents provided their children with input about magnitude comparison frequently during the current study, including while the study's focus on magnitude comparison was masked. Importantly, parents in the current study provided input about both symbolic and nonsymbolic magnitude comparison. There is evidence that both types of magnitude comparison knowledge are uniquely related to young children's math skills (see Fazio, Bailey, Thompson, & Siegler, 2014 for a review). Specifically, previous research has found strong and significant relations between young children's nonsymbolic magnitude knowledge and their concurrent and later math achievement (e.g. Fazio et al., 2014; Fyfe et al., 2019). Likewise, children's symbolic magnitude knowledge uniquely predicts their concurrent and later math achievement (e.g. Fazio et al., 2014). Previous research has reported very infrequent instances of parent magnitude comparison input during parent-child play and have not examined symbolic and nonsymbolic magnitude comparison separately (e.g. Ramani et al., 2015).

Furthermore, the current study indicates that the card game *War* elicits parent magnitude comparison input (both symbolic and nonsymbolic) and so is an effective way to promote parent

input about the magnitude of numbers to their preschoolers. Parents provided their preschoolers with magnitude comparison input dramatically more often while playing *War* than while playing a different card game of their choice. In tandem with previous research (Douglas et al., 2019), the current study suggests that encouraging parents to play *War* with their preschool-aged child is an effective way to promote frequent parent input about magnitude comparison. Furthermore, this is likely an effective way to support the development of children's early magnitude comparison skills (Scalise et al., 2019). This may be a particularly good way for parents of low socioeconomic status to support their children's numeracy development since playing cards are inexpensive and can be purchased widely. In addition, playing *War* does not have to be time consuming (parents in the current study played two 5-minute rounds with their children).

Further evidence of the utility of encouraging parents to play *War* with their children comes from the current study's findings about parent-child *War* play at home. Parents reported that they generally play *War* infrequently at home with their children (once per month or less on average). Interestingly, they reported playing *War* once on average in the week following the play session. Previous research has not asked parents to report on the frequency of parent-child *War* play at home. Additionally, parents reported engaging their children in symbolic magnitude comparison at home more often after the play session (2- to 3- times during that week) than before (once per week). The latter is consistent with previous research (e.g. Zippert & Rittle-Johnson, 2018).

Child gender and parents' early numeracy input. The current study suggests that future research on promoting parents' early numeracy input should consider child gender. The frequency of parents' initial input about nonsymbolic magnitude comparison to their preschoolers differed by gender, with parents proving more input to their daughters than sons.

Additionally, there was a significant gender by time interaction effect on the frequency of parents' magnitude comparison talk, with parents of girls providing significantly more input about magnitude comparison than parents of boys after receiving information. Few studies have examined whether parents' magnitude comparison input differs by children's gender. No observational studies have reported on analyses with child gender and parents' magnitude comparison input. However, studies examining parents' reports of numeracy input at home (average frequency of input about various numeracy concepts including magnitude comparison) have reported mixed findings on gender differences, sometimes favoring girls and sometimes finding no gender difference (del Rio et al., 2017; del Rio, Susperreguy & Salinas, 201; Vandermaas-Peeler et al., 2007).

Parents' numeracy-related beliefs and their early numeracy input. Parents' numeracy-related beliefs were not related to the frequency of their input about magnitude comparison. Specifically, there was no significant relationship between parents' beliefs about the importance of their child doing well at magnitude comparison and the frequency of their magnitude comparison input. Consistent with the current study's findings, no study has found significant relations between parents' beliefs about the importance of early numeracy for their children and their numeracy input (i.e. observed talk about numeracy; Douglas et al., 2019; Elliot et al., 2017). This might suggest that parents discuss numeracy concepts during play with their children regardless of their beliefs about the importance of the concept. Perhaps, the context of parent-child play is a more important factor in the frequency of parents' numeracy input than parents' beliefs about the importance of numeracy. On the contrary, some researchers have found that parents' beliefs about the importance of numeracy relates to parents' self-reported engagement in numeracy activities with their children (Missall et al., 2015; Musun-Miller &

Blevins-Knabe, 1998; Sonnenschein et al., 2012). However, this finding did not hold for specific numeracy concepts in the current study; parents' beliefs about the importance of magnitude comparison was not related to their reported magnitude comparison input at home.

Similarly, parents' own math anxiety was not related to their magnitude comparison input in the current study. While previous studies suggest that parents' math anxiety is negatively related to the frequency of their self-reported numeracy input at home (del Rio et al., 2017), little is known about how parents' math anxiety relates to their observed early numeracy input. Douglas et al. (2019) did not find a relation between parents' math anxiety and their observed magnitude comparison input, though parents' math anxiety was positively correlated with their children's observed exploration of magnitude comparison. Thus, the current study's play sessions will be coded for child talk to allow for analyses examining how child magnitude comparison talk relates to parents' beliefs and child age and gender as well as the effects of game and time on child talk.

Malleability of Parents' Early Numeracy Beliefs

Parents in the current study rated magnitude comparison as more important for their children one week after they received information about the importance of preschoolers' magnitude comparison skills. This suggests that parents' beliefs about early numeracy concepts are malleable and researchers can promote more positive beliefs among parents. Importantly, parents' beliefs about the importance of other number concepts, patterning knowledge, and literacy (controlling for child gender) did not change significantly after the play session. Thus, only the belief that was manipulated was impacted. The improvement in parents' belief about the importance of magnitude comparison, but no significant increase in parents' magnitude

comparison talk suggests that information about the importance of numeracy may not promote parents' numeracy input immediately or directly.

Limitations and Future Directions

First, I did not measure children's magnitude comparison skills and so could not discuss how parents' input related to their children's skills. Future research should examine this. Additionally, the current study's sample was not diverse. As such, the results may not generalize to more diverse samples. Future research should replicate the study with a more diverse sample. Generalization to other parent-child play contexts (other than card games) is also needed.

Conclusion

The results suggest that parents' magnitude comparison input (i.e. observed talk about magnitude comparison) is not easily promoted by providing them with brief information about magnitude comparison. However, it indicates that identifying games which elicit parent input about specific numeracy concepts and encouraging parents to play them with their children is an effective way to promote their numeracy input. It also suggests that providing parents with information about early numeracy concepts can promote more positive beliefs about the importance of the concepts for their child, which may have longer-term impacts on how they support their children's math achievement and on their children's math achievement.

REFERENCES

Blom-Hoffman, J., O'Neil-Pirozzi, T., Volpe, R., Cutting, J., & Bissinger, E. (2007). Instructing Parents to Use Dialogic Reading Strategies with Preschool Children: Impact of a Video-Based Training Program on Caregiver Reading Behaviors and Children's Related Verbalizations. *Journal of Applied School Psychology*, *23*(1), 117–131. https://doi.org/10.1300/J370v23n01_06

Borriello, G. A., & Liben, L. S. (2017). Encouraging Maternal Guidance of Preschoolers' Spatial Thinking During Block Play. *Child Development*, *0*(0). https://doi.org/10.1111/cdev.12779

Cannon, J., & Ginsburg, H. P. (2008). "Doing the Math": Maternal Beliefs About Early Mathematics Versus Language Learning. *Early Education & Development*, *19*(2), 238–260. https://doi.org/10.1080/10409280801963913

Casey, B. M., Lombardi, C. M., Thomson, D., Nguyen, H. N., Paz, M., Theriault, C. A., & Dearing, E. (2016). Maternal Support of Children's Early Numerical Concept Learning Predicts Preschool and First-Grade Math Achievement. *Child Development*. https://doi.org/10.1111/cdev.12676

Cheung, S. K., & McBride, C. (2017). Effectiveness of Parent–Child Number Board Game Playing in Promoting Chinese Kindergarteners' Numeracy Skills and Mathematics Interest. *Early Education and Development*, *28*(5), 572–589. https://doi.org/10.1080/10409289.2016.1258932

Cohen, J. (1960). A coefficient of agreement for nominal scales. *Educational and Psychological Measurement*, *20*(1), 37–46.

De Smedt, B., Noël, M.-P., Gilmore, C., & Ansari, D. (2013). How do symbolic and non-symbolic numerical magnitude processing skills relate to individual differences in children's mathematical skills? A review of evidence from brain and behavior. *Trends in Neuroscience and Education*, *2*(2), 48–55. https://doi.org/10.1016/j.tine.2013.06.001

Dearing, E., Casey, B. M., Ganley, C. M., Tillinger, M., Laski, E., & Montecillo, C. (2012). Young girls' arithmetic and spatial skills: The distal and proximal roles of family socioeconomics and home learning experiences. *Early Childhood Research Quarterly*, *27*(3), 458–470. https://doi.org/10.1016/j.ecresq.2012.01.002

del Río, M. F., Susperreguy, M. I., Strasser, K., & Salinas, V. (2017). Distinct Influences of Mothers and Fathers on Kindergartners' Numeracy Performance: The Role of Math Anxiety, Home Numeracy Practices, and Numeracy Expectations. *Early Education and Development*, *28*(8), 939–955. https://doi.org/10.1080/10409289.2017.1331662

Duncan, G. J., Dowsett, C. J., Claessens, A., Magnuson, K., Huston, A. C., Klebanov, P., … Japel, C. (2007). School readiness and later achievement. *Developmental Psychology*, *43*(6), 1428–1446. http://dx.doi.org.proxy.library.vanderbilt.edu/10.1037/0012-1649.43.6.1428

Elliott, L., Braham, E. J., & Libertus, M. E. (2017). Understanding sources of individual variability in parents' number talk with young children. *Journal of Experimental Child Psychology*, *159*, 1–15. https://doi.org/10.1016/j.jecp.2017.01.011

Fazio, L. K., Bailey, D. H., Thompson, C. A., & Siegler, R. S. (2014). Relations of different types of numerical magnitude representations to each other and to mathematics achievement. *Journal of Experimental Child Psychology*, *123*, 53–72. https://doi.org/10.1016/j.jecp.2014.01.013

Ferrara, K., Hirsh-Pasek, K., Newcombe, N. S., Golinkoff, R. M., & Lam, W. S. (2011). Block Talk: Spatial Language During Block Play. *Mind, Brain, and Education*, *5*(3), 143–151. https://doi.org/10.1111/j.1751-228X.2011.01122.x

Fyfe, E. R., Rittle-Johnson, B., & Farran, D. C. (2019). Predicting success on high-stakes math tests from preschool math measures among children from low-income homes. *Journal of Educational Psychology*, *111*(3), 402–413. https://doi.org/10.1037/edu0000298

Gulick, M. E. (2012). Anxiety In Action: A Study On Math Anxiety Among College Students. *Unpublished Manuscript*, 54.

Gunderson, E. A., & Levine, S. C. (2011). Some types of parent number talk count more than others: relations between parents' input and children's cardinal-number knowledge: Types of parent number talk. *Developmental Science*, *14*(5), 1021–1032. https://doi.org/10.1111/j.1467-7687.2011.01050.x

Huebner, C. E., & Meltzoff, A. N. (2005). Intervention to change parent–child reading style: A comparison of instructional methods. *Journal of Applied Developmental Psychology*, *26*(3), 296–313. https://doi.org/10.1016/j.appdev.2005.02.006

Jordan, N. C., Kaplan, D., Ramineni, C., & Locuniak, M. N. (2009). Early math matters: Kindergarten number competence and later mathematics outcomes. *Developmental Psychology*, *45*(3), 850–867. https://doi.org/10.1037/a0014939

LeFevre, J.-A., Skwarchuk, S.-L., Smith-Chant, B. L., Fast, L., Kamawar, D., & Bisanz, J. (2009). Home numeracy experiences and children's math performance in the early school years. *Canadian Journal of Behavioural Science/Revue Canadienne Des Sciences Du Comportement*, *41*(2), 55–66. https://doi.org/10.1037/a0014532

Leyva, D., Davis, A., & Skorb, L. (2018). Math Intervention For Latino Parents and Kindergarteners Based on Food Routines. *Journal of Child and Family Studies*. https://doi.org/10.1007/s10826-018-1085-5

Missall, K., Hojnoski, R. L., Caskie, G. I. L., & Repasky, P. (2015). Home Numeracy Environments of Preschoolers: Examining Relations Among Mathematical Activities, Parent Mathematical Beliefs, and Early Mathematical Skills. *Early Education and Development*, *26*(3), 356–376. https://doi.org/10.1080/10409289.2015.968243

Mix, K. S., & Cheng, Y.-L. (2012). Chapter 6 - The Relation Between Space and Math: Developmental and Educational Implications. In J. B. Benson (Ed.), *Advances in Child Development and Behavior* (Vol. 42, pp. 197–243). https://doi.org/10.1016/B978-0-12-394388-0.00006-X

Musun-Miller, L., & Blevins-Knabe, B. (1998). Adults' beliefs about children and mathematics: how important is it and how do children learn about it? *Early Development and Parenting*, *7*(4), 191–202. https://doi.org/10.1002/(SICI)1099-0917(199812)7:4<191::AID-EDP181>3.0.CO;2-I

National Mathematics Advisory Panel. (2008). *Foundations for Success: The Final Report of the National Mathematics Advisory Panel*. Retrieved from https://www2.ed.gov/about/bdscomm/list/mathpanel/report/final-report.pdf

National Research Council. (2009). *Mathematics Learning in Early Childhood: Paths toward Excellence and Equity* (C. T. Cross, T. A. Woods, & H. Schweingruber, Eds.). National Academies Press.

Niklas, F., Cohrssen, C., & Tayler, C. (2016). Improving Preschoolers' Numerical Abilities by Enhancing the Home Numeracy Environment. *Early Education and Development*, *27*(3), 372–383. https://doi.org/10.1080/10409289.2015.1076676

Ramani, G. B., Rowe, M. L., Eason, S. H., & Leech, K. A. (2015). Math talk during informal learning activities in Head Start families. *Cognitive Development*, *35*(Supplement C), 15–33. https://doi.org/10.1016/j.cogdev.2014.11.002

Ritchie, S. J., & Bates, T. C. (2013). Enduring Links From Childhood Mathematics and Reading Achievement to Adult Socioeconomic Status. *Psychological Science*, *24*(7), 1301–1308. https://doi.org/10.1177/0956797612466268

Rittle-Johnson, B., Fyfe, E. R., Hofer, K. G., & Farran, D. C. (2017). Early Math Trajectories: Low-Income Children's Mathematics Knowledge From Ages 4 to 11. *Child Development*, *88*(5), 1727–1742. https://doi.org/10.1111/cdev.12662

Scalise, N. R., Daubert, E. N., & Ramani, G. B. (2018). Narrowing the Early Mathematics Gap: A Play-Based Intervention to Promote Low-Income Preschoolers' Number Skills. *Journal of Numerical Cognition*, *3*(3), 559–581.

Scalise, N. R., Daubert, E. N., & Ramani, G. B. (2019). Benefits of Playing Numerical Card Games on Head Start Children's Mathematical Skills. *The Journal of Experimental Education*, 1–21. https://doi.org/10.1080/00220973.2019.1581721

Siegler, R. S. (2016). Magnitude knowledge: the common core of numerical development. *Developmental Science*, *19*(3), 341–361. https://doi.org/10.1111/desc.12395

Skwarchuk, S.-L. (2009). How Do Parents Support Preschoolers' Numeracy Learning Experiences at Home? *Early Childhood Education Journal*, *37*(3), 189–197. https://doi.org/10.1007/s10643-009-0340-1

Skwarchuk, S.-L., Sowinski, C., & LeFevre, J.-A. (2014). Formal and informal home learning activities in relation to children's early numeracy and literacy skills: The development of a home numeracy model. *Journal of Experimental Child Psychology, 121*, 63–84. https://doi.org/10.1016/j.jecp.2013.11.006

Sonnenschein, S., Galindo, C., Metzger, S. R., Thompson, J. A., Huang, H. C., & Lewis, H. (2012). Parents' Beliefs about Children's Math Development and Children's Participation in Math Activities [Research article]. https://doi.org/10.1155/2012/851657

Susperreguy, M. I., & Davis-Kean, P. E. (2016). Maternal Math Talk in the Home and Math Skills in Preschool Children. *Early Education and Development, 27*(6), 841–857. https://doi.org/10.1080/10409289.2016.1148480

Thompson, R. J., Napoli, A. R., & Purpura, D. J. (2017). Age-related differences in the relation between the home numeracy environment and numeracy skills. *Infant and Child Development, 26*(5), e2019. https://doi.org/10.1002/icd.2019

Vanbinst, K., Ansari, D., Ghesquière, P., & De Smedt, B. (2016). Symbolic Numerical Magnitude Processing Is as Important to Arithmetic as Phonological Awareness Is to Reading. *PLOS ONE*, *11*(3), e0151045. https://doi.org/10.1371/journal.pone.0151045

Vandermaas-Peeler, M., Boomgarden, E., Finn, L., & Pittard, C. (2012). Parental support of numeracy during a cooking activity with four-year-olds. *International Journal of Early Years Education, 20*(1), 78–93. https://doi.org/10.1080/09669760.2012.663237

Vandermaas-Peeler, M., Ferretti, L., & Loving, S. (2011). Playing the Ladybug Game : parent guidance of young children's numeracy activities. *Early Child Development and Care, 182*(10), 1289–1307. https://doi.org/10.1080/03004430.2011.609617

Xenidou-Dervou, I., Molenaar, D., Ansari, D., van der Schoot, M., & van Lieshout, E. C. D. M. (2017). Nonsymbolic and symbolic magnitude comparison skills as longitudinal predictors of mathematical achievement. *Learning and Instruction*, *50*(Supplement C), 1–13. https://doi.org/10.1016/j.learninstruc.2016.11.001

Zippert, E. L., & Ramani, G. B. (2017). Parents' Estimations of Preschoolers' Number Skills Relate to at-Home Number-Related Activity Engagement. *Infant and Child Development*, *26*(2), n/a-n/a. https://doi.org/10.1002/icd.1968

Appendix A

Survey before Play Session

Please answer the following questions about <u>your child</u>:

1. How good is your child in each area listed below?

	1 (Not good at all)	2	3	4	5	6	7 (Very good)
Noticing and making patterns	O	O	O	O	O	O	O
Comparing the magnitudes (size) of numbers	O	O	O	O	O	O	O
Learning to read and write	O	O	O	O	O	O	O
Counting and naming numbers	O	O	O	O	O	O	O

2. How well do you think your child will do in each of these areas in Kindergarten?

	1 (Not at all well)	2	3	4	5	6	7 (Very Well)
Noticing and making patterns	O	O	O	O	O	O	O
Comparing the magnitudes (size) of numbers	O	O	O	O	O	O	O
Learning to read and write	O	O	O	O	O	O	O
Counting and naming numbers	O	O	O	O	O	O	O

3. Compared to other children, how much innate ability or talent does your child have in each of these areas?

	1 (Much less than other children)	2	3	4	5	6	7 (Much more than other children)
Noticing and making patterns	O	O	O	O	O	O	O
Comparing the magnitudes (size) of numbers	O	O	O	O	O	O	O
Learning to read and write	O	O	O	O	O	O	O
Counting and naming numbers	O	O	O	O	O	O	O

4. How important is it to you that your child does well in each of these activities?

	1 (Not very Important)	2	3	4	5	6	7 (Very Important)
Noticing and making patterns	O	O	O	O	O	O	O
Comparing the magnitudes (size) of numbers	O	O	O	O	O	O	O
Learning to read and write	O	O	O	O	O	O	O
Counting and naming numbers	O	O	O	O	O	O	O

5. How useful do you think each of these kinds of activities will be to your child in the future?

	1 (Not at all useful)	2	3	4	5	6	7 (Very useful)
Noticing and making patterns	O	O	O	O	O	O	O
Comparing the magnitudes (size) of numbers	O	O	O	O	O	O	O
Learning to read and write	O	O	O	O	O	O	O
Counting and naming numbers	O	O	O	O	O	O	O

Please answer the following questions about your family:

Please indicate your child's date of birth: _____

Did your child attend preschool last year (the 2017-2018 school year)?
O Yes

O No

Please indicate your child's gender:

O Male

O Female

Indicate **your child's** race/ethnicity (Select the one that best describes your child):

O African-American or Black
O Caucasian or White
O American Indian or Alaska Native
O Asian or Pacific Islander
O Biracial/Mixed Race

Which language(s) does your child hear at home? (Select all that apply):

O English

O Spanish

O Other language(s) (select all that apply)

Please indicate the languages that the child hears at home. _____

Does your child receive Special Education services at school?

O Yes

O No

Please indicate your relation to the child:
O Mother

O Father

Please indicate the highest level of education completed by the child's **MOTHER**:

O Elementary school

O Some high school

O High school diploma or GED

O Some college or 2-year degree

O Bachelor's degree

O Some graduate work

O Master's, professional or doctoral degree

Please indicate the highest level of education completed by the child's **FATHER**:
O Elementary school

O Some high school

O High school diploma or GED

O Some college or 2-year degree

O Bachelor's degree

O Some graduate work

O Master's, professional or doctoral degree

Please indicate **your** race/ethnicity (Select the one that best describes you):
O African-American or Black
O Caucasian or White
O American Indian or Alaska Native
O Asian or Pacific Islander
O Biracial/Mixed Race (please list all groups)
_____
_____

Are you Hispanic or Latino (Choose one):

O Yes

O No

Appendix B

Play Session Materials

How to Play "Top It"

To play "Top It", first divide the deck of cards evenly between players. Next, each player flips over one of his or her cards and the player with the card that has more takes both cards and places them in a separate stack. If the two cards are the same, both players put three additional cards down, then flip over a fourth card. The player whose fourth card has more takes all the cards. The game ends when the players have used all of their first stack of cards or when time is up. The player with more cards at the end of the game is the winner.

Figure B1. *Top It* instructions.

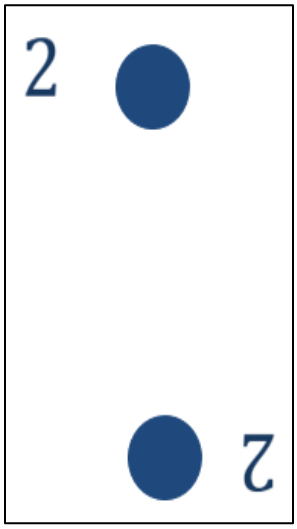

Figure B2. Number Cards

Appendix C

Information about Magnitude Comparison Provided to Parents

Information Provided Verbally

I would like you to challenge each other to two more quick and fun games, but first I would like to share some information with you about a very important number skill called magnitude comparison!

Magnitude comparison has to do with the size of numbers. It includes knowing which set of objects is bigger or smaller than another set of objects. It also includes knowing which number word or written number is bigger or smaller than another number word or written number. An example is understanding that five donuts are more in number than two donuts. Likewise, the word five refers to more than the word two, and the written number 5 is a higher number than the written number 2. Studies have found that young children who are very good at comparing numbers do better at math than their peers who are not very good at comparing numbers up to five years later.

Parents can support their children's growing magnitude comparison knowledge by *talking* about the relative size of numbers while they talk or play together! If you bake cookies with your child, you could ask him or her to tell you which tray has more cookies. If you play a board game together, you could help your child figure out who has to move more spaces. Another example is you could put your child's toys into groups and talk about the number of toys in each group, including which group has the least and most number of toys.

Here's a summary of what I just shared with you.

Handout with Summary of Information

- Magnitude comparison has to do with the size of numbers. It includes knowing:
    - which set of objects is larger or smaller than another
    - which number words and written numbers refer to larger quantities.
- Magnitude comparison is a very important number skill for preschoolers.
- Preschoolers who are better at comparing magnitudes do better at math when they are older.
- Parents can help their children learn about and practice comparing magnitudes by talking with them about the size of numbers while they play together. For example:
    - You could ask your child which of two trays has more cookies, and then say which is more
    - You could help your child decide who has to move more spaces after you both roll dice while playing a board game together.
    - You could put your child's toys into groups and then talk about the number of toys in each group, including which group has the least and most number of toys.

Appendix D

Survey after Play Session

Please answer the following questions about <u>your child</u>:

1. How good is your child in each area listed below?

	1 (Not good at all)	2	3	4	5	6	7 (Very good)
Noticing and making patterns	O	O	O	O	O	O	O
Comparing the magnitudes (size) of numbers	O	O	O	O	O	O	O
Learning to read and write	O	O	O	O	O	O	O
Counting and naming numbers	O	O	O	O	O	O	O

2. How well do you think your child will do in each of these areas in Kindergarten?

	1 (Not at all well)	2	3	4	5	6	7 (Very Well)
Noticing and making patterns	O	O	O	O	O	O	O
Comparing the magnitudes (size) of numbers	O	O	O	O	O	O	O
Learning to read and write	O	O	O	O	O	O	O
Counting and naming numbers	O	O	O	O	O	O	O

3. Compared to other children, how much innate ability or talent does your child have in each of these areas?

	1 (Much less than other children)	2	3	4	5	6	7 (Much more than other children)
Noticing and making patterns	O	O	O	O	O	O	O
Comparing the magnitudes (size) of numbers	O	O	O	O	O	O	O
Learning to read and write	O	O	O	O	O	O	O
Counting and naming numbers	O	O	O	O	O	O	O

4. How important is it to you that your child does well in each of these activities?

	1 (Not very Important)	2	3	4	5	6	7 (Very Important)
Noticing and making patterns	O	O	O	O	O	O	O
Comparing the magnitudes (size) of numbers	O	O	O	O	O	O	O
Learning to read and write	O	O	O	O	O	O	O
Counting and naming numbers	O	O	O	O	O	O	O

5. How useful do you think each of these kinds of activities will be to your child in the future?

	1 (Not at all useful)	2	3	4	5	6	7 (Very useful)
Noticing and making patterns	O	O	O	O	O	O	O
Comparing the magnitudes (size) of numbers	O	O	O	O	O	O	O
Learning to read and write	O	O	O	O	O	O	O
Counting and naming numbers	O	O	O	O	O	O	O

6. How often do you do the following activities with your child?

Activity	Frequency of Activity						
	Never	Once a month or less	2-3 times a month	Once a week	2-3 times a week	4-6 times a week	Daily
Count items	O	O	O	O	O	O	O
Count out loud without objects	O	O	O	O	O	O	O
Play card games that involve numbers	O	O	O	O	O	O	O
Read books that show and talk about numbers	O	O	O	O	O	O	O
Play the card game “Top It” which is also known as“War”	O	O	O	O	O	O	O
Talk about written numbers (e.g., "That's a 7")	O	O	O	O	O	O	O
Add simple sums or talk about number facts (e.g., 2+2=4)	O	O	O	O	O	O	O
Compare quantities (e.g., when serving food for dinner or sharing toys)	O	O	O	O	O	O	O
Play board games that involve counting (e.g. Chutes & Ladders)	O	O	O	O	O	O	O
Compare written numbers (e.g., "5 is bigger than 4")	O	O	O	O	O	O	O
Play the card game that you and your child chose to play with our cards last week	O	O	O	O	O	O	O
Make or copy patterns with objects or sounds (e.g. putting blocks in a red-green-red-green pattern; clap-clap-snap pattern)	O	O	O	O	O	O	O

Figure out what comes next in a pattern	O	O	O	O	O	O	O
Describe patterns in words	O	O	O	O	O	O	O
Copy a pattern by making the same kind of pattern, but with different materials (e.g., use circles and squares to make the same kind of pattern as in a red-blue pattern)	O	O	O	O	O	O	O

7. How often did you do the activities below with your child in the PAST WEEK?

Activity	Frequency of Activity				
	Never	Once	2-3 times	4-6 times	Daily
Count items	O	O	O	O	O
Count out loud without objects	O	O	O	O	O
Play card games that involve numbers	O	O	O	O	O
Read books that show and talk about numbers	O	O	O	O	O
Play the card game “Top It” which is also known as “War”	O	O	O	O	O
Talk about written numbers (e.g., "That's a 7")	O	O	O	O	O
Add simple sums or talk about number facts (e.g., 2+2=4)	O	O	O	O	O
Compare quantities (e.g., when serving food for dinner or sharing toys)	O	O	O	O	O
Play board games that involve counting (e.g. Chutes & Ladders)	O	O	O	O	O
Compare written numbers (e.g., "5 is bigger than 4")	O	O	O	O	O
Play the card game that you and your child chose to play with our cards last week	O	O	O	O	O

Make or copy patterns with objects or sounds (e.g. putting blocks in a red-green-red-green pattern; clap-clap-snap pattern)	O	O	O	O	O
Figure out what comes next in a pattern	O	O	O	O	O
Describe patterns in words	O	O	O	O	O
Copy a pattern by making the same kind of pattern, but with different materials (e.g., use circles and squares to make the same kind of pattern as in a red-blue pattern)	O	O	O	O	O

8. Some individuals feel anxiety when in certain situations involving mathematics. Please rate your level of anxiety when considering the following situations:

Activity	Frequency of Activity				
	Low anxiety	Some anxiety	Moderate anxiety	Quite a bit of anxiety	High anxiety
Looking through pages in a math book	O	O	O	O	O
Being asked to add 976 and 777 in your head	O	O	O	O	O
Determining the amount of change you should get back from a purchase involving several items	O	O	O	O	O
Calculating a tip at a restaurant without using a calculator	O	O	O	O	O
Having someone explain bank interest rates as you decide on a savings account	O	O	O	O	O
Being asked by a friend to answer the question: How long will it take to get to New York City if I drive 70 miles per hour?	O	O	O	O	O

Appendix E

Magnitude Comparison Coding Scheme

Table D1

Magnitude Comparison Coding Scheme

Code Abbreviation	**Code Name**	**Definition**	**Examples**
MSL	Magnitude Comparison: **Explicit *Symbolic Labeling***	Compares or matches numbers by verbally referring to the numerals	"Eight is bigger than six" "This number is smaller than this number"
MAO	Magnitude Comparison: ***All Others***	Compares or matches numbers or quantities *without* explicitly referring to the numerals	"This 1 is more" "I win" "My card has more dots than yours" "Whose is bigger?" "Who wins?" "Who takes it?" "We tied." "They're all the same number."

Notes. Coding was hierarchical (priority given to the code that appears higher in the table) and mutually exclusive, and was done for each 10-second interval of the videotaped parent-child play sessions.