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Applied Developmental and Educational Psychology Program

"IT'S ALMOST LIKE YOU'RE LEARNING THROUGH COOKING": A CONVERSATION ANALYTIC STUDY OF PARENT-CHILD NUMBER TALK DURING AN EARLY MATH INTERVENTION

Dissertation
by

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submitted in partial fulfillment
of the requirement for the degree of
Doctor of Philosophy

August 2021

ABSTRACT

"It's almost like you're learning through cooking": A Conversation Analytic Study of Parent-Child Number Talk during an Early Math Intervention

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Research has shown that parents' number talk predicts preschoolers' concurrent and prospective math skills; yet, there is considerable heterogeneity in parents' use of number talk (e.g., Ramani et al., 2015). Given this, researchers are developing resources and interventions designed to encourage family numeracy (e.g., Hanner et al., 2019). Interventions, however, are based on a limited understanding of how families engage in numeracy conversations, particularly when parents are working to teach their children. Developmental researchers tend to operationalize parent talk as discrete, decontextualized instances of environmental input. In contrast, scholars using Conversation Analysis (CA) argue that understanding interactional phenomenon requires attention to how it is collaboratively and incrementally constructed through turn-taking sequences and how it allows interlocutors to accomplish social actions across stretches of interaction (e.g., Schegloff, 2007).

The current study used CA to examine parent-preschooler conversations about numeracy during a home-based math intervention for which parents and children cooked together. The 30 parents—primarily middle-class, college educated parents of color—and their 3- to 5-year-old children received a cookbook with domain-general learning tips and 15 recipes. Families in the treatment condition received additional numeracy tips, some specific to the recipes provided and some broadly applicable to any recipe. Families were asked to audio record themselves cooking twice a month for three months.

Results indicated that exchanges in which numeracy pedagogy was irrelevant (i.e., low-relevance pedagogy) for completing the recipe were qualitatively different from exchanges in which numeracy pedagogy facilitated children's participation in cooking tasks (i.e., high-relevance pedagogy). While low-relevance pedagogy engaged children in rehearsing their numeracy skills, high-relevance pedagogy invited children to use their numeracy knowledge to plan and implement recipe tasks. Counting occurred primarily within low-relevance pedagogy, meaning parents' prompts to count were disconnected from cooking. The recipes, ingredients, and cooking tools families selected shaped the affordances for numeracy pedagogy. This dissertation has implications for improving early learning interventions.

ACKNOWLEDGEMENTS

This dissertation would not have been possible without the generosity and support of so many people. First, this research was supported by the Heising–Simons Foundation Development and Research in Early Mathematics Education (DREME) Network. Second and most significantly, I am deeply grateful to the families who participated in the cooking intervention study. I feel so blessed to have had this opportunity to view a snapshot of their lives and learn from their interactions. Third, I am thankful to all who worked on the development, implementation, and evaluation of the intervention study, including: Eric Dearing, Lindsay Clements, Hope Dragelin, Alexia Kovatsis, Rebekah LeMahieu, Alden Burnham, Amanda Stroiman, Meghan Coughlan, Miladi Teo Najera, and Julie Kim. Fourth, I am so grateful to my dissertation committee: Drs. Eric Dearing, Kristen Bottema-Beutel, and Gilda Morelli. I have benefited tremendously from their mentorship over the years, with each shaping my scholarly interests and identity in distinct ways. I indebted to Eric for his faith in me as a scholar, for pushing me to refine my thinking and writing, and for ensuring I got this project across the finish line, as well as serving as my advisor and mentor throughout my doctoral training. Kristen introduced me to conversation analysis and provided me with tremendous support throughout the analysis. This would not have been possible without her. And, Gilda was pivotal in shaping the lens through which I understand human development with her course on the cultural processes of development. And finally, I am so grateful for the support I've received from friends and family during the six years of my doctoral training, especially for my wife, Daisy, and for my cohort-mate, Bryn, who navigated each step of this process in lockstep with me.

TRANSCRIPT NOTATION

Jeffersonian transcription notation based on Hepburn and Bolden (2017):

.	Falling or final intonation contour
?	Strongly rising intonation
!	Animated delivery
↓↑	Rise or fall in pitch
::	Elongation of sound
-	Hyphen indicates a cut-off sound
°word°	Whisper or barely audible speech
WOrd	Elevated volume, more capitalization means louder
Word	Emphasis on word, more underline means more emphasis
=	Talk continues from previous talk without ordinary pause
<word>	Talk is slowed down
>word<	Talk is speed up
((comment))	Transcriber comments
(guess)	Uncertain hearing of speech
( )	Unable to identify speech
(.6)	Silence measured in seconds
(.)	Micropause
[overlap]	Section of overlapping speech
£	Smiley voice
#	Creaky delivery or vocal fry
(h)	Laughter within speech
•	Audible inhale
(…)	Lines omitted
I→	Initiation turn of an IRE sequence
R→	Response turn of an IRE sequence
E→	Evaluation turn of an IRE sequence

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CHAPTER 1: INTRODUCTION

As young as 3 and 4 years of age, children's numeracy skills are robust predictors of their later school achievement, in both mathematics and literacy (e.g., Duncan et al., 2007). This has drawn increased attention to the role of young children's math learning experiences at home. Much of this attention has focused on the role of parents' *number talk* or language that models and elicits discussion of early numeracy concepts. This research has shown that the quantity, diversity, and complexity of parents' number talk during parent-child interactions predicts children's concurrent (e.g., Elliot et al., 2017; Ramani et al., 2015) and future math skills (e.g., Casey et al., 2018; Levine et al., 2010). In addition, a recent experimental study has found causal evidence that parent number talk promotes children's early cardinality knowledge (Gibson et al., 2020). Despite the importance of early math, studies have demonstrated considerable heterogeneity in parents' use of number talk (e.g., Eason et al., 2021; Levine et al., 2010; Ramani et al., 2015), and there is evidence that children participate in fewer math activities and parents are less confident about supporting their child's math learning compared to literacy (Sonnenschein et al., 2016, 2020).

Given this, researchers have begun developing educational resources and interventions designed to encourage family number talk and promote young children's numeracy skills (e.g., Berkowitz et al., 2015; Casey et al., 2020; Gibson et al., 2020; Hanner et al., 2019; Leyva et al., 2018; Starkey & Klein, 2000; Vandermaas-Peeler et al., 2012a, 2012b; Zippert et al., 2019). These interventions tend to take one of two forms: 1) families are given an activity that elicits number talk, such as a number book, educational math app, card game, or board game, often with guidance on supporting children's

engagement with numeracy during the activity or 2) parents are provided with brief tips or extended training on how to engage children in numeracy during everyday activities, like grocery shopping.

Within the larger field of developmental psychology, parent talk interventions are often developed and implemented with the goal of ameliorating the effects of poverty and systemic inequities by augmenting how low-income families and families of color interact with young children (e.g., Suskind et al., 2013; Leung et al., 2019; Wong et al., 2020). These interventions have been critiqued for their singular focus on individual solutions to historic and ongoing systemic marginalization within schools and society at large and for the erasure and devaluation of the cultural and interactional practices of minoritized families and communities (e.g., Avineri et al., 2015; Kuchirko, 2019; Morelli et al., 2018a; Ochs & Kremer-Sadl, 2020; Rogoff et al., 2017; Sperry et al., 2019). Parent talk interventions were developed based on correlational research that identified differences between racial and socioeconomic groups in children's early experiences, namely their families' communicative practices, as well as in children's performance on standardized assessments of language and achievement (e.g., Hart & Risley, 1995). Based on these studies, researchers have drawn causal conclusions, attributing differences in outcomes to differences in children's home environment (Avineri et al., 2015; Blum, 2017; Jarrett et al., 2015).

This research has been critiqued for several reasons. First, researchers have neglected the role of social inequity and discriminatory policies in children's development (Avineri et al., 2015; Blum, 2017; Brown et al., 2019; García Coll et al., 1996; Johnson, 2015). Second, researchers have assumed standardized assessments

provide unbiased and meaningful reflections of children's skills and that observations of parent-child interactions reflect families' everyday practices, despite evidence to the contrary (Baugh, 2017; Dudley-Marling & Lucas, 2009; Marlaire & Maynard, 1990; Reynolds et al., 2021). Third, given that the field of psychology, including developmental psychology, has persistently relied on convenience samples that overrepresent White, middle-class families living in the United States and other English-Speaking countries, theories of human development do not reflect the lived experiences and cultural practices of the vast majority of humans (Arnett, 2008; Nielsen et al., 2017; Roberts et al., 2020). Instead, researchers—who have historically been White and middle-class—have long assumed that White, middle-class children's development is 'normal', 'optimal', and 'universal', neglecting to view their development as culturally and contextually situated (Brown et al., 2019; Kline et al., 2018; Rogoff, 2003). From this perspective, differences in developmental outcomes between White, middle-class children and minoritized children have been assumed to reflect deficiencies in minoritized children's experiences rather than reflecting cultural differences in family practices, socialization goals, and developmental pathways (Jarrett et al., 2015; Kline et al., 2018; Morelli et al., 2018a; Ochs & Schieffelin, 1984; Rogoff, 2003).

Together, this has resulted in persistent deficit perspectives of Black, Indigenous, Latinx, and other minoritized children within developmental psychology and a focus on quantifying and solving disparities in their early experiences (Avineri et al., 2015; Dudley-Marling & Lucas, 2009; Johnson, 2015; Kline et al., 2018; Jarrett et al., 2015; Rogoff et al., 2017). The interventions developed to promote the development of children living in poverty and children of color have largely been based on a limited

understanding of the cultural ways of being, practices for socializing and teaching children, and lived experiences of their families (Dudley-Marling & Lucas, 2009; Kelly et al., 2002; Morelli et al., 2018a; Rogoff et al., 2017). When interventions are not based in deep understanding of families' communicative and cultural practices, these interventions risk adverse or unforeseen consequences for family interactions and wellbeing (Morelli et al., 2018a, 2018b).

Deficit discourses also permeate research on early math (Gutiérrez & Dixon-Román, 2011; Martin, 2019; Martin et al., 2019), with much of the research on parent number talk framed around the need to identify specific characteristics of parent talk that explain differences in children's early math skills so that other families can be encouraged to use this talk with their children. Given that there is less attention to math and wide variability in number talk among both low-income and middle-class families, early math interventions have not been targeted exclusively to families perceived to be at risk. However, parent number talk is seen as a possible lever for addressing the systemic disparities in opportunity between middle-class White families and low-income families and families of color. Researchers studying children's early math experiences with their families need to heed the critiques of research examining and interventions seeking to augment children's early language and literacy environments. There is growing consensus that interventions are most effective and meaningful when they are developed and implemented in partnership with parents and when they reflect and build upon families' cultural and communicative practices (Civil, 2016; Halgunseth, 2009; Ishimaru et al., 2016; Jarrett et al., 2015; McWayne et al., 2018; National Academies of Sciences, Engineering, and Medicine, 2016; Rogoff et al., 2017). Early math interventions should,

therefore, be based in nuanced understandings of families' everyday practices of using math and of interacting with and socializing children.

In addition to efforts to develop strength-based, culturally-relevant early math interventions, it is also valuable to examine families' use of intervention materials, with careful attention to how families engage with the materials and how guidance provided to parents shapes family interactions. However, researchers developing and evaluating early math activities and interventions have generally limited their analysis to comparisons of children's math skills or the frequency of parent-child math talk (e.g., Berkowitz et al., 2015; Gibson et al., 2020; Hanner et al., 2019; Leyva et al., 2018; Starkey & Klein, 2000; Vandermaas-Peeler et al., 2012a, 2012b; Zippert et al., 2019). For instance, Zippert et al. (2019) compared parents' and children's math talk while playing a board game on a tablet during a visit to a museum when parents were given guidance that encouraged them to use the game to teach their child about numbers and when parents did not receive this guidance. They found that parents who received the guidance engaged in more math talk statements and prompts, particularly pertaining to the numeracy domains of numerical identification and cardinal values, than parents in the control group (Zippert et al., 2019).

However, this provides limited insights into how parents and children in the guidance and control groups used number talk while playing the game, how they approached the game in similar or different ways, whether the additional number talk in the guidance group was experienced as meaningful by parents and children, how families might engage with the game at home, and so on. Nuanced analysis of how families engage with educational activities and interventions is important for both improving the

relevance, usefulness, and effectiveness of intervention materials and for clarifying possible mechanisms underlying differences—or the lack of differences—observed between intervention conditions. The present dissertation examined family participation in a home-based early numeracy intervention in which parents were asked to cook with their preschool-age children.

Two gaps in the existing number talk literature present challenges for developing interventions aimed at promoting family engagement in number talk. First, the research has not examined how parents and children collaboratively construct sequences of number talk during activities and what these sequences allow parents and children to do together. Developmental research on parent talk, including number talk, has been theoretically and methodologically limited by operationalizing parent talk as discrete, decontextualized instances of environmental input, overlooking the dynamic and collaborative nature of parent-child interactions. Developmental psychologists have acknowledged the importance of the back-and-forth exchange of parent-child interactions for children's learning (e.g., Golinkoff et al., 2019; Susperreguy & Davis-Kean, 2016). Yet, researchers examining the role of these interactions in children's math learning have tended to focus on parent talk, using word- or utterance-level frequencies—or other summative quantitative indicators—to represent the scaffolding and socialization children experience. This approach largely ignores the overall sequence of the interaction, neglects the full range of embodied resources (e.g., pitch, volume, stress, gaze, gesture) that interlocutors draw on to construct meaning, and limits understanding of how children construct knowledge through their moment-to-moment exchange with caregivers during interactions (Gardner & Forrester, 2010; Hengst, 2015; Tarplee, 2010). As a result, our

current understanding of the meaning and function of parent number talk in parent-child interactions is likely incomplete, or perhaps even inaccurate. This limits knowledge on precisely how parent-child interactions contribute to young children's numeracy skills and hinders efforts to develop interactionally grounded guidance for families on supporting early numeracy.

Second, there has been minimal attention to how parents enact number talk when they are working to teach their child numeracy. In fact, existing studies have not differentiated between number talk that is pedagogically oriented and number talk that occurs more in passing and serves other functions in parent-child interaction (e.g., making a request, sanctioning child behavior, reminiscing about a shared experience, providing instruction on how to perform a household chore). Parents may use distinct interactional practices to engage their children in pedagogical conversations and activities about numeracy, and these may vary by families' ethnic, linguistic, geographic, and socioeconomic cultural context, with the use of child-focused pedagogical activities being less common in some communities (Morelli et al., 2003). It is possible that number talk that engages children in numeracy conversations or perhaps demonstrates the relevance of numeracy for daily life and for the completion of specific activities has particular benefits for children's numeracy engagement and learning. Indeed, interventions designed to encourage parent number talk aim to increase parents' use of pedagogical and contextually meaningful number talk, such as helping children count in instrumental ways when playing a game (Zippert et al., 2019), over other types of number talk. For this reason, it is important to understand more about when, how, and for what purposes parents and children engage in numeracy pedagogy within different activities.

The Present Study

To address these gaps in the extant literature, the present dissertation used conversation analysis (CA) to examine the interactional practices undertaken when parents and their 3- to 5-year-old children engaged in numeracy pedagogy during cooking as their participation in a home-based math intervention. The intervention aimed to encourage parent-child numeracy conversations during home cooking activities and advance children's numeracy skills. All 30 participating families received a cookbook that included domain-general tips on engaging children in learning conversations and 15 simple recipes. The families randomly assigned to the treatment condition received a version of the cookbook that contained additional suggestions on supporting children's early numeracy skills, some specific to the recipes provided and some broadly applicable to parent-child interactions while cooking. Parents were asked to audio record themselves cooking with their 3- to 5-year-old child twice a month for three months. Families were encouraged to use the provided learning tips but were invited to cook any recipe they wished, including their own recipes, and were observed cooking in parent-child dyads as well as larger family units.

Participants of the intervention study were predominantly middle-class families that were racially diverse, with almost half of the parents reporting their child was Black (45%) and the remaining parents reporting their child was Multiracial (23%), White (16%), Latinx (13%), or Asian (3%). The majority of the children's mothers had received a college degree. Existing research on parent number talk has tended to focus on two distinct racially and socioeconomically situated communities: White, middle-class families with college experience and families utilizing Head Start programs, who

reported lower income and educational attainment and were more likely to identify as families of color. It is important for early math research to represent the diversity of families. The present study takes a step in this direction by analyzing participation in numeracy pedagogy within a sample that includes primarily middle-class, college educated parents of color and their children.

Analytically, the focus of the dissertation was on answering two questions. First, what were parents and children doing when they talked about numeracy? In answering this question, I identified distinct ways that families engaged in number talk, addressed how parents and children constructed sequences of pedagogical talk about number, and described the specific activities parents and children enacted through these sequences of numeracy pedagogy. Second, how did different aspects of the cooking activity afford different kinds of number talk? Addressing this question demonstrated the role of recipes, ingredients, and cooking tools in shaping the affordances for numeracy pedagogy.

Methodology

CA is an inductive, qualitative methodology for examining the sequential organization of social action in interaction. It is based on the theoretical perspective that talk-in-interaction cannot be attributed to individual interlocutors but must instead be viewed as an interactional accomplishment (Raymond & Sidnell, 2014; Sterponi & De Kirby, 2017). Conversation analysts argue that talk is produced collaboratively and incrementally through turn-taking sequences (whether back-and-forth, synchronous, or overlapping), with speakers' talk making particular next actions relevant and constraining the possibilities for their social partners' subsequent turns (Raymond & Sidnell, 2014; Schegloff & Sacks, 1973). Given that turns create an expectation for what will follow,

subsequent turns display to the participants of an interaction—and researchers analyzing the interaction—how prior turns were understood (Raymond & Sidnell, 2014; Schegloff, 2007; Schegloff & Sacks, 1973; Tarplee, 2010). CA is also part of an intellectual tradition that asserts that talk-in-interaction is not just the exchange of ideas, but rather that interlocutors together enact social action through their use of language and nonverbal behavior (Austin, 1962; Duranti, 2006). Conversation analysts examine the organized methods interlocutors use to jointly produce shared understandings and accomplish meaningful social action (Raymond & Sidnell, 2014; Schegloff & Sacks, 1973).

For the purposes of examining family participation in numeracy pedagogy, CA has several notable strengths. By attending to family members' interlocking turns within the unfolding of interaction, for example, CA allows for examining number talk within the interactional and activity contexts in which it occurred as families construct sociocultural activities. Moreover, theoretically, CA is aligned with sociocultural perspectives that contend learning is a collaborative process embedded within sociocultural activities that is best examined with attention to transformations in individuals' participation rather than their internalized knowledge (Lave & Wenger, 1991; Rogoff, 1998). With its focus on the sequential organization of interactional partners' publicly displayed conduct, CA provides a tool for examining how learning is enacted as children participate in the moment-to-moment construction of social exchanges and how this participation changes over time (Kasper, 2008; Sahlström, 2009). This can inform researchers' understanding of human cognition by documenting how children competently navigate the mutual dependencies of interaction (Lerner et al., 2011; Wootton, 1997). Additionally, using CA to study family number talk can

illuminate how families' interactional routines socialize children into cultural ways of enacting caregiver-child relationships and doing math (Ochs, 1986; Tarplee, 2010).

Significance of the Study

The present dissertation had two primary motivations. First, it sought to describe how the families participated in a home-based early learning intervention. While not directly comparing the families in the treatment and control conditions, the analysis addressed how families engaged in number talk during their participation in an intervention and how intervention materials, including tips, may have contributed to how families constructed the activity of cooking together. Examining family participation in numeracy pedagogy within the context of this particular intervention was useful because the design of the intervention allowed for greater flexibility in how families organized and oriented to the cooking activities than is afforded by other interventions (e.g., Gibson et al., 2020; Vandermaas-Peeler et al., 2012a; Zippert et al., 2019). Families were allowed to select what they cooked and to include whomever they wanted in the activity, and they used their own ingredients, cooking tools, and kitchen, with these choices and materials resulting in different opportunities for child participation. Additionally, as a goal-oriented activity, these interactions allowed for analyzing how parents and children worked toward accomplishing a shared objective. While this study cannot illuminate how the participating families might engage in number talk outside of the context of this intervention or how families from other cultural backgrounds might participate in this intervention, the analysis provides preliminary insights into how middle-class families, including middle-class families of color, might engage with school-provided materials or interact in other contexts that evoke dominant, school-like pedagogical practices.

Second, this dissertation aimed to address existing gaps in the literature on number talk by examining how parents and children collaboratively constructed sequences of pedagogical talk about number. Existing research largely has not examined number talk within the interactional and activity contexts in which it occurred or considered what sequences of number talk allowed parents and children to accomplish together within an activity. Within the literature, there has been minimal attention to how families engage in pedagogy practices related to numeracy or how variations in the same activity (e.g., different recipes, cooking tools, ingredients) shape the affordances for numeracy pedagogy. The current dissertation was designed to help address these aims for the purpose of informing developmental science and applied work with families.

CHAPTER 2: LITERATURE REVIEW

In this literature review, I present theory and research from the fields of developmental psychology and conversation analysis (CA) that provide a foundation for understanding the present dissertation. First, I describe existing developmental research on the role of the home environment, particularly parents' use of number talk, in children's early numeracy learning. Second, I delineate methodological and theoretical limitations of existing research on number talk and introduce the value of applying CA theory and methods to the study of family number talk. Third, I discuss fundamental tenets of CA and present the multidimensional view of talk that guides CA research. Fourth, I present developmental and CA research relevant to understanding family engagement in pedagogy. Finally, I describe the research questions and aims of the present study.

Early Numeracy and the Home Environment: The Role of Parent Number Talk

Importance of Children's Early Math Skills

Developmental theory has long emphasized cognitive development as a hierarchically organized skill progression by which early learning forms a foundation for later, more sophisticated, skill acquisition (Fischer, 1980; Piaget, 1985). And, more recently, human capital theories from economics have underscored the critical role of early skills in long term academic achievement and life chances (Cunha et al., 2006). These perspectives have become all the more influential as neuroscience has demonstrated the exceptional importance of context, experience, and learning in the first years of life for healthy brain growth (Institute of Medicine & National Research Council, 2000; Noble et al., 2012). As a result, there is wide consensus that young children's learning experiences prior to kindergarten provide a foundation for their later achievement (Watts et al., 2014; for a review, see Blair, 2002). Among the early learning skills that may prepare children for school, early math skills appear vital. Analyses using data from large-scale longitudinal studies in the United States, Canada, and the United Kingdom have shown that children's cognitive skills at school entry predict their academic achievement later in elementary school, with early math skills being one of the strongest predictors of children's later performance on standardized assessments of both math and literacy (Duncan et al., 2007; Duncan & Magnuson, 2011; Pagani et al., 2010; Romano et al., 2010). These findings suggest lasting implications of children's early math skills for their academic achievement and underscore the importance of understanding the experiences that support young children's math development.

Early Numeracy Skills

A major focus of kindergarten math instruction in the United States is supporting children's development of skills in representing, comparing, and conducting basic operations with whole numbers (Common Core State Standards Initiative, n.d.). These skills include (Common Core State Standards Initiative, n.d., Nguyen et al., 2017):

- *Numerical identification*: recognizing and writing numerals; mapping numerals to number words and quantities
- *Counting*: memorizing the order of the counting sequence; learning to count sets of objects with one-to-one correspondence
- *Cardinality*: learning to label the quantity of objects in a set; recognizing that the last number uttered when counting a set represents the quantity of the entire set; producing sets of a particular quantity; quickly labeling the size of small sets
- *Quantity comparison*: comparing numerals and the magnitude of sets
- *Basic addition and subtraction*: gaining awareness of vocabulary and symbols of addition and subtraction problems; solving addition and subtraction equations and word problems; developing fluency with basic addition and subtraction problems

Research has shown that preschoolers' early numeracy skills, particularly their cardinality skills, are a stronger predictor of their fifth-grade math achievement, compared to other domains of early math (Nguyen et al., 2016). Developing a strong foundation in these skills prior to kindergarten appears to lay a foundation for children's

math achievement in kindergarten and beyond (Duncan et al., 2007; Galindo & Sonnenschein, 2015).

The Role of Parents and the Home Environment

The home learning environment has been shown to be critical for children's early cognitive development and accounts for variation in young children's academic skills at school entry (for a review, see Bradley & Corwyn, 2004; Dearing & Tang, 2010). Research has demonstrated that several aspects of the physical and social environment children experience at home are associated with the growth of their early cognitive skills: organization and physical structure of the home (e.g., Vernon-Feagans et al., 2012); access to learning materials, such as books and puzzles (e.g., Galindo & Sonnenschein, 2015); family engagement in learning activities (e.g., Sonnenschein & Sun, 2017); parent-child conversations (e.g., Thompson, 2006); parental efforts to teach skills (e.g., Huntsinger et al., 2016); and sensitive and responsive parenting (e.g., Bradley et al., 2001).

Empirical evidence documenting the critical role of the home environment for early math is less robust than that for literacy, but has grown considerably over the last decade. Researchers have identified several factors related to children's home learning experiences that predict their early math competence, with most of this research focused on children's early numeracy skills (e.g., Levine et al., 2010; Niklas & Schneider, 2014; Skwarchuk et al., 2014). For instance, drawing data from a sample that was representative of the U.S. population, Galindo and Sonnenschein (2015) found that the general learning support kindergarteners received from their parents, specifically children's access to learning resources at home, the frequency of parent-child storybook

reading, parents' expectations for their children's future educational attainment, and parents' involvement at their children's school, predicted their math achievement at the end of kindergarten, above and beyond their math proficiency at kindergarten entry, when controlling for various child, family, and school covariates. These researchers found that together children's math proficiency at the start of kindergarten and their home environment partially mediated the relation between family SES and children's math achievement at the end of kindergarten, when comparing across five SES quantiles (Galindo & Sonnenschein, 2015).

In addition to the general learning support children receive at home, many studies have found that *parent-reported* frequency of engaging children in numeracy-related activities at home predicts their concurrent and later math skills (Anders et al., 2012; Blevins-Knabe & Musun-Miller, 1996; del Río et al., 2017; Huntsinger et al., 2016; Kleemans et al., 2018; LeFevre et al., 2009; Mutaf Yıldız et al., 2018; Niklas & Schneider, 2014; Skwarchuk et al., 2014; Susperreguy et al., 2020; Vasilyeva et al., 2018). Underscoring the importance of home activities that explicitly teach math skills, such as practicing basic arithmetic, Huntsinger et al. (2016) found that parents' reports of the frequency with which they engaged with their child in these activities during preschool or kindergarten was a stronger predictor of not only children's math skills but also their reading skills concurrently and one year later, compared to engagement in home reading activities. This sample was predominantly White and relatively advantaged, with all children attending high quality early education programs, suggesting parent support of early math skills contributes to children's achievement above and beyond participation in early education programs.

Over the past decade, researchers have also used *direct observations* of parent-child interactions at home and in laboratory contexts to understand the relation between parents' numeracy support and young children's math skills (e.g., Levine et al., 2010; Ramani et al., 2015). Similar to research on children's language and literacy development examining the effects of parent talk (e.g., Hart & Risley, 1995; Hoff, 2003; Weizman & Snow, 2001), research on parent number talk has examined the role of the quantity, diversity, and complexity of numeracy-related words and utterances. In general, this research is aligned with sociocultural perspectives on children's learning, contending that caregivers, through their use of language and provision of support during social interactions, enable children to engage in more advanced thinking than they could do alone (Gauvain, 2013; Vygotsky, 1978). Vygotsky (1978) argued that children initially rely on the speech of others to organize their thinking and problem solving, but through repeated exposure, this language is internalized and inner speech begins to guide their thinking processes. From this perspective, parents' use of number talk is thought to structure and advance young children's thinking about numeracy concepts.

Empirically, this research on parent math talk has generally focused on parents' use of language that models and elicits discussion of numeracy concepts, often referred to as *number talk*, during free play (e.g., Casey et al., 2018; Elliot et al., 2017), daily routines (e.g., Levine et al., 2010, Susperreguy & Davis-Kean, 2016), cooking activities (Son & Hur, 2020), and math-specific activities (e.g., Ramani et al., 2015). In general, this research has shown that parents' use of number talk predicts their concurrent (e.g., Elliot et al., 2017; Ramani et al., 2015) and future math skills (e.g., Casey et al., 2018;

Levine et al., 2010; Susperreguy & Davis-Kean, 2016). Below, these studies are reviewed.

Existing Research on Parent Number Talk

Studies of children's naturalistic interactions with their parents have shown that the frequency of parents' use of number talk during daily activities predicts children's later numeracy skills (Levine et al., 2010; Susperreguy & Davis-Kean, 2016). Levine et al. (2010) conducted five 90-minute (for a total of 7.5 hours) home video observations of 44 parent-child dyads living in the Chicago metropolitan area when the children were 14 to 30 months of age. The families were predominantly White (70%), with most parents reporting college experience (M = 15.9 years, SD = 2.1). They found that the total number words (i.e., words *one* through *ten*) parents used during the observations predicted children's cardinal number knowledge at 46 months, controlling for family socioeconomic status and the frequency of parents' and children's overall talk (i.e., total amount of non-numeric words spoken). This study provides evidence that the domain specificity of parent talk is important for children's learning and development: children's numeracy skills at 46 months were associated with parents' early use of numerical language but not their general level of talkativeness (Levine et al., 2010). Similarly, parents' use of number words predicted only their numeracy skills and not their overall vocabulary at 54 months. This underlines the value of understanding how specific parental behaviors during their interactions with their children relates to their learning and development within specific domains.

Susperreguy and Davis-Kean (2016) found similar results when examining mothers' use of number talk during mealtimes with their 4- and 5-year-old children. The

participants—40 families living in a midwestern metropolitan area of the United States—were largely White (65%) and most parents reported college experience (M = 15.5 years, SD = 2.17). Using LENA devices, mothers were asked to record their interactions with their child over the course of three days (Susperreguy & Davis-Kean, 2016). In order to analyze a similar context across families and a context with plentiful opportunities for family conversation and discussion of math concepts, the researchers selected to analyze instances of maternal talk about numeracy concepts or talk eliciting child discussion of numeracy concepts during 4 hours of mealtimes. When controlling for maternal education, child age, and child self-regulation skills, Susperreguy and Davis-Kean (2016) found that maternal number talk predicted children's math ability one year later (measured using TEMA-3). After accounting for these three covariates, mothers' use of number talk explained an additional 9% of the variance, with all four variables explaining 50% of the variance in children's math ability (Susperreguy & Davis-Kean, 2016).

In addition to examining the association between the total quantity of parent number talk and children's numeracy skills, researchers have begun to identify variations in parents' use of number talk that appear to be more effective at promoting their children's learning. Using the same data as Levine et al. (2010), Gunderson and Levine (2011) further examined instances of parent number talk involving counting and cardinal values. They found that instances of parent counting and cardinal values about present objects, but not talk about non-present objects, predicted children's cardinal number knowledge at 46 months, when controlling for family SES. Additionally, parent number talk about large sets (4-10) of present objects was a stronger predictor of children's cardinal number knowledge than parent number talk about small sets (1-3) of present

objects. When controlling for parents' overall speech and family SES, parent number talk about large sets of present objects explained an additional 15.7% of the variance in children's cardinal number knowledge.

Elliot et al. (2017) found similar results examining mothers' use of number talk with their 5- or 6-year-old children during 10 minutes of free play within the context of a research laboratory. The 54 participating families lived in a medium-sized U.S. city, the children were predominantly White (89%), and the majority of mothers had a bachelor's degree or advanced degree (89%). Mothers' overall use of number words did not predict their children's concurrent math ability (measured using TEMA-3). However, the proportion of large number words (>10), but not the proportion of small (1-5) or medium number words (6-10), used by parents significantly predicted children's concurrent math skills. This association between parents' use of number words larger than 10 and children's math skills remained significant when controlling for children's use of number words. Elliot et al. (2018) argued that the results of their study in tandem with Gunderson and Levine's (2011) analysis underscore the importance of parents tailoring their number talk based on children's current numeracy knowledge and skills, such that their number talk pushes children to engage within their zone of proximal development. Three-year-old children appear to benefit from having heard more talk about sets of 4-10 present objects during their toddler years, while children in kindergarten and first grade may benefit from exposure to numbers above 10.

Other researchers have investigated associations between specific domains of number talk and children's numeracy skills. Ramani et al. (2015) distinguished between three types of caregiver support for preschool children's number learning: a) engaging

their children in home numeracy activities, b) providing number talk about foundational numeracy concepts, specifically counting and numeral identification, during math-related activities, and c) providing number talk about advanced numeracy concepts, specifically cardinality, arithmetic, and ordinal relations, during math-related activities. Thirty-three caregivers and their 3- to 5-year-old children were recruited from Head Start classrooms in the Mid-Atlantic area of the United States: the children were predominantly children of color (67% African-American/Black, 12% Hispanic/Latinx, 12% Multiracial), and although 63% of the caregivers reported some college or vocational training, only 9% had received a bachelor's or advanced degree.

Ramani and colleagues (2015) video recorded the caregiver-child dyads interacting together for 15 minutes using a standardized set of three play materials depicting numerals (i.e., counting book, puzzle, and board game) in an empty classroom and administered multiple measures to assess children's concurrent foundational and advanced numeracy skills. Ramani et al. (2015) examined number talk at the utterance level, calculating the proportion of parent (and child) utterances that discussed or prompted the discussion of foundational and advanced numeracy concepts. They found that neither parents' foundational or advanced number talk during the interaction was significantly associated with children's foundational numeracy skills; rather, child age and parent report of the frequency of engaging in direct teaching of number skills at home positively predicted children's foundational numeracy skills. Conversely, children's advanced number skills were significantly predicted by only parents' advanced number talk, suggesting that exposure to more advanced numeracy concepts during math-

related activities is important for helping children move beyond counting and numeral identification and develop knowledge of more advanced numeracy skills.

Similarly, Casey et al. (2018) analyzed the predictive value of three types of number talk: one-to-one counting of present objects, numeral identification, and use of cardinal values to label the quantity of a set of objects. To do so, they coded mother's use of number talk utterances that modeled or elicited discussion of these three numeracy concepts during mother-child interactions that were video recorded for 140 dyads participating in the Boston site of the NICHD Study of Early Child Care and Youth Development (84% White). Mothers and children were observed during 10-minutes of semi-structured free play in a laboratory setting when children were 36 months old. Controlling for various child and maternal covariates, maternal support for cardinality (i.e., labeling sets), but not numeral identification and one-to-one counting, predicted children's performance on WJ Applied Problems (and not WJ Letter Word) at both age 4.5 and first grade.

For another study, Son and Hur (2020) examined associations between three domains of caregiver numeracy-related utterances and 4-year-old children's fall and spring math skills: number talk (e.g., counting objects, numeral identification), operation talk (e.g., arithmetic, magnitude comparison), and measurement talk (e.g., measuring time, amount, or temperature). At the beginning of the school year, 46 children attending a Head Start program in a midwestern city in the U.S. participated in a 15- to 20-minute semi-structured cooking interaction with their caregivers. The children were ethnically diverse (50% White, 18% African American, 10% Hispanic, 10% Multiracial, 2% other) and less than half (42%) of the caregivers had college experience. The caregiver-child

dyads made cupcakes in their own home using a box of cake mix. All required ingredients, materials, and a portable oven were provided to families to complete the activity.

While caregivers' total math talk was not associated with children's fall math scores, caregivers' number talk was positively associated with children' fall math scores. There were no direct associations between caregivers' total math talk or the specific measures of math talk and children's spring scores. However, Son and Hur (2020) found that caregivers' use of task-orienting talk moderated the association between parents' math talk and children's spring math skills. Task-orienting talk (i.e., talk that described and provided a rationale for recipe tasks) was hypothesized to scaffold children's attention and behavioral participation in the cooking activity. They found that when caregivers engaged in more task-orienting talk, their math talk was positively associated with children's spring math scores. When caregivers engaged in less task-orienting talk, their math talk was negatively associated with children's spring math scores. The same pattern was observed for caregivers' use of measurement talk. This moderation analysis raises the possibility that other types of parent talk occurring within an activity, and perhaps happening within courses of action that involve math talk, structure children's engagement with numeracy or otherwise influence children's attention to numeric information within an activity (Son & Hur, 2020). This draws attention to the importance of examining how number talk is embedded within larger sequences of talk and embodied action.

The literature on number talk has found that particular characteristics of parents' talk about numbers and quantity are associated with children's concurrent and later

numeracy skills. The variations across these studies in terms of the age of participants (i.e., toddlers vs preschoolers); how number talk was measured (i.e., word- or utterance level; whether and how specific domains were coded and analyzed); the activity contexts observed (i.e., naturalistic vs semi-structured observations; affordances for math within different activities); the type of numeracy skills assessed (i.e., specific cardinality task vs standard math assessments); and the demographic characteristics of the families (i.e., White, middle-class families vs families utilizing Head Start) make it challenging to draw conclusions about when, for whom, and for which measures of number talk is parent number talk associated with children's math skills. However, there is some evidence that number talk that is within children's current zone of proximal development (e.g., quantities of 4-10 for toddlers; quantities above 10 for preschoolers; more advanced numeracy for preschoolers) at the time of observation is more likely to be linked to children's numeracy skills. To understand the mechanisms through which parents' number talk might promote children's numeracy skills, there is a need for more nuanced examination of how parents and children participate in number talk within different activity contexts, how variations in parents' number talk shape how children engage in number talk, how parent-child numeracy exchanges contribute to their participation in different activities, and how the affordances of activities influence family number talk.

An additional limitation of existing number talk research are the families represented in the literature. Four of the six samples used to examine parent-child number talk consisted primarily of White, college educated parents and their young children. The two other samples involved families utilizing Head Start programs that were either ethnically diverse (Son & Hur, 2020) or primarily families of color (Ramani et al., 2015),

with the primary caregivers in these families reporting lower household income and educational attainment. There is value in understanding how ethnically, geographically, linguistically, and socioeconomically diverse families participate in number talk and how family number talk is linked with children's skills within different contexts and communities. This present study takes an initial step in this direction by examining family participation in number talk within a sample that includes primarily middle-class, college educated parents of color and their children. Additional methodological and theoretical limitations of the extant number talk literature are discussed in the next section.

Methodological and Theoretical Limitations of Number Talk Research

Research on number talk has followed more general trends in the field of developmental psychology, particularly with regard to the language constructs of interest and methodological conventions. With regard to constructs of interest, studies have tended to focus primarily on *understanding the effects of parent talk* on children's thinking. Within the field at large and in studies of number talk, researchers have generally identified characteristics of parent talk (e.g., quantity, diversity, and complexity) and verbal behaviors (e.g., use of pedagogical questions) that vary by child, parent, or family factors (e.g., socioeconomic status) and predict child outcomes (e.g., Doan & Wang, 2010; Hoff, 2003; Levine et al., 2010).

By focusing primarily on parent talk, this research fails to capture how children and parents jointly negotiate and construct what occurs within their interactions. According to research from the field of conversation analysis (CA), interlocutors collaboratively produce their turns through their ongoing exchange, with the talk of each

participant shaping the subsequent contributions of their social partners (Raymond & Sidnell, 2014; Schegloff & Sacks, 1973). Even when developmental psychologists do account for children's contributions in parent-child interactions, their efforts do not reflect the collaborative nature and interactional purpose of parent and child talk. For instance, researchers examining parent number talk have controlled for child talk variables (e.g., total child utterances, total child number words; Elliot et al., 2017; Levine et al., 2010) or child characteristics (e.g., age, gender, and self-regulation skills; Casey et al., 2018; Levine et al., 2010; Susperreguy & Davis-Kean, 2016) in their regression models to account for child interests and traits that might evoke particular types of talk from parents.

The purpose of this practice is to isolate the effects of parent talk on children's skills by statistically accounting for the influence children have on their own skill development. This line of inquiry has identified characteristics and categories of parent talk that predict children's numeracy skills. However, this research does not allow for understanding how these categories of parent talk are produced, understood, or made relevant within interactions and how they contribute to children's construction of math knowledge. Moreover, this research aims to statistically control for children's active participation in their interactions, rather than making their participation—including when and how they "evoke" parent number talk during an interaction—the focus of study.

Methodologically, it is conventional for these studies to use word- or utterance-level frequencies—or similar summative quantitative indicators—to represent the scaffolding and socialization children experience. This methodological approach isolates talk from its context within interaction and overlooks the full range of embodied

resources (e.g., pitch, volume, stress, gaze, gesture) that interlocutors draw on to construct meaning (Gardner & Forrester, 2010; Hengst, 2015). Scholars from the field of sociolinguistics have argued that the meaning of an utterance cannot be determined separate from the context in which it was uttered and received; social partners rely on a variety of contextual cues, such as word choice, prosodic and paralinguistic features, and shared history within and prior to the ongoing interaction, to infer the meaning of talk (Gee, 2005; Gumperz, 1992). Thus, attempting to separate instances of talk from the sequential exchange of interaction and focusing primarily on the semantic content of utterances undermines researchers' understanding of the meaning and function of talk for the participants of the interaction (de Ruiter & Albert, 2017; Tarplee, 2010). This may lead to an incomplete, or even inaccurate, understanding of what parents and children are doing within an interaction and through their use of number talk.

To gain a comprehensive understanding of how parents and children co-construct number talk within an interaction, researchers need to examine what parents and children are doing through their sequential exchange and attend to how individual turns comprise larger courses of action. While there has been increasing acknowledgement of the importance of the back-and-forth exchange of parent-child interactions for children's learning (e.g., Golinkoff et al., 2019; Susperreguy & Davis-Kean, 2016), initial studies aimed at capturing the role of this exchange in children's language development have taken a similarly reductionist approach to parent-child interactions, using the frequency of conversational turns and rating scales to quantify children's conversations with their parents (Hirsh-Pasek et al., 2015; Romeo et al., 2018; Zimmerman et al., 2009).

Researchers studying early math development have also computed correlations between the amount of parent and child number talk within observations with evidence that the two are positively associated (e.g., Elliot et al., 2017; Gürgah Oğul & Aktaş Arnas, 2020; Levine et al., 2010; Ramani et al., 2015). Moreover, recent investigations have sought to better understand the relation between parent and child number talk, by examining how the total frequency and variations in the design (i.e., prompts versus statements) of parent number talk utterances predict characteristics of child number talk (e.g., quantity and diversity of number words, frequency of spontaneous number utterances; Eason et al., 2021; Nelson et al., 2019). Again, all of this research treats parent and child talk as discrete events within an interaction, rather than as a collaborative, sequentially-organized exchange that both parents and children actively work to produce. Indeed, given that parent and child talk is inherently mutually dependent, it is unsurprising that researchers find associations between the two.

The Theory Behind the Methods

Attention to theoretical orientation is helpful for understanding the conventional empirical focus in early math research to date. Research on parent number talk has been largely situated within a theoretical tradition that views cognition as an individual process that is altered and influenced by social, contextual, and cultural factors; children's social interactions are thought to provide them with environmental *input* that they consume and internalize, leading to changes in their internal mental representations and cognitive processes (Gauvain, 2013; Vygotsky, 1978). Researchers from this cognitivist perspective view children's math competence as an internal resource that contributes to but is separate from their engagement in math discussions and activities and, thus, seek

'pure' measures of children's math knowledge and attempt to isolate the effect of children's social environments on their math development (Kasper, 2008; Rogoff 1998). Conducting research at the individual level, researchers from this tradition reduce children's social and cultural experiences to distinct variables (e.g., parent talk, family socioeconomic status) and examine how these variables are associated with measures of children's competence (Rogoff, 1998; Rogoff et al., 2018).

In contrast, sociohistoric-cultural theorists (e.g., Lave & Wenger, 1991; Rogoff, 2003) view cognition as embedded and inseparable from children's participation in sociocultural activities and as a collaborative process distributed between humans, cultural tools, and institutions (Gallagher, 2013). Rather than trying to identify children's underlying cognitive competencies, researchers from this perspective examine children's lived experiences within their everyday contexts, describing children's participation—their observable behavior—in the daily activities of their community and documenting how this participation changes over time (Rogoff, 1998; Rogoff et al., 2018). This theoretical orientation calls for examining how children's math learning is enacted through their daily interactions, with parent-child participation in number talk being viewed as a sociocultural activity worthy of studying in its own right. Although rarely used in developmental psychology, a method that is closely aligned with this theoretical perspective is conversation analysis (CA) (Kasper, 2008; Sahlström, 2009).

Making the Case for Conversation Analysis in Early Math Research

One way to address the limitations of existing number talk research may be through the use of CA. CA provides researchers with a method of examining the sequential exchange of human interactions, enabling a focus on how parents and children

collaboratively produce turns of talk. This can allow for investigating how parents and children construct sequences of number talk and illuminate the interactional meaning and function of number talk for parents and children. Moreover, the focus of CA research is on the organization of interlocutors' conduct—their talk and use of embodied communicative resources—within an interaction. Thus, consistent with sociohistoric-cultural theory, CA provides a tool for analyzing parents' and children's participation in number talk and how they construct courses of action within and through their number talk. This analytic approach can expand the field's understanding of how parents and children together construct numeracy knowledge during their interactions and has implications for intervention efforts aimed at encouraging family numeracy engagement.

Conversation Analysis as a Tool for Studying Family Number Talk

CA is a theoretical and methodological approach that examines how social action is organized in human interaction, documenting how interactional partners build shared understandings through turn-taking sequences (i.e., intersubjectivity) and accomplish actions that are recognizable and meaningful (Bateman & Church, 2016; Sidnell, 2013; Sterponi et al., 2015). In recent years, there has been an increased interest in using conversation analysis (CA) to study children's social interactions (Bateman & Church, 2016; Butler, 2017; Gardner & Forrester, 2010).

Originating from the sociological field of ethnomethodology, CA is based on the premise that social order is constructed through the everyday methods people use to accomplish joint action (Bateman & Church, 2016; Kasper, 2008; Sahlström, 2009). From this perspective, mundane interaction is posited to be the foundation of human institutions and society and the context within which human language, cognition, and

culture evolved (Goodwin, 2006; Raymond & Sidnell, 2014; Schegloff, 1989, 2006). Conversation analysts have demonstrated that social interaction is inherently orderly, governed by a system of practices and regularities that are independent of individual psychology and emerge interpersonally to constrain interlocutors' behavior within an interaction (Enfield & Levinson, 2006; Schegloff, 2006; Schegloff & Sacks, 1973; Sidnell, 2013). It is through orienting to—that is, through behaving and interpreting behavior with reference to—these norms and regularities that interactional partners perform intelligible social actions and recognize the social actions being enacted by others (Raymond & Sidnell, 2014; Schgeloff, 2007). While the field of CA seeks to identify the organizational structures of interaction, researchers of other disciplines have increasingly applied CA methods and empirical evidence to enhance their understanding of social and interactional phenomena, such as learning, socialization, and pedagogical practice (e.g. Bateman & Church, 2016; Kasper, 2008; Sahlström, 2009).

Using CA to study family number talk involves shifting from viewing number talk as an individual cognitive activity occurring within the social context of an interaction to viewing number talk as a joint interactional practice that is enacted by adults and children for the purpose of doing things together (Kasper, 2008; Sahlström, 2009; Sterponi et al., 2015; Sterponi & De Kirby, 2017). Given that human interaction is organized according to its own emergent properties, family discussion of numeracy concepts during everyday interactions is likewise organized according to these properties (Enfield & Levinson, 2006; Schegloff, 1989). Thus, to understand the meaning of number talk for parents and children—what it allows them to accomplish within an interaction—it is necessary to examine parents' and children's use of number talk within the context in

which it is uttered and received. Studying family number talk in this way allows researchers to understand how parents structure children's participation in number talk through their own talk and how children use the understandings and resources available to them through the sequence of interaction to participate in number talk (Lerner et al., 2011; Tarplee, 2010; Wootton, 1997, 2010). The focus of CA research on examining parents' and children's observable conduct within an interaction can shed light on how children's participation in number talk socializes them into cultural ways of interacting, engaging in social relationships, enacting learning, and doing math.

Below, I offer a multidimensional view of talk-in-interaction that expands upon the traditional theoretical understanding of language in developmental science and describe its implications for studying family number talk.

Towards a Multidimensional View of Family Number Talk

Aligned with the theorizing of Vygotsky (1978), development psychologists primarily view language as a symbolic system through which individuals exchange ideas and represent the world (e.g., Gauvain, 2013). From this perspective, more competent social partners expose children to cultural ideas through their use of language, modeling particular ways of thinking and solving problems (Gauvain, 2013; Vygotsky, 1978). Through repeated interactions, children internalize this language, such that it becomes integral to their own thinking and problem solving, and use it to express their own ideas (Gauvain, 2013; Vygotsky, 1978). Researchers aligned with this theoretical perspective on language view utterances spoken within an interaction as directly reflecting individual cognition (Sterponi et al., 2015; Sterponi & De Kirby, 2017) and study parent talk with the purpose of identifying the information it transmits to children (e.g., number words

represent quantities of objects in the world) and the opportunities it creates for children to internalize this information and practice using it to organize their thinking and behavior (e.g., parent use of *Wh*-questions during storybook reading; Gauvain, 2013).

Drawing on scholarship from the fields of linguistic anthropology and CA, Sterponi and colleagues (2014; 2017) have demonstrated that this perspective limits researchers and practitioners understanding of interactional phenomena (e.g., verbal behavior of children diagnosed with autism), with implications for research examining and interventions aim at addressing perceived deficiencies in children's and families' communication. They present a framework for understanding and studying social interaction that draws attention to dimensions of language overlooked by developmental psychologists, arguing that talk is *constitutive of social action*, an *interactional accomplishment*, and a *mode of experience*.

Talk is Social Action

CA is part of an intellectual tradition that asserts that social interaction is not simply the exchange of ideas; rather, conversation analysts and linguistic anthropologists argue that the primary function of talk-in-interaction is the performance of social action (Duranti, 2006; Ochs, 2012; Raymond & Sidnell, 2014; Schegloff, 1989; 2006; 2007; Sterponi et al., 2015; Sterponi & De Kirby, 2017). Catalyzed by Austin's (1962) speech act theory, these scholars contend that interlocutors use language and embodied resources, such as pitch, volume, posture, gaze, and manipulation of objects, to collaboratively enact social actions, such as promising, accusing, apologizing, greeting, teasing, complaining, offering, accepting, rejecting, agreeing, disagreeing, asking, answering, and reporting (Hengst, 2015; Schegloff, 2006; 2007). Thus, through talk-in-

interaction, social partners actually construct, rather than reflect, their social worlds (Austin, 1962; Bateman & Church, 2016). Researchers using CA examine how interactional participants perform social actions through their talk, identifying the actions implemented through particular linguistic forms and interactional behaviors, and how their actions are organized within turn-taking sequences to form larger action trajectories (Levinson, 2013; Raymond & Sidnell, 2014).

Conversation analysts stress that the meaning of interactional turns—that is, the social actions they enact—is only evident through examining them within their context in the sequence of interaction (Sterponi et al., 2015; Sterponi & De Kirby, 2017). As will be described in more depth below, social actions are not produced randomly over the course of social interaction; instead, actions are implemented through sequences of turns, with preceding turns making particular subsequent actions relevant (e.g., inviting makes relevant accepting or declining) and timing within the larger interaction making some actions more relevant than others (e.g., greetings occur at the opening of an interaction; Schegloff, 2006; 2007; Tarplee, 2010). In addition to designing talk based on prior turns and its location within the overall interaction, interlocutors also design their conversational turns for their social partners, considering, for instance, the intended recipients' knowledge and their shared interactional history (Drew, 2013; Hengst, 2015).

While some actions are accomplished through single turns, other actions are pursued over the course of multiple turns, with the project being pursued often becoming evident through the unfolding of the interaction (Levinson, 2013). Co-participants also often pursue larger joint activities within interaction (e.g., completing a recipe, building a block tower, moving a bench), implementing the activity through a series of

interconnected projects, which sometimes consist of two or more subprojects (Bangerter & Clark, 2003). These endeavors often require interactional partners to coordinate their embodied actions through talk as they plan and implement the activity (Bangerter & Clark, 2003).

Given that talk is produced for the primary purpose of enacting particular actions within an interaction, it is important to analyze what it is that parents and children are doing through their use of number talk. Identifying the actions produced through parent and child number talk and the specific methods they use to do so requires analyzing individual parent and child turns within their local context in the turn-taking sequence and the overall context of a particular interaction. This can help clarify what information parents and children draw on to construct their turns of talk containing discussion or references to number and quantity and what these turns allow them to accomplish together. This information is particularly important for designing interventions aimed at increasing or enhancing family number talk. Encouraging or discouraging parents' use of particular forms of talk without a clear understanding of their function within interaction and their interdependencies with other parent and child talk, embodied resources, interactional practices, and the larger family context could undermine the effectiveness of the suggested language practices or, worse, have unintended consequences for families' communicative processes (Bottema-Beutel et al., 2020; Sterponi et al., 2015; Sterponi & De Kirby, 2017; Yu, 2016).

Talk is an Interactional Accomplishment

As explained above, developmental psychologists view language as a cognitive tool that reflects and guides individual thinking, seeing utterances as resulting from

individual psychology (Sterponi et al., 2015; Sterponi & De Kirby, 2017). Based on this theoretical perspective, developmental psychologists treat utterances as isolated entities that can be aggregated and have meaning outside of the social exchange in which they occur (Sterponi et al., 2015; Sterponi & De Kirby, 2017). Conversation analysts argue this approach overlooks how talk is produced collaboratively and incrementally through turn-taking sequences within the context of specific interactions, stressing that talk cannot be separated from its communicative and interactional function for the participants involved (Raymond & Sidnell, 2014; Sterponi et al., 2015; Sterponi & De Kirby, 2017).

At its core, CA aims to document how human interaction works. Early studies in the field on adult conversation were focused on identifying the organizational structures of interaction that enable human communication (e.g, Schegloff, 1982; Schegloff & Sacks, 1973). Emanuel Schegloff (2006; 2007), one of the founders of CA, has argued that all human interaction, regardless of the larger context in which it occurs, presents practical problems for its participants, such as:

- Who gets to talk when and for how long?
- How are turns designed to perform actions that are intelligible?
- How do speakers and recipients carry out coherent courses of actions?
- How are issues of speaking, hearing, and understanding identified and addressed?

Conversation analysts have identified organizational structures of interaction that provide generic solutions to each of these practical problems: practices of turn-taking, turn design, sequence organization, and interactional repair, respectively (e.g., Schegloff, 2006, 2007). While additional cross-cultural research is needed to identify the extent to

which the solutions to these generic problems are universal or culturally variable, there is some evidence of a universal infrastructure of interaction that is enacted in culturally-specific ways (Ochs, 1996; Schegloff, 2006; Stivers et al., 2009). From this perspective, the universal features of interaction, which likely arise from universal resources and constraints of human life, are thought to be the genesis of human culture, enabling the diversity seen among human communities (Ochs, 1996; Schegloff, 2006).

The organizational structures of interaction are thought to operate at the interpersonal level, providing interlocutors with a system of norms and expectations that they use to construct shared understandings and accomplish joint action (Enfield & Levinson, 2006; Schegloff, 2006; Schegloff & Sacks, 1973; Sidnell, 2013). This is not to say that these organizational structures rigidly determine interlocutors' behavior. Rather, interactional behaviors are produced and interpreted with reference to these regularities (Raymond & Sidnell, 2014; Schegloff, 1982). Interlocutors frequently deviate from these norms in ways that convey particular meaning and perform social actions that are recognizable to their social partners. For instance, there is an expectation that when a speaker asks a question, the recipient will provide a relevant response. Within adult interaction, if, however, the recipient does not respond, the speaker might interpret this lack of response as indicating hesitancy, a personal slight, or a misunderstanding, depending on the context (Schegloff, 1982). Given that human interaction is organized according to its own emergent properties that constrain social partners' behavior and enable meaning-making, any activities taking place within and through interaction, such as family number talk, are likewise organized according to these properties. Thus, any analysis of number talk that does not attend to these organizational structures may lead to

an incomplete, or even inaccurate, understanding of what parents and children are doing together through their use of number talk (Schegloff, 1989).

Two primary organizational features of social interaction enable interlocutors to produce sequences of interlocking actions. Both of these features are generic solutions governing the sequence organization of human interaction (Schegloff, 2007). First, each turn-at-talk within an interaction makes particular next actions relevant, constraining the interactional possibilities of subsequent turns (Raymond & Sidnell, 2014; Schegloff, 2006, 2007; Schegloff & Sacks, 1973; Tarplee, 2010). For example, when a speaker invites their friend to an event, this creates an expectation that the friend will respond by accepting or rejecting the offer in the next turn. In its simplest form, social interaction is organized into pairs of actions that are produced through a sequence of two adjacent turns (Raymond & Sidnell, 2014; Schegloff, 1982, 2006, 2007; Schegloff & Sacks, 1973). These sequences, called adjacency pairs, are evident in both dyadic and multiparty interaction and are a ubiquitous feature of human interaction, though some interactional activities, like storytelling and lecturing, are constructed according to different interactional norms (Schegloff, 2007; Stivers, 2021). Adjacency pairs are comprised of a 'first pair part', such as a request for information or an invitation, and a 'second pair part', such as the provision of relevant information or the acceptance or rejection of the invitation, respectively (Raymond & Sidnell, 2014; Schegloff & Sacks, 1973). By enacting a first pair part, an interlocutor creates an expectation that their co-participant will provide a relevant second pair part at the earliest opportunity (e.g., Raymond & Sidnell, 2014; Schegloff & Sacks, 1973).

The absence of a relevant second pair part will be marked as meaningful within an interaction, with it being interpreted as accomplishing a particular social action (Raymond & Sidnell, 2014; Schegloff & Sacks, 1973). For instance, a long pause after an invitation may indicate the recipient is hesitant to accept the offer or plans to decline the offer; thus, a recipient's silence in the space following an invitation performs an intelligible social action within its local context in the ongoing sequence (Raymond & Sidnell, 2014; Schegloff, 1982). Similarly, if a recipient responds by asking a question about the event, this will likely be interpreted as a purposeful attempt to gain additional information to inform their acceptance or rejection of the invitation (Sacks, 1972; Schegloff, 2007). In this way, the basic two sequence unit of interaction can be elaborated through additional sequences that accomplish relevant preparatory, intervening, or follow-up actions (Schegloff, 2006, 2007).

The second and related feature of interaction is that subsequent turns display the current speaker's understanding of what social actions were performed by their social partner in the prior turn (Raymond & Sidnell, 2014, Schegloff, 2006, 2007; Schegloff & Sacks, 1973; Tarplee, 2010). Thus, speakers' publicly available conduct—their observable verbal and nonverbal behavior—displays their understanding of the prior turn. This provides interaction with a built-in infrastructure for interlocutors to verify that their talk was understood as intended (Raymond & Sidnell, 2014; Tarplee, 2010). This enables them to address any issues in speaking, hearing, and understanding that might arise within a social exchange through repair practices (Raymond & Sidnell, 2014; Sacks, 1972).

The interlocking nature of interlocutors' turns means that each turn cannot be attributed to individual social partners but must instead be viewed as an interactional accomplishment (Raymond & Sidnell, 2014; Schegloff & Sacks, 1973). In fact, interlocutors often preface particular types of actions, like requests and invitations, with sequences aimed at determining whether their request (e.g., "Are you gonna be using your car tomorrow?") or invitation (e.g., "What are you doing tonight?") is likely to be accepted; if it is determined through these pre-sequences that the request or invitation will be declined, the actual request or invitation is typically not spoken (Levinson, 2013; Schegloff, 2007). Thus, some courses of action initially pursued by individuals are stalled or thwarted before they come to fruition (Levinson, 2013). Additionally, while questions generate pressure for recipients to provide answers, the provision of an answer is not guaranteed: instead, the recipient could pretend they do not hear, walk away from the interaction, or respond in some way that does not constitute an answer (Schegloff, 2007; Stivers, 2010). Therefore, the completion of adjacency pairs is a collaborative endeavor.

CA researchers rely on the two features of talk described—that prior turns constrain next turns and that subsequent turns display interpretations of prior turns—to analyze how social partners interpret what they are jointly accomplishing through their sequences of talk (Raymond & Sidnell, 2014; Tarplee, 2010). In other words, conversation analysts use the same organizational structures and properties of interaction that interlocutors use to produce sequences of coherent talk to conduct their analyses (Raymond & Sidnell, 2014; Sidnell, 2013; Tarplee, 2010; ten Have, 2007). A brief example from the current data will be used to demonstrate these two features of talk. Prior to Extract 1, the mother and her daughter had turned to the Chocolate Chip Cookie

recipe in the intervention cookbook and began discussing what was on the page. After the child labeled graphics of cookies, cake mix, and eggs with assistance from the parent, the parent issued a first pair part in line 1.

Extract 1: Mother and her daughter (3 years) [1101-2_43]

```
1  Mom:        How many chocolate chips do you see on the picture?
2  Child:      One two three four five six
3  Mom:        You counted five but you said six.
4  Child:      One two three four five
5  Mom:        Five. Awesome.
```

The parent's question in line 1 served as a first pair part, constraining what would constitute as a relevant next action. This turn created the expectation that the child would provide a second pair part that served as a fitted answer in their next turn. The child responded by counting and, given how the sequence unfolds, she presumably counted the chocolate chips. The child's response displayed to the parent—and displays to the analyst—that the child interpreted the parent's question as a prompt to count the chocolate chips on the page. At this point, the parent could have rejected the child's interpretation of her prior turn (e.g., "No, not everything. Just the chocolate chips.", "You were supposed to guess how many") or addressed an issue of hearing (e.g., "Wait, what did you say?"). Since she did not perform either of these actions, the parent's turn in line 3 affirmed the child's interpretation of her first pair part as a request to count the chocolate chips and signaled there was no interactional trouble requiring attention. However, the parent's turn in line 3 ("You counted five but you said six") did deem the child's second pair part—her counting—as insufficient. This made it relevant for the child to count again in order to

complete the adjacency pair initiated in line 1. This example will be addressed in more detail later in the chapter.

It is important to underscore that CA researchers seek to avoid speculation about participants' underlying cognitive processes or psychological states or impose *a priori* theories of social identities or relationships on the data; rather, they analyze what interlocutors' conduct within the exchange displays as relevant to the activities they are constructing together (Raymond & Sidnell, 2014; Sidnell, 2013; Wootton, 1997). Turn by turn, co-participants construct and negotiate "a single over-all definition of the situation" and work to make their talk intelligible and coherent within the context of that definition (Goffman, 1959, as cited in Wootton, 1997, p. 25). This definition does not necessarily reflect participants' individual intentions, desires, or thoughts, but instead what interlocutors make available to their co-participants (Wootton, 1997). As an example, in issuing her first part, the parent in Extract 1 may not have intended to have her child count the chocolate chips, but her conduct treats the child's counting as an appropriate response. Any alternative intentions the parent may have had are not relevant to the analysis because the parent did not make them relevant for the interaction. It is this emergent definition that CA researchers analyze.

Using CA to study family number talk enables researchers to examine the sequential organization of family number talk and reveal the interactional meaning and function of number talk for the parents and children engaged in it. Given that each speaker narrows the field of possible actions that are relevant for their social partners in subsequent turns, parents' and children's talk cannot be meaningfully studied without attending to how their talk is constructed through turn-taking sequences. CA research

suggests that family number talk, like all interactional behaviors, is produced collaboratively by social partners in orderly ways that depend on the norms and regularities of social interaction, with sequences of number talk reflecting both generic organizational structures and particular idiosyncratic enactments (Schegloff & Sacks, 1973; Sidnell, 2013).

There are multiple possibilities for when and how number talk can occur within family interaction, but talk about numeracy must be enacted in a way that makes it meaningful and relevant for the participants of the interaction and what they are working to accomplish together (Schegloff & Sacks, 1973; Sidnell, 2013). By examining patterns in the sequential organization of number talk, researchers can identify how adults and children design their number talk turns within different contexts and with each other in mind. By paying attention to what follows different number talk turns, the researcher can better understand the interactional implications of different ways of enacting number talk (Tarplee, 2010). For instance, how caregivers' design their use of pedagogical questions about numeracy concepts, may have different implications for how children respond.

Talk is Experience

Researchers across many disciplines, including psychology, have traditionally viewed language as principally a symbolic system through which humans use arbitrary symbols to represent their experiences and the world, from concrete objects to abstract ideas (Ochs, 2012; Sterponi et al., 2015; Sterponi & De Kirby, 2017). From this perspective, language is separate from the experiences it represents (Ochs, 2012; Sterponi et al., 2015; Sterponi & De Kirby, 2017). While not contesting this symbolic dimension of language, Ochs (2012), a linguistic anthropologist, has drawn attention to ways that

language, as it becomes instantiated in embodied interaction, becomes inseparable from interlocutors' experience. For instance, words and linguistic forms become part of our experience of physical and abstract objects (Ochs, 2012).

This perspective contrasts the traditional understanding of language that Shakespeare expressed with his famous line, "A rose by any other name would smell as sweet" in *Romeo and Juliet*. Ochs (1996, 2012) would argue that the word "rose" has become integrally connected to how this flower is experienced, and its use brings into awareness prior personal experiences and cultural associations that have become connected to this word, such as particular emotions, relationships, identities, and actions. Additionally, speakers and recipients attend to the poetic qualities of everyday talk, utilizing pitch, volume, repetition, silence, word play, rhythm, word choice, and so on to create a multisensory experience, with affective and relational qualities (Ochs 2012; Sterponi et al., 2015; Sterponi & De Kirby, 2017; Sterponi & Fasulo, 2010). Moreover, through engaging in cultural discourse practices and interactional routines, interlocutors enact and experience particular manifestations of social life, with social partners living out particular experiences of being a subjective self in relation to others (Duranti et al., 2012; Schieffelin & Ochs, 1986; Ochs, 1986).

This perspective on language suggests that the unfolding of parent and child talk within an interaction constitutes an affective, multisensory, embodied experience of the world and social relationships (Ochs, 2012). Conversation analysts conduct their analyses using detailed transcripts of everyday interaction that include social partners' use of embodied communicative resources. This allows them to look beyond the symbolic content of speakers' turns and attend to the experiences they construct through their talk.

In her analysis of teachers' interactions involving counting with young children, Arrowsmith (2005) demonstrated that teachers draw on paralinguistic features, especially intonation and choral speech, to make evident to children three important principles involved in counting: one-to-one correspondence, stable order, and cardinality. The current study attended to the variety of features of speech available through audio recordings to examine the affective and multisensory experiences parents and children enact through their use of number talk.

Family Pedagogy: Questions and Initiation-Response-Evaluation Sequences

In addition to the methodological and theoretical limitations of number talk research described above, there is a notable gap in the literature that limits the field's understanding of the role of number talk in children's learning and presents challenges for the development of educational resources and interventions aimed at encouraging family engagement in numeracy. Previous research has focused minimally on how parents and young children engage in number talk when parents are working to teach their children numeracy. The majority of existing studies do not differentiate between number talk that is pedagogically oriented and number talk that is a brief component of an action trajectory that serves other instrumental functions in parent-child interactions (e.g., making a request, sanctioning child behavior, reminiscing about a shared experience, providing instruction on how to perform a household chore). To begin to address this gap in the literature, the present study examined how parents and children participated in pedagogical sequences of number talk during the cooking sessions and how numeracy pedagogy shaped the activity of cooking together.

One cultural practice for engaging children and other learners in pedagogical interactions is through asking learners questions that prompt them to display their knowledge or work to advance their thinking (Heritage & Heritage, 2013; Redfield & Rousseau, 1981; Yu et al., 2019). Within Western educational settings and among families who have substantial experience with these institutions, it is common for adults to use a particular kind of question—pedagogical questions—to engage children in formal and informal learning activities (Chavajay, 2006; Gardner, 2013; Heath, 1982; Mehan, 1979; Morelli et al., 2003; Yu et al., 2019). Pedagogical questions, also termed known-answer or test questions, are "questions for which the questioner already knows the answer" (Yu et al., 2019, p. 147). Pedagogical questions contrast from genuine requests for information that questioners use to elicit information that is currently unknown to them, not only in the types of questions asked but also how answers are received (Mehan, 1979; Yu et al., 2019).

Pedagogical questions are often embedded within interactional sequences called initiation-response-evaluation (IRE) sequences (e.g., Bottema-Beutel et al., 2020; Gardner, 2013; Mehan, 1979; Tarplee, 2010). Adults often launch these sequences through asking a pedagogical question (i.e., the initiation), which typically prompts children to respond with a knowledge display (i.e., the response; Bottema-Beutel et al., 2020; Mehan, 1979). In the third turn, adults evaluate the acceptability of the child's response (i.e., the evaluation); if the response is deemed acceptable, the evaluation serves to close the sequence, but if the response is deemed insufficient, the sequence is typically expanded as the adult and child work to achieve a response the adult finds acceptable (Bottema-Beutel et al., 2020; Mehan, 1979; Tarplee, 2010).

Given the prevalence of IRE sequences in the data analyzed for the present study, these interactional sequences became a focus of this dissertation. Developmental research has typically analyzed parents' use of pedagogical questions as well as their feedback to children's responses in isolation, providing an incomplete picture on the function of these sequences in parent-child interaction (Bottema-Beutel et al., 2020; Tarplee, 2010). In this section, I begin by addressing three areas of development research that present the field's current knowledge on the role of questions or prompts—a more inclusive term for utterances that function to elicit child responses, including questions and directives—in young children's learning and development. First, I discuss correlational research investigating associations between parents' questions and children's concurrent and prospective cognitive skills. Second, I describe experimental research testing the effect of pedagogical questions on children's engagement and learning. Third, I present the results of a recent study that examined associations between parent number prompts and number statements and children's number talk during a play activity. After this review of existing development research, I end the section by presenting CA research on the sequence organization and underlying assumptions of IRE sequences.

Developmental Research on Questions, Prompts, and Pedagogical Exchanges

Parents' Questions Predict Children's Cognitive Skills

Extant research has demonstrated that parents' use of questions during parent-child interactions predicts their young children's concurrent and prospective academic and cognitive skills (e.g., Cristofaro & Tamis-LeMonda, 2012; Kuchirko et al., 2016; Reynolds et al., 2019; Rowe et al., 2017; Zambrana et al., 2020). Studies have given particular attention to parents' use of *Wh*-questions (e.g., how, what, when), which are

believed to be more beneficial for children's cognitive development than questions eliciting a yes/no answer (Rowe et al., 2017; Zambrana et al., 2020). For instance, using data for 41 African American families participating in the Father Involvement with Toddlers Substudy of the Early Head Start Research and Evaluation Project, Rowe et al. (2017) found that the frequency of fathers' *Wh*-questions to their 24-month-old children during a 10-minute semi-structured video observation in their home with standardized materials (e.g., book, toys) predicted children's concurrent vocabulary and verbal reasoning at 36 months, when controlling for parental education. This result was specific to *Wh*-questions: neither fathers' use of other types of questions nor their total quantity of utterances were associated with children's skills (Rowe et al., 2017). They found that children provided a verbal response more frequently to fathers' *Wh*-questions and provided responses with a higher mean length of utterance to *Wh*-questions than to fathers' use of other types of questions.

As another example, analysis of data for 567 two-parent families living in rural, high-poverty communities in Pennsylvania and North Carolina found similar results when including three distinct measures of mothers' and fathers' language use in the same model (Reynolds et al., 2019). Mothers and fathers separately participated in a 10-minute book sharing observation with their child at 6, 24, and 36 months using researcher-provided wordless books in their home (Reynolds et al., 2019). Using composite variables for the three time points, mothers' and fathers' use of *Wh*-questions predicted children's vocabulary skills and fathers' use of *Wh*-questions predicted children's math skills at kindergarten, controlling for child, parent, and family demographic variables and the parents' observed mean length of utterance and word types (Reynolds et al., 2019).

While this correlational research provides evidence of a link between the frequency of parents' questions—particularly *Wh*-questions—and children's cognitive skills, it has similar theoretical and methodological limitations as the literature on number talk. Given that the studies do not analyze how parents and children collaboratively completed question-answer sequences within the context of the play interactions, our understanding of what these questions allowed parents and children to do together and how these sequences might contribute to children's development is limited. For instance, while Rowe et al. (2017) found that *Wh*-questions were more likely to elicit responses and more syntactically complex responses than other types of questions, their analysis does not uncover how *Wh*-questions and other questions functioned within father-toddler interaction, what made *Wh*-questions interactionally relevant during the play activities, or why children responded verbally to some questions but not others. Understanding the function and meaning of *Wh*-questions within parent-child interaction, which may vary based on families' linguistic, ethnic, and socioeconomic background, would be invaluable if and when researchers turn to developing intervention materials to encourage families to engage in these types of questions.

Experimental Research Testing the Effect of Pedagogical Questions

In addition to this correlational research, recent experimental studies have begun to examine the causal effects of pedagogical questions on children's play and learning (Daubert et al., 2020; Yu et al., 2018). While adults often design pedagogical questions using the form of *Wh*-questions (e.g., "What is that?", "How many bananas?", "Where is the number one?"), they also use other formulations (e.g., "Can you find the number one?", "One plus one equals?", "This number is…"; Bottema-Beutel et al., 2020; Yu et

al., 2019). Additionally, some *Wh*-questions are not pedagogical but instead serve other interactional functions, such as requesting unknown information or seeking clarification (e.g., "Where did you put your shoes?", "What did you say?"; Yu et al., 2019). This highlights how questions can vary both in terms of their *form* (i.e., how they are designed in terms of word choice, syntax, and other features of talk) and *function* (i.e., what they do in an interaction; Zambrana et al., 2020). These two characteristics of questions are not equivalent and yet are connected, with interlocutors designing questions to perform specific actions within the sequence of interaction (de Ruiter, 2012; Hayano, 2013).

The experimental studies on pedagogical questions have examined the effect of using pedagogical questions when presenting preschool children with a novel toy (Yu et al., 2018) or instructional content (Daubert et al., 2020) on children's solitary use of the toy and children's learning and recall, respectively. For instance, Daubert et al. (2020) compared 3- and 4-year-old children's learning and recall when exposed to one of two versions of a storybook designed to teach children about psychosomatic symptoms (e.g., stomach ache from feeling scared): one version presented all instructional content in the form of statements (e.g., "When you feel happy, you might also smile.", "your brain changes the signals to the muscles in your face") and one presented some of the content in the form of questions (e.g., "When you feel happy, might you also smile?", "Does your brain change the signals to the muscles in your face…?"). Children exposed to the storybook that included pedagogical questions scored higher on assessments testing psychosomatic knowledge and recall of the story details compared to children exposed to the storybook without questions.

However, these experiments do not examine pedagogical questions as they occur within adult-child interaction. Yu et al. (2018) and Daubert et al. (2020) manipulated the *form* of interactional turns and sentences in books, while overlooking the *function* of questions in human interactions, more broadly, and pedagogical questions in adult-child interaction, in particular (e.g., Mehan, 1979; Raymond & Sidnell, 2014; Schegloff, 2007). For instance, in the study conducted by Daubert et al. (2020), the pedagogical questions included in the storybook were not meant to elicit a verbal or embodied response from the children, rather they delivered instructional content to children in the form of a question rather than a statement. However, CA research has demonstrated that questions overwhelmingly serve as first pair parts and create pressure for the recipient to provide a fitted second pair part (e.g., Raymond & Sidnell, 2014; Schegloff, 2007), with the child typically performing a knowledge display following a pedagogical question (Mehan, 1979). Moreover, the "pedagogical questions" children encountered during the study conducted by Daubert et al. (2020) were rather distinct from those typically seen in adult-child interaction.

By trying to isolate the possible cognitive benefits of pedagogical questions, these researchers created unusual laboratory conditions that lack ecological validity. While these studies may provide insights on how the delivery of novel materials and instructional content affects children's solo exploration and learning, they cannot speak to how pedagogical questions function in caregiver-child interactions or possible benefits of caregivers asking young children pedagogical questions in everyday contexts.

Parent Numeracy Prompts and Children's Participation in Number Talk

While previous number talk research has not differentiated between pedagogical number talk and number talk that serves other interactional functions, a recent study examined associations between parents' use of number prompts and statements and children's use of number words during a 6-minute play interaction with a play kitchen set (Eason et al., 2021). Prior studies using utterance-level measures of number talk (e.g., Casey et al., 2018; Ramani et al., 2015; Susperreguy & Davis-Kean, 2016) have tended to group parent number talk that provides children with numeric information or demonstrates a numeracy task (e.g., "We have one two three apples", "That's the number two") with parent number talk that elicits numeric information from children or prompts them to perform a numeracy task (e.g., "How many carrots?", "Let's count the plates"). This differentiation does not clarify whether number talk was pedagogical or not, particularly when considering the parent number statements. However, given that parent prompts (defined as "parent asks a question about number or tells child to perform numeracy skills such as counting" (Eason et al., 2021, p. 7) are frequently pedagogical and are common within pedagogical practices, this study provides some indication of how parent initiations might contribute to children's engagement in number talk.

Using observational data collected from 50 predominantly White, college educated parents and their 2- to 4-year-old children, Eason et al. (2021) found that parents' total use of number prompts was a stronger predictor of the frequency (i.e, tokens) and diversity (i.e., types) of child number words than parents' total use of number statements. They, then, analyzed each episode of number talk that occurred during the play interactions to examine if episodes initiated by a parent prompt, parent statement, or child number utterance proceeded differently. They found that parents and children engaged in more

number talk utterances following a parent number prompt than following a number statement. Additionally, children used more diverse and higher number words in responses to parent number prompts than in utterances that initiated discussion of number within the exchange.

These results offer a step toward understanding parent-child participation in number talk. However, they do not go much further than validating the fact that parent prompts, like "How many did you cut?" or "Let's count the pieces", typically are embedded within multi-turn IRE sequences in which there is pressure for children to provide a fitted answer—a response that would require using number words—and in which parents typically reply with affirmative or corrective feedback that could extend the sequence and make it relevant for children to use additional number words. Parent number statements do not carry the same response pressure as parent number prompts, so there is less of an interactional need for children to respond with number talk. This study underscores the relevance of CA research, particularly research on adjacency pairs and IRE sequences, for developmental research on parent-child talk, in general, and pedagogical practices, in particular.

IRE Sequences: Organization, Constraint, and Authority

The sections above have called attention to the instructional functions of IRE sequences. IRE sequences are, in fact, a form of institutional talk that occurs within traditional, Western classrooms, providing a mechanism for teachers to engage individual students in lessons, conduct formative assessments of children's knowledge, and provide instruction (Gardner, 2013; Heritage & Heritage, 2013; Mehan, 1979). Research has documented that middle-class parents use these sequences to engage young children in pedagogical activities, like labeling sequences (e.g., "What is this?") during book reading (e.g., Kelly et al., 2002; Heath, 1982; Ochs & Schieffelin, 1984; Tarplee, 2010).

However, interactionally-grounded analyses of IRE sequences have demonstrated that these sequences can serve important *interactional* functions beyond instruction, such as facilitating individuals' participation in interaction when their communicative skills are emergent or limited and scaffolding children's completion of tasks (Bottema-Beutel et al., 2020; Cook-Gumperz, 1979; Fitneva, 2012; Ochs & Schieffelin, 1984; Wilkinson, 2013).

Returning to the example presented above, I will now walk through each conversational turn comprising IRE sequences, describing relevant literature that illuminate the interactional work accomplished within and through these sequences. I added arrows to Extract 2 to label the initiation, response, and evaluation turns making up this sequence.

Extract 2: Mother and her daughter (3 years) [1101-2_43]

```
1  Mom:    I⟶ How many chocolate chips do you see on the picture?
2  Child:  R⟶ One two three four five six
3  Mom:    E⟶ You counted five but you said six.
4  Child:  R⟶ One two three four five.
5  Mom:    E⟶ Five. Awesome.
```

As discussed earlier, in a prototypical IRE sequence, the first two interactional turns—the initiation and the response—constitute an adjacency pair, with the adult issuing the first pair part, often in the form of a pedagogical question (Bottema-Beutel et al., 2020; Mehan, 1979). Questions and other first pair parts exercise control within interaction by constraining the actions that are relevant in the next turn and generating pressure for the recipient to provide a response (Hayano, 2013). Known-answer questions and prompts are more constraining than genuine requests for information because there is

often only a single relevant and correct answer, which the adult already knows (Bottema-Beutel et al., 2020; Mehan, 1979; Schegloff, 2007). This puts children in the position of needing to identify the type of response that constitutes a type-fitted response (e.g., count; identify a shape; label a picture in a book) and to sufficiently provide the correct answer (e.g., "One two three"; "Square"; "Elephant"; Mehan, 1979; Schegloff, 2007). In the case of the "how many" initiation in line 1 of Extract 2, the correct response is "five," and to achieve this response, the child needs to accurately count to five.

Previous CA research has documented that IRE sequence can be a resource for engaging individuals with more limited communicative skills, including young children, in interaction (Bottema-Beutel et al., 2020; Cook-Gumpertz, 1979; Sterponi & Fasulo, 2010; Wilkinson, 2013). Given that caregivers already know the answer to an initiation, they can work to help children provide the second pair part and if necessary provide it themselves (Bottema-Beutel et al., 2020). In this way, IRE sequences offer a method for facilitating children's participation in interaction when the adult does not trust the child's capacity to actively collaborate with keeping the interaction moving forward (Bottema-Beutel et al., 2020; Cook-Gumpertz, 1979; Sterponi & Fasulo, 2010). From this perspective, using initiations to engage children in conversation is thought to be a resource for avoiding a breakdown in the interaction (Bottema-Beutel et al., 2020).

However, the constrained nature of initiations can also be liability for the interaction if the child does not cooperate with completing the sequence, especially when parents approach pedagogy more rigidly (Bottema-Beutel et al., 2020; Sterponi & Shankey, 2014). Once an adjacency pair is launched, it remains open until a second pair part is provided (Schegloff, 2007). There are two primary barriers to completing an

adjacency pair launched by an initiation: the child does not respond at all, making no attempt to provide a fitted second pair part, or the child does not respond with the correct answer that would constitute a fitted second pair part. If a second pair part is not forthcoming, parents and teachers have been shown to pursue child response or provision of the correct answer by 1) repeating or simplifying the initiations, 2) providing hints or questions that scaffold provision of a response, or 3) upgrading to a directive that frames the child's behavior as noncompliance and claims entitlement to demand compliance (Filipi, 2009; Kent, 2012a, 2012b; Mehan, 1979; Sterponi & Shankey, 2014).

Evaluation turns are one way that adjacency pairs are expanded following the provision or attempted provision of a second pair part (Schegloff, 2007). As explained above, the third turn of an IRE sequence evaluates the acceptability of the child's response and functions to close the sequence once a sufficient second pair part has been achieved. Generally, evaluations will either accept the response and close the sequence; provide corrective feedback but move to close the sequence; or reject the response, making it relevant for the child to make another attempt at providing a sufficient second pair part (Bottema-Beutel et al., 2020; Mehan, 1979; Tarplee, 2010). In the case of Extract 2, the child readily responds to the parents' initiation but the parent evaluates her response as insufficient, stating "You counted five but said six", prompting the child to count again. After the child counted to five, the parent repeated "Five" before providing the assessment "Awesome". At this point, the sequence initiated by the parent's first pair part is considered closed.

It is, in part, through evaluation turns that parents constitute their initiations as known-answer prompts (Heritage & Heritage, 2013; Mehan, 1979). In providing an

evaluation turn, parents position themselves as having epistemic authority and construct the parent-child relationship as being characterized by an asymmetry in authority and knowledge (Heritage & Heritage, 2013; Tarplee, 2010). In this sense, IRE sequences construct particular kinds of social relationships between parents and children (Tarplee, 2010). However, research has also showed that parents and teachers can enact a variety of different actions through evaluations turns (Bottema-Beutel et al., 2020; Mehan, 1979), with these turns being a primary site for providing instruction that advances children's thinking (Cohrssen & Church, 2016; Heritage & Heritage, 2013).

The present study analyzed how parents and children work to achieve complete IRE sequences within numeracy pedagogy and how these sequences functioned within the cooking sessions.

The Present Study

The present dissertation used CA to examine the interactional practices undertaken when parents and their 3- to 5-year-old children engaged in numeracy pedagogy during cooking as their participation in a home-based math intervention. The intervention aimed to encourage parent-child numeracy conversations during home cooking activities and advance children's numeracy skills. All 30 participating families received a cookbook that included domain-general tips on engaging children in learning conversations and 15 simple recipes. The families randomly assigned to the treatment condition received a version of the cookbook that contained additional suggestions on supporting children's early numeracy skills when carrying out each recipe. Parents were asked to audio record themselves cooking with their child twice a month for three months. Families were encouraged to use the provided learning tips but were invited to

cook any recipe they wished, including their own recipes, and were observed cooking in parent-child dyads as well as larger family units.

The analysis conducted for the present study was aimed at answering two research questions about families' participation in number talk, particularly numeracy pedagogy, during the cooking sessions:

1. *What were parents and children doing when they talked about numeracy?* Answering this question involved examining the extent to which families' number talk prioritized cooking or pedagogy; identifying the specific cooking and pedagogical activities families enacted through numeracy pedagogy; and analyzing the types of interactional sequences within which number talk was embedded. As a whole, this analysis described how parents and children engaged in sequences of numeracy pedagogy and what these sequences allowed them to do within the cooking sessions.
2. *How did different aspects of the cooking activity afford different kinds of number talk?* Answering this question involved attending to how the recipe, ingredients, and cooking tools shaped the affordances for numeracy pedagogy. In other words, I examined how the tasks involved in completing a recipe, the properties of the ingredients, and the cooking tools used influenced when and how parents and children engaged in numeracy pedagogy.

There were two primary motivations driving the analytic focus of the present study. First, this dissertation sought to describe how the families participated in this home-based early learning intervention. Second, this dissertation aimed to advance the field's understanding of number talk. Each of these aims are discussed below.

Examine Family Participation in this Home-Based Math Intervention

The present study sought to examine how the families participated in a home-based early learning intervention. While not directly comparing the families in the treatment and control conditions, the analysis addressed how families engaged in number talk during their participation in an intervention and how intervention materials, including tips, may have contributed to how families constructed the activity of cooking together. This analysis was not meant to uncover families' everyday ways of interacting. Instead, the purpose of the dissertation was to examine how the participants participated in number talk within activities that a research team framed as explicitly learning-oriented—a study called the "Cooking and Learning Together Project"—and provided tips on engaging children in learning conversations. The participants of the current study—primarily middle-class, college educated parents of color and their children—demonstrated awareness of the performative nature of the interactions, often discussing the function of the recorder at some point in the interaction and sometimes talking to "the people listening" in the words of one parent. This means families—particularly families in the treatment condition—likely oriented to the cooking sessions based on their values of what constitutes "good parenting" and their expectations of what the research team valued as "good parenting". While this study cannot illuminate how the participating families might engage in number talk outside of the context of this intervention or how families from other cultural backgrounds might participate in this intervention, the analysis provides preliminary insights into how middle-class families, including middle-class families of color, might engage with school-provided materials or interact in other contexts that evoke dominant, school-like pedagogical practices.

Examining family participation in numeracy pedagogy within the context of this particular intervention was useful because the design of the intervention allowed for greater flexibility in how families organized and oriented to the cooking activities than is afforded by other interventions (e.g., Gibson et al., 2020; Zippert et al., 2019). In addition, the previous studies focusing specifically on parent-child number talk during cooking provided the participants with a specific recipe and all the ingredients and materials they needed for completing it (Son & Hur, 2020; Vandermaas-Peeler et al., 2012a). In contrast, for the present study, families were allowed to select what they cooked and to include whomever they wanted in the activity, and they used their own ingredients, cooking tools, and kitchen, with these choices and materials resulting in different opportunities for child participation. While the cooking interactions were not naturalistic, this allowed families greater flexibility in how they organized and approached the activity. Again, this might shed light on how families might implement an activity that is sent home by their child's teacher.

Additionally, these cooking interactions allowed for analyzing how parents and children worked toward accomplishing a shared objective. Cooking is a goal directed activity aimed at preparing something that someone would wish to eat. In general, cooking involves some degree of risk not only in terms of safety but also in regards to achieving this overarching goal of the activity. Not completing the full activity or making an error that results in something being uncooked, burnt, or bad tasting is not a satisfactory end. Thus, cooking requires some degree of precision and this may be less straightforward to accomplish with a young child. Cooking is also an activity for which parents have greater experience, competence, and authority than children, making it

relevant for families to discussed safety concerns ("Because you don't touch the stove right?") and the limits of what children are permitted to do ("So you always want to cook with an adult, right?"). The activity context for these interactions likely shaped how parents approached the activity and the extent to which they shared control with the child in planning and implementing recipe tasks.

Advance Research on Number Talk

The present study aimed to advance the field's understanding of how parents and children engage in number talk in three ways. First, this dissertation addressed methodological and theoretical limitations in existing research on number talk. Using CA to examine the families' participation in number talk allowed for analyzing how parents and children collaboratively and incrementally constructed number talk across turn-taking sequences. Aligned with a CA approach, this dissertation analyzed family number talk within the action trajectories or projects in which it was embedded. Unlike previous studies that largely[1] operationalize number talk at the word- or utterance-level, this allowed for identifying the larger courses of action in which number talk occurred (e.g., read the list of ingredients needed for the recipe, add two cups of flour to mixing bowl, count strawberries as add them to 1-cup measuring cup, telling a story about what happened at school) and the activities families implemented through numeracy pedagogy.

[1] A few recent studies have conducted some analysis at the sequence level. Eason et al. (2021) conducted exploratory analyses looking at episodes of number talk based on their utterance-level coding of number talk. They did not capture the larger action trajectories in which number talk occurred and did not identify the activities families enacted through their episodes of number talk. Recent studies by Vandermaas-Peeler and colleagues (Vandermaas-Peeler et al., 2018, 2019) involved both utterance-level coding of math and scientific inquiry support and coding conversational exchanges involving math and scientific inquiry based on whether they were inquiry-oriented or teaching-oriented. They compared the frequency of inquiry-oriented and teaching-oriented exchanges based on whether families received guidance on engaging children in inquiry.

Second, the present study examined how parents and children participated in pedagogical talk about number. Previous research on number talk has not differentiated between pedagogical number talk and number talk that serves other functions within parent-child interactions. This limits the field's understanding of how parents and children collaboratively construct sequences of numeracy pedagogy and what these sequences allow parents and children to accomplish within interactions. Given that early math interventions are typically designed to encourage parents to make use of opportunities within math-relevant activities to engage in pedagogical talk about number (e.g., encourage child to count or engage in arithmetic, provide feedback on child numeracy errors), it is important for developmental researchers to understand when, how, and for purposes parents and children engage in numeracy pedagogy within different activities.

Third, this dissertation analyzed how the recipe, ingredients, and cooking tools the families used shaped the affordances for numeracy pedagogy. Recent studies have found that the frequency of parent math talk varies based on the type of activity families are engaged in (Eason & Ramani, 2020; Vandermaas-Peeler et al., 2018), suggesting that activities may offer different affordances for parent-child engagement in math and that parents may make use of affordances for math engagement in some activities more than others. The present study offers a unique context for examining factors that influence the affordances for number talk within an activity. All of the families were working to complete a recipe, but the families selected different recipes, which involved different cooking tasks, called for different ingredients, and made it relevant for families to use different cooking tools. Even when completing the same recipe, families were cooking in

their own homes with the materials they had available. The variations between and within cooking sessions allowed for considering how these aspects of the activity afforded numeracy pedagogy.

CHAPTER 3: METHODOLOGY

Study Procedures

Intervention Design

For the present study, I analyzed recordings of parent-child dyads and larger family units cooking together at home as they participated in a math intervention study designed to promote family engagement in number talk. The intervention was delivered through a cookbook developed by the research team. The families were randomly assigned to receive either the treatment version of the cookbook that included numeracy-specific learning tips or the control version of the cookbook that included only general learning tips. The purpose of the larger study was to examine whether families who received the treatment version of the intervention cookbook demonstrated higher frequency and quality of number talk than the families who received the control version of the cookbook and whether the children in the treatment group exhibited greater growth in their numeracy skills than the children in the control group.

Recruitment

Families with a 3- to 5-year-old child were recruited through the preschool classrooms of three private religious schools located within the Boston metropolitan area. The three schools participating in the project had an existing partnership with Dr. Eric Dearing, the principal investigator leading the study. These schools primarily serve families of color, including immigrant families from diverse countries of origin, and

families with varying access to socioeconomic resources. Two consecutive cohorts of families were recruited to participate in the study: the first participated in the cooking sessions during the spring and summer of 2018 and the second cohort participated during the following winter and spring. During the fall of 2017, Eric attended informational events for parents at the schools and shared information about the upcoming study. Families who expressed interest in participating at these events were sent recruitment information by email the following spring. Parents who wished to participate completed either an online or physical consent form.

Data Collection

After providing consent, parents were asked to complete a questionnaire that consisted of logistical questions related to study participation; demographic questions about the parent, study child, and their family; and questions about the parent's beliefs and attitudes about their child's early learning and their family's engagement in home learning activities. Research assistants visited the schools to assess the participating children's math, literacy, and executive functioning skills. Families then received their intervention cookbook; a First Aid, Choking, and CPR Chart created by the American Academy of Pediatrics; a USB audio recorder; and a $30 gift card either by mail or through their child's classroom.

Parents were asked to audio record themselves cooking with their child twice a month for three months. After completing their two cooking sessions each month, parents were asked to submit their recordings to the research team. Parents were given the option of either uploading their audio recordings to a private Google Drive folder or mailing the audio recorder to the study team using a prepaid and pre-addressed envelope. The

cookbook included instructions on each of these options. The research team reached out to families on a monthly basis to check in on their progress in completing their cooking sessions. In reality, most families' participation in the study extended beyond the intended three months, with most families completing their participation within five months. After receiving each batch of two audio recordings, the research team sent families an additional $30 gift card. In total, families could receive up to $120 in gift cards over the course of their participation in the study.

After parents sent their final audio recordings or decided to discontinue their participation, the study team sent them a final survey to complete that included open-ended questions about their family's experience participating in the project and their perception of the cookbook as well as the same measures of their beliefs and attitudes about their child's early learning and their family's engagement in home learning activities. Children's academic skills were assessed again approximately 3 and 7 months after their family received their cookbook.

Audio-Recorded Cooking Sessions

Families were asked to begin their recordings of the cooking sessions by introducing who would be cooking, what they would be cooking, and when they were cooking. While families varied in the extent to which they did this, the recordings generally began with introductions of the people present and a declaration of what they were going to cook. The intention was to observe family cooking on different days, but, occasionally, families recorded two cooking sessions on the same day. Families largely ended their recordings by addressing "the people listening" in the words of one parent. This often involved describing how their food turned out, reporting their enjoyment of the

activity, or simply saying goodbye. It was common for families to talk about the recorder at some point during the cooking session, which sometimes involved children or parents talking to "the recorder." For instance, children occasionally took on an "announcer" voice, describing what the family was doing.

Families varied in what they treated as part of the activity and worth recording. Given that families decided when they started and stopped the audio recorder, there was variability across the recordings in what parts of the cooking activity could be analyzed. For instance, when a meal required baking, some families considered the activity over when they put the food in the oven, some families stopped recording during baking but came back on after they removed the food from the oven to conclude the activity, and some families continued recording while the food was baking requiring them to generate activities to do together while they waited. At a minimum, the families recorded their active preparation of the recipe. For the present analysis, I examined whatever occurred within the recordings provided.

Video-Recorded Cooking Sessions

Two families agreed to have me visit their home to video record two of their cooking sessions and to participate in a parent interview after the second video recording. Only one of the families completed both video recordings and the parent interview. The other family was only able to participate in the first video recorded cooking activity due to family scheduling conflicts and the remodeling of their kitchen. When I visited the families' homes, after exchanging pleasantries, I set up the video camera based on where the family intended to cook. When they were ready, I started the recording and sat nearby —out of view if possible—and read a book.

Participating Families

Fifty-eight parents of a preschool-age child completed a consent form. Thirty of these parents provided recordings of themselves and their child cooking together. All families participated in and provided audio recordings for at least two cooking sessions. Twenty-three of the families participated in at least four cooking sessions and 19 of the families participated in six or more cooking sessions.

One family had two children participating in the study, such that 31 target children (61% female) participated in the cooking sessions. The children ranged in age from 36 to 64 months (M = 49.65, SD = 8.72) when their family received their cookbook. For all families who sent recordings of cooking sessions, the parent who completed the demographic survey and was the primary contact throughout data collection was the child's mother. The mothers reported that 14 of the children were Black or African American, 5 were White, 4 were Latinx or Hispanic, 1 was Asian American, and 7 were Multiracial. Of the Multiracial children, 4 were Black and Latinx, 2 were Black and White, and 1 was Latinx and White.

All but four of the mothers (87%) had received a college degree, with their highest educational attainment being an associate's degree (3 mothers), bachelor's degree (13 mothers), or graduate or professional degree (10 mothers). For the mothers who had not received a college degree, all had completed high school, with two of the mothers having had at least 1 year of college. Twenty-eight of the mothers reported their annual household income: one mother reported their household income was less than $20,000; three mothers reported it was $20,000-$49,999; seven mothers reported it was $50,000-

79,999; two mothers reported it was $80,000-$100,000; and 15 mothers reported that it was above $100,000.

All of the mothers reported that their family speaks some English at home, with 14 mothers reporting that English is their sole home language; 12 mothers reporting that English is their primary home language (i.e., the language spoken most often) but that their family also speaks at least one additional language at home; 2 mothers reporting their family has two primary home languages; and 2 mothers reporting that their family's primary home language is not English. Of the 16 families that speak a language other than English at home, eight families speak Spanish; eight families speak a French-Creole language, namely Haitian Creole; one family speaks Vietnamese; and one family speaks American Sign Language. A few of the participating children were enrolled in a dual language Spanish-English program at their school. The families overwhelmingly spoke in English during the cooking sessions, though there were some instances of families engaging in short exchanges (e.g., parent talking to another person in the home, reprimanding child) in another language. There were some pedagogical exchanges involving counting in Spanish or discussion of Spanish vocabulary.

Intervention Cookbook

The intervention cookbook was developed by the research team with assistance from the university's graphic design services. The treatment and control versions were identical beyond the experimental manipulation and formatting differences of the recipes due to the inclusion or exclusion of numeracy tips. Both versions of the intervention cookbook included instructions for participating in the study; safety and health information related to cooking; tips for supporting preschool children's learning; and

fifteen simple recipes. The treatment version included numeracy-specific learning tips. These materials are described below.

Introductory Materials

The intervention cookbook was spiral bound with thick, water-resistant card stock, a clear plastic front cover, and black plastic back cover. The title page read "Cooking and Learning Together" with graphics of food items, such as a set of two eggs and three strawberries. The treatment and control versions of the cookbook both included the following introductory pages:

- "Steps for Participation" that outlined the steps for participating in the cooking sessions (e.g., "Pick a recipe to cook", "Review suggested learning tips", "Minimize unnecessary background noise", "Introduce who is cooking, what you are cooking, and when you are cooking"). The contact information for the research team and principal investigator was provided at the bottom.
- A welcome page that provided information about the study (e.g., reminder that participation is voluntary and could be discontinued for any reason, request for parents to cook with their child twice a month for three months) and encouraged families to check out the learning tips and safety information before getting started with cooking.
- Cooking and kitchen safety tips that were taken from the website of the American Red Cross. Tips included "Watch children closely in the kitchen", "Never hold a child while cooking", "Keep children at least three feet away from all cooking appliances and sharp knives", and "Turn pot handles in, away from reaching hands."

- Information on food allergies available from the American Academy of Allergy, Asthma & Immunology's website, including information on common food allergies, symptoms, treatment, and severe reactions.
- Instructions on using the USB audio recorder provided to each family, including how to charge the recorder, how to turn the recorder on and off, how to record the cooking sessions, and how to submit recordings to the research team.
- A list of questions the research team thought families might have about their participation. Most notably, this page urged the families to "Cook whatever you like. Any time preparing food together will do. The cookbook is just a way to give you recipe ideas and helpful tips for cooking and learning together." Additionally, this page explained, "whether you decide to cook a special recipe or a favorite meal, we would like you to try the learning tips."
- A list of "Common Ingredient Substitutions" and a reminder that "The recipes in this cookbook are only our suggestions: you can add, change, or eliminate any ingredients to best fit your family's tastes!"
- A table of contents that divided the recipes into three categories: "Breakfast", "Lunch & Dinner", and "Snacks & Sweets."

Recipes

The intervention cookbook included 15 simple recipes (e.g., Fun Pancakes with Mix-Ins, Berry Smoothie, Easy Macaroni and Cheese, Easy Personal Pizzas, Cheesy Chicken Enchiladas, Vegetable Soup, Chocolate Chip Cookies, Dirt Cups) that were adapted from cooking websites and blogs. As seen in Figure 1, the primary page for each recipe included three sections of text: a list of materials needed to complete the recipe,

the ingredient list, and the directions for completing the recipe. The recipes in both the treatment and control versions of the cookbook included graphics of the ingredients and sometimes the final product (e.g., pancakes, smoothie, cookies). When the recipe included discrete ingredients (e.g., bananas, chocolate chips, eggs), the graphics included at least one small set of an ingredient (e.g., two bananas, seven blueberries) to afford family counting. Within both version of the cookbook, numeric information (e.g., "2 cups", "8-10 minutes", "425°F", "9-inch", "1/4 cup") was printed in red font and the ingredients (e.g., "In a large bowl, mix FLOUR, SUGAR, BAKING POWDER, and SALT") were printed in blue, uppercase font. This was meant to draw families' attention to the numeric information in the recipes while making the research team's focus on early math learning less transparent to families in the control condition.

Tips for Promoting Learning

Both the treatment and control versions of the cookbook included tips on promoting children's learning in the initial pages of the cookbook following the welcome page. As depicted in Figure 2, all families received domain general tips designed to encourage parents to engage their child in conversation as they cooked together (e.g., "Ask lots of questions", "Help your child connect words, numbers, foods, or pictures to everyday life and things that are important to your family", "Don't always worry about your child getting the right answer, but encourage your child to explain") and to follow their child's lead.

Figure 1

Example of a Recipe with Numeracy Tips Provided in Treatment Cookbook

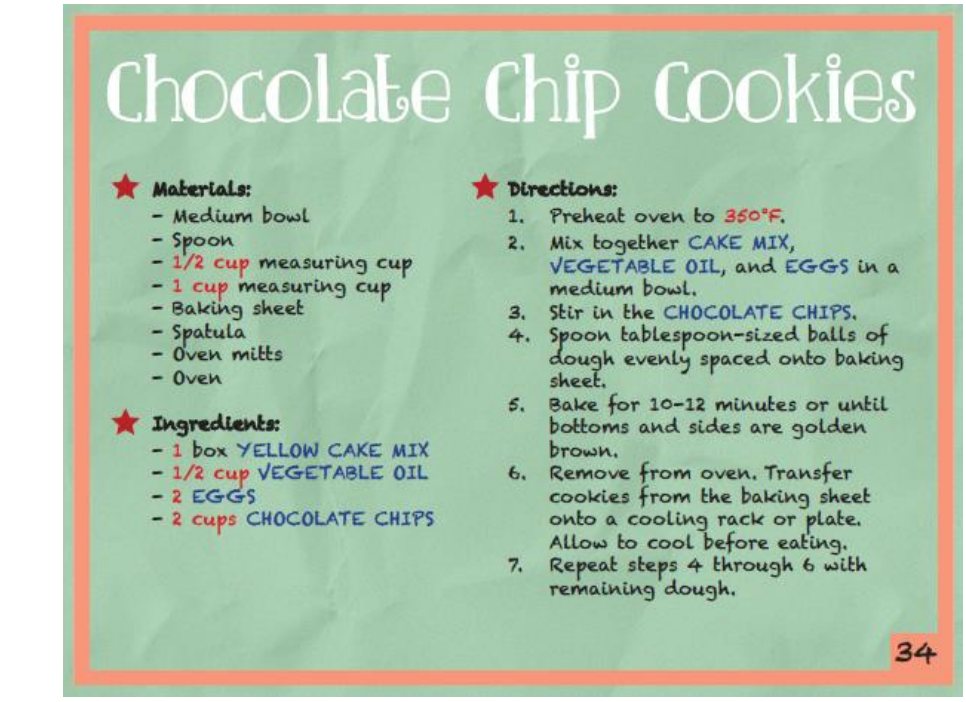


Figure 2

Tips Provided in The Front of the Intervention Cookbooks

Numeracy Tips (Treatment Only)	Domain General Tips (Treatment and Control, with slight edits)
The Fun of Cooking and Learning Together Cooking is a great way to talk with your child. You can talk about letters, words, foods, colors, shapes, and patterns, and it is a great way to talk about numbers. In the recipes, we included tips for you to try out to help your child's math learning. **1. Count objects one-by-one.** Carefully counting objects one-by-one helps preschool children learn to count. Sometimes they don't realize that each object is only counted once or they try to count too quickly and skip numbers. To help, ask your child to count pieces of food, using a finger to point to each piece of food while counting. **2. Count sets of objects.** When children are learning to count, they need to learn that the last number they say is, in fact, the total number of things in the set. Have your child count out 2, 3, or 4 pieces of food and after your child finishes ask, "So, how many are there?" If they are incorrect, help them recount. If they are correct, try a bigger number. **3. Estimate and compare sets of objects.** Have your child compare two small piles of food and guess which one has more. Then have your child count to see if the guess was correct. **4. Practice addition and subtraction.** After your child correctly counts out a group of items, ask them addition and subtraction questions. Add one more item and ask, "How many are there all together?" Or, take one item away and ask, "How many are left?"	Cooking is also a great way to have fun together and follow your child's interests. Here are some other tips to try out while you are cooking together: **1. Ask lots of questions.** "Can you tell me what you see on this page?" "Tell me what's in this picture." "What letter is this?" "How many are there?" "What words start with this letter?" **2. Help your child connect words, numbers, foods, or pictures to everyday life and things that are important to your family.** "Where else have you seen this food?" "Have we eaten this before?" **3. Encourage your child to make predictions.** "What do you think is the next step?" "What do you think this will taste like?" **4. Don't always worry about your child getting the right answer, but encourage your child to explain.** "How did you know?" "How did you figure that out?" "What did you do to get that answer?" **5. Follow your child's interest.** If your child likes certain types of cooking better than others, as long as it is safe, go with it. **6. Try experimenting.** You can try different ingredients, or different cooking tools, or help your child make up your own recipe. And, the most important tip: Have fun!

The treatment version of the intervention cookbook included numeracy tips that were aimed at helping parents provide the type of scaffolding that research suggests promotes children's understanding of cardinality. While parents generally encourage rote counting and numeral identification, less attention is typically given to labeling set size (Mix et al., 2012). The numeracy tips were provided in two different locations and formats:

1. As provided in Figure 2, one of the introductory pages of the treatment version of the cookbook included four suggestions for numeracy activities parents could engage their child in during cooking (e.g., "Count objects one-by-one", "Practice addition and subtraction") with some explanation of why these activities were important for children's early numeracy learning. These tips were designed to apply to any recipe a family might choose to cook. However, they do require the presence of ingredients or other materials that are countable.
2. As illustrated in Figure 1, the second page of each of the 15 recipes in the treatment version of the cookbook include five suggestions for engaging children in numeracy when completing the recipe. Some of the tips were framed as questions or prompts parents might pose to children (e.g., "How many English muffins do we need so everyone in our family can have one?", "How many different ingredients do we need to make the pot pie?", "How many muffins can this muffin tin make?", "Count out 7 chocolate chips"). Other tips provided guidance on helping children gain fluency with one-to-one correspondence (e.g., "When counting, it helps your child to point at the objects as they say the numbers!") and develop a sense of cardinality (e.g., "After your child counts, ask

'So how many chocolate chips are there in all?'"). Finally, some of the tips—particularly the "Extra Challenge" tip provided with each recipe—suggested a particular activity for the family to engage in (e.g. "Play a guessing game! Once the pancakes are all on a plate, have your child guess how many you made. Count them together to see if their guess was correct!").

Number Talk Data

For this project, I analyzed the number talk occurring within 62 cooking sessions, totaling 1198 minutes or 20 hours of recorded interaction. I selected to analyze the first two cooking sessions available for each of the 30 families, all of which were audio recorded by the family[2]. In addition, I analyzed one video-recorded session from each of the two families who allowed me to visit their home to videotape one or two of their later sessions.[3] This allowed me to gain insights into how each family participated while keeping the project manageable. The video recordings allowed for gaining insights into how the families used nonverbal communicative resources and implemented the embodied actions of completing the recipe and engaging in pedagogy.

Of the 30 families who provided audio recordings of their cooking sessions, 18 were in the treatment condition and 12 were in the control condition. The two families who participated in video recorded cooking sessions were in the treatment condition. This means I analyzed 38 sessions involving families who received the numeracy tips and 24 sessions involving families who only received the domain-general learning tips.

[2] Audio recordings for the first or first two sessions were not available for two of the families. One family was only able to record 44 seconds of their first session, so I analyzed this family's second and third sessions. The other family created edited videos of their first two cooking sessions, so I analyzed this family's third and fourth sessions.

[3] I video recorded the third and sixth session of one family and the fourth session of another family. I selected to analyze the third session of the first family and the fourth session of the second family.

Beyond these audio and video recordings, the present study did not use data from the parent questionnaires, parent interview, or child assessments, beyond using the demographic information collected in the pre-intervention questionnaire to describe the participants as a whole and to present child age and gender with the extracts presented in the results.

Description of Family Participation in the Cooking Sessions

How long were the audio recordings?

The recordings of the cooking sessions ranged from 2.33 to 61.98 minutes in length, with a mean length of 19.32 minutes (*SD* =13.22). The variability in the length of the cooking sessions was due not only to how much of the interaction the families chose to record but also what the family selected to cook. The food preparation the families took on varied in complexity, ranging from families placing store bought, preformed cookie dough on a baking sheet to families preparing cookies from scratch. Families also sometimes prepared more than one food item—usually only one item was from the intervention cookbook—within a single cooking session, such as making eggs and bacon in addition to preparing the Pancakes with Fun Mix-ins recipe from the intervention cookbook. There were also a few occasions in which the recordings of cooking sessions were incomplete because either the recorder died, the family needed to wait before proceeding with the recipe, or the child got hurt (e.g., one child got cinnamon in their eyes).

What did the families cook?

Families reported what they were going to cook at the beginning of the cooking sessions. Table 1 provides examples of common recipes families completed during the

sessions. The most popular recipes completed were pancakes or waffles (10 families), cookies from scratch (9 families), fruit smoothies (8 families), and pizza (7 families).

Two research assistants reviewed the transcripts of the cooking sessions to determine whether the families used a recipe from the intervention cookbook. As shown in **Error! Reference source not found.**, in 40 of the cooking sessions, it was clear or v ery likely that the family cooked a recipe from the intervention cookbook (i.e., family references intervention cookbook, reads text from a recipe in intervention cookbook, used the same ingredients and quantities called for by a recipe in the intervention cookbook, substitutes a recipe ingredient but makes it clear they are using intervention cookbook), or the family looked at the intervention cookbook but used a recipe from another source (e.g., family discussed graphics in intervention recipe before parent stated they were going to use their own recipe). In 12 of the cooking sessions, the family cooked a variation of a recipe in the intervention cookbook (e.g., smoothie with different ingredients, pancakes using pancake mix); while it was possible the family looked at or referenced the cookbook as they completed their cooking session, there was no clear evidence of this. In 10 sessions, the family cooked a food item that was not one of the recipes included in the intervention cookbook. During these sessions, the family did not make it explicit whether or not they looked at the intervention cookbook.

Table 1

Description of What Families Cooked and Source of Recipes Used

Source of Recipe	Frequency	Most Popular Recipes
Family cooked a recipe from intervention cookbook or cooked similar recipe but clearly looked at intervention cookbook	40 sessions: 24 treatment	Berry Smoothie – 6 families Chocolate Chip Cookies – 7 families Easy Personal Pizzas – 5 families Fun Pancakes with Mix-Ins – 5 families Easy Macaroni and Cheese – 4 families Two families cooked: Chocolate Oatmeal No-Bake Cookies, Dirt Cups, Fruit Salad, and Peanut Butter and Fruit Sandwich
Family cooked a variation of an intervention recipe; unclear if they referenced intervention cookbook	12 sessions: 9 treatment	Pancakes or Waffles – 5 families Pizza – 2 families Smoothie – 2 families Macaroni and Cheese – 1 family
Family cooked a recipe not included in intervention cookbook	10 sessions: 5 treatment	Brownies or Chocolate Cake – 3 families Others included: cheeseburgers, scrambled eggs, chocolate dipped strawberries, tacos, stir-fry, pasta with meatballs

Who participated in the cooking sessions with the target child?

Overwhelmingly (94%), the child's mother facilitated the cooking sessions. In 8 of the 57 sessions led by mothers, another adult, usually the child's father, contributed in a more minimal way (e.g., brief conversation about something irrelevant to activity, fulfilling a cooking-relevant request, providing positive feedback to child on cooking project underway, or present but only making occasional comments). Three sessions were led by the child's father, with the child's mother providing more minimal contributions in one of these sessions. For the two sessions of one family, the mother and father shared the responsibility of supporting their preschooler in completing the activity and looking after their toddler, generally with each parent interacting with one child at a time.

In 36 sessions (58%), only one child—the target child—participated in the activity, with no other children present or participating. In 5 sessions (8%), one additional child was present for some portion of the session but not actively involved in carrying out the activity. Two or more children were actively involved in 21 sessions (34%): two sessions involved two target children, 17 sessions involved one child in addition to the target child, one session involved two additional children, and one session involved three additional children. When additional children participated in the activity, they were usually the target child's sibling or cousin and ranged in age from a couple of years younger than the target child to several years older.

Positionality

I was a member of the research team that developed and implemented the cooking intervention and served as a co-led through each stage of the research process. The research team developing the intervention were overwhelmingly White and immersed within academia, and none of the individuals involved were currently parents of young children. Efforts were made to collaborate with the participating schools in developing the intervention. The principal investigator, Eric Dearing, and members of the research team met with the school principals and preschool teachers to discuss options for partnering to promote family math engagement. Through these conversations, school staff endorsed the idea of using cooking as a means for encouraging math engagement. During the spring of 2017 (i.e., the year prior to the implementation of intervention study), the research team was conducting a separate study at the schools and invited families attending the preschools to mail us their favorite recipes, so they could be featured in a cookbook the following year. There was minimal response from families,

which may have been due to the timing of the request and the method used to solicit recipes (e.g., sheet of paper to fill out and return in pre-stamped envelope).

Nevertheless, families expressed enthusiasm about the project, named The Cooking and Learning Project, the following school year. Ultimately, the team decided to include a variety of simple, child friendly recipes (e.g., pancakes, macaroni and cheese, English muffin pizzas) in the cookbook, encourage families to cook whatever they wished, and provided tips that could be applicable to any recipe, as well as recipe-specific numeracy tips in the treatment version of the cookbook. The team had school staff, colleagues at other DREME sites, and collaborators at community-based organizations provide feedback on some of the recipes. Yet, the intervention cookbook—the recipes and the learning tips—are cultural artifacts that communicate explicit and implicit cultural values, expectations, and practices, which may have been experienced as discordant or imposing for some families.

Through this analysis, I was guided by the desire to understand what we were asking of the families who participated in the study. It is probably fair to say that the present analysis privileges the perspective of parents more than the perspective of the children. I was guided by an interest in uncovering the interactional work involved in engaging young children in numeracy pedagogy at home and in the complex activity that is cooking. This does not mean that the interactional work children were engaged in during the cooking sessions is absent from the analysis but the analysis was more centered on what we were asking of parents and what this meant for what they asked of their children. This was, in part, due to the fact that I selected to focus on numeracy projects launched by parents due to the greater frequency of these projects compared to

numeracy projects launched by children. Within projects launched by parents, there were plentiful examples of children pursuing their own interactional agendas, asserting their competence, and negotiating control and authority with parents. However, this will be addressed only minimally within the present dissertation and will be pursued in later work with this data.

As will be described in more detail below, the analysis was focused on examining patterns within the extracts of family number talk as well as notable variations and counterexamples. CA as a theory and methodology is focused on—in the words of Schegloff (2010), paraphrasing Goffman (1967)— "not persons and their moments, but the organization of those moments" (as cited in Raymond & Sidnell, 2014). This means the analysis was focused on identifying overall patterns in how families accomplished sequences of pedagogical talk about number in context-specific ways within extracts, rather than on characterizing or comparing the families. CA research has largely not concerned itself with issues of generalizability but instead works to understand the underlying logic of stretches of talk (de Ruiter & Albert, 2017; Raymond & Sidnell, 2014). In other words, it matters not—from a CA perspective—if these families do not engage in numeracy pedagogy outside of the context of these interactions, just that they did within this data and did so in orderly ways (Raymond & Sidnell, 2014; Schegloff, 2007). In conducting the analysis, my interest was in understanding patterns and variations on these patterns within the extracts as well as variability within and across sessions due to the materials the families were using (i.e., recipe, ingredients, cooking tools, version of the intervention cookbook).

Due to the methodological commitments of CA research and the limited information available on families' cultural identities, values and practices, I did not analyze patterns in the data based on families' race/ethnicity or other demographic characteristics. From my review of the data, I did not find evidence that families engaged in number talk differently based on their social position, but I also did not investigate this directly. Given this study did not allow for collecting emic understandings of families' lives and cultural ways of being, I did not feel comfortable comparing based on the information families provided regarding their race/ethnicity or socioeconomic status. For instance, within the families that reported their race/ethnicity as Black or African American—the largest racial/ethnic group among the participants—there were ethnic differences that would make conclusions based on race possibly muddled or meaningless.

While I was focused on identifying and understanding patterns within the interactional sequences involving number talk, I built up snapshots of some of the families who were most represented within the corpus of extracts involving numeracy pedagogy. This revealed patterns in how some of the families were orienting to the cooking activity and how they made this orientation evident through their numeracy pedagogy. The families who engaged in very little number talk and, in particular, very little numeracy pedagogy, are more absent from my analysis of the data. In selecting transcript extracts to represent the analysis in the results, I was motivated by a desire to include as many of the families as I could, including families in both the control and treatment conditions of the intervention.

Finally, it is important to note that language, dialect, and cultural differences between myself and participants could have led to misinterpretations or bias in the

analysis. CA researchers esteem to ground their analysis in interlocutors' local and public understandings of what they are doing together: *local* in the sense that these understandings are constructed and negotiated through turn-taking sequences and *public* in the sense that these understandings are displayed to co-participants and analysts through interlocutors' conduct (Raymond & Sidnell, 2014; Wootton, 1997). To interpret participants' interlocking sequences of action, CA researchers rely on their own tacit resources as members of linguistic and cultural communities to interpret stretches of talk, just as the co-participants did to accomplish those stretches of talk in the first place (Raymond & Sidnell, 2014; Sacks, 1972). As a White, middle-class, monolingual English speaker who is not a parent or immersed in current kid culture, my interpretations of participants' conduct may not have always been aligned with participants' own meaning-making and may have been unknowingly biased.

Analytic Process

CA is a qualitative, micro-analytic methodological approach to the study of social interaction (e.g., Raymond & Sidnell, 2014). CA proceeds inductively, with specific research questions emerging and narrowing as candidate phenomena and patterns are identified within the data (ten Have, 2007; Hoey & Kendrick, 2017). The purpose of CA research is to describe the methods interlocutors use to accomplish social actions through talk (e.g., Hoey & Kendrick, 2017). CA researchers work to articulate generic patterns in the organization of interaction and how those patterns are instantiated in context-specific ways within individual cases (Sidnell, 2013). I conducted the analysis according to the guidance of Hoey and Kendrick (2017), Sidnell (2013), and ten Have (2007). Below, I describe the analytic process I used to transcribe the cooking sessions; refine the analytic

focus of the project; build a corpus of number talk extracts; identify and analyze patterns in how families participated in number talk, specifically numeracy pedagogy; and elaborate the findings through the analysis of individual extracts.

Transcription

The transcripts of the families' recorded cooking sessions were produced and edited through multiple iterations. First, an external transcription company transcribed the talk produced during the cooking interactions, indicating if each speaker was an adult or a child. Second, a team of trained research assistants edited the transcripts for the purpose of conducting utterance-level coding using the *Child Language Analysis* (CLAN) software (MacWhinney, 2000). This process involved listening to the audio recordings[4] while making the following edits to the transcripts in CLAN:

1. Correct transcription errors and add vocalizations missed by previous transcriber, including verbal actions like laughing and whining;
2. Demarcate speakers' turns-at-talk into utterances (i.e., "speech bounded by syntactic structure, intonation, or a pause of more than 2 s by the speaker", Eason et al., 2021, p. 6);
3. Specify the participants of the interaction (i.e., identify target child and their relationship to the other participants);
4. Format the transcript according to the Codes for the Human Analysis of Transcripts (CHAT) conventions (MacWhinney, 2000); and

[4] For the video recorded cooking sessions, the external transcription company only had access to audio recordings of the interactions. The research assistants, likewise, were only assigned to transcribe the vocalizations produced during these sessions.

5. Apply CHAT notation to indicate details about the timing, sequencing, and pronunciation of the talk (e.g., trailing off, pauses within utterances, interruptions, overlapping utterances, assimilations).

Twenty-four of the 62 transcripts were verified by a second research assistant.

Next, to conduct the present analysis, I copied each of the CLAN transcripts into a *Transana* database and attached the corresponding audio or video recording. As I worked to refine the analytic focus and build a corpus of number talk extracts (described in the next two sections), I verified the accuracy of the transcripts and added time codes to link the transcript to the recording. This round of verification was focused on verifying the speakers attributed to the vocalizations within the multiparty cooking sessions; it was frequently harder to distinguish between children's voices when two or more preschool-aged children actively participated in the sessions.

As I conducted the analysis and wrote up the results, I listened to the audio or watched the video recordings as I reviewed the transcripts. On occasion, I used the transcripts alone to sort extracts into subcategories, before proceeding with analyzing extracts using both the transcript and audio or video recording. After selecting extracts to use in the results, I amended the transcripts to adhere to Jeffersonian transcription conventions as is typical of CA research (as described by Hepburn & Bolden, 2017).[5] This involved adding notation to specify the length of pauses within turns and gaps between speakers; precise timing of overlapping speech; speed of delivery; and quality of delivery (e.g., pitch, intonation, volume, stress). For each extract presented in the results,

[5] I did not select to use any extracts for the two families who participated in the video recorded cooking sessions, so it was not relevant to transcribe families' embodied actions.

I included the relationships between the interlocutors, the age of the target child[6] and other children present if known, and the identification code for that project[7]. All names used in the transcripts are pseudonyms. As relevant for the analysis, I also provided a description of the interactional context in which the extract occurred, including the recipe the family was completing and whether they had received the treatment or control version of the intervention cookbook.

Refining Analytic Focus and Building Number Talk Corpus

I began this project with an interest in examining the sequential organization of family number talk during the cooking sessions. My proposal specified that I would analyze parents' and children's use of number talk with attention to sequence organization, turn design, and position in larger action trajectories. While indicating that my analytic focus would emerge inductively, I proposed the following questions as possible topics to be pursued:

- How do parents and children collaboratively produce number talk through their turn-taking sequences?
- How do parents and children make number talk relevant and meaningful within their interactions?
- What social actions do parents and children accomplish in and through number talk?

[6] While parents provided the target child's birthday when completing a demographic questionnaire prior to completing the cooking sessions, they did not consistently report the date of their cooking sessions at the beginning of the recordings. For this reason, I present the target child's age in years. It was common for families to discuss the target child's age (and sometimes the age of other participating children) during the sessions. If this occurred, I used these ages. If not, I present the child's age when the family received the intervention cookbook.

[7] The identification code is presented in brackets. The first four digits are the family's identification number. The fifth digit indicates the session in which the project occurred. The digits after the underscore specify the utterance that launched the project.

- Within what action trajectories is family number talk embedded?

The process of refining the analytic focus of this dissertation was iterative and continued as the results were written. For clarity purposes, the description I provide here is an abbreviated version of the full process, in some cases ignoring minor nonlinear or recursive steps. I begin with a brief summary before proceeding to describe each step in more detail.

As I started out the analysis, I proceeded transcript by transcript, establishing processes for identifying number talk, demarcating extracts with number talk, and categorizing the extracts according to emerging patterns as I went. After reviewing six transcripts, I determined that the relevance of number talk to the task of completing the recipe appeared to be an important factor in what families were doing together as they engaged in number talk and how sequences of number talk unfolded. I decided to proceed with building the corpus of number talk projects by categorizing number talk projects based on their task-relevance. This ultimately led to the decision to focus on projects within which families enacted numeracy pedagogy. Throughout this process, I participated in data sessions with members of my dissertation committee and other doctoral students to present extracts, validate the emerging findings, and receive feedback.

Selecting Initial Transcripts

Based on my previous quantitative coding of the transcripts, I began the analysis with a transcript of an audio recorded session that involved a high amount of number talk. I selected this transcript because it offered many sequences to work with as I developed my process for analyzing the data. Additionally, within this session, the child appeared to

resist some of the parent's efforts to engage him in numeracy and the parent displayed different strategies for recruiting his participation in numeracy tasks. It seemed this would offer insights into the interactive work involved in engaging children in numeracy conversations. After working with this transcript, I proceed with the two video recorded sessions. Then, I randomly selected additional transcripts to review. After reviewing another three transcripts, I felt I had a sufficient grasp on the patterns in families' participation in number talk to proceed with building the corpus with attention to the task-relevance of number talk.

Identifying Number Talk

Based on extant number talk research (e.g., Eason et al., 2021; Levine et al., 2010; Ramani et al., 2015) and my previous work with these transcripts, I defined number talk as the use of specific numeric language, the performance of numeracy tasks, or a speakers' elicitation of numeric information or numeracy tasks from other participants. Specifically, as I reviewed the transcripts, I looked for the following actions:

- Participants index the quantity of entities (e.g., present objects; abstract, hypothetical, or imaginary objects; actions) using cardinal numbers[8] (e.g., "We need two cups of flour", "Two eggs", "It needs five more minutes") or prompt another participant to label a specific numeric quantity (e.g., "How many carrots do we have?", "How many times will it take to crack the egg?")

[8] When reviewing the initial 6 transcripts, I also captured examples of parents and children indexing quantity through the use of grammatical number (e.g., plurals) and unspecified quantifiers (e.g., "few", "couple", "some", "a lot"). Aligned with linguistic research on how languages index number (e.g., Acquaviva, 2017), these examples highlighted how the use of cardinal numbers is just one resource for indexing quantity and that the use of unspecified quantities served important functions within the interactions. I ultimately decided to focus on families' use of cardinal numbers and other specific numeric language given that this was the type of talk the intervention was designed to encourage.

- Participants use numeric language to discuss numerals (e.g., "This is the number three"), time (e.g., "It's five thirty"), temperature (e.g., "Four hundred degrees"), temporal order (e.g., "The first step"), measurement and fractions (e.g., "Half cup of flour"), or for other cooking or interactional purposes
- Participants perform a numeracy task or prompt another participant to perform a numeracy task (e.g., counting, arithmetic, set size comparison)

Cases in which participants discussed performing a numeracy task or using numeracy as a strategy for addressing a problem arising during the cooking sessions, even if these actions were ultimately not completed, were included in the analysis.

Demarcating Number Talk Projects

In previous research, number talk has been analyzed at the word- or utterance-level (e.g., Levine et al., 2010, Ramani et al., 2015). In contrast, I analyzed number talk at the level of the *project*, defined as a course of action pursued by at least one participant (e.g., read the list of ingredients needed for the recipe, add two cups of flour to mixing bowl, have child count strawberries as add them to 1-cup measuring cup, share what happened at school that day; Levinson, 2013). Demarcating number talk at the level of the project required identifying the boundaries of the activity being undertaken. I did this through attending to what parents treated as the boundaries between activities and to the hierarchical organization of the courses of action implemented within the cooking sessions.

Parents tended to move the cooking sessions forward by launching the next project within the activity as the previous project ended or following family engagement in a tangential activity. Parents marked the launching and closing of projects using

language that has been shown to index the completion of an activity and project readiness for a next activity (Bangerter & Clark, 2003; Beach, 1995). Parents predominately implemented the transition to a new project by first using a boundary marker, typically one or a combination of "okay", "so", "all right", and "now" (but also other forms such as "and then" or "look") and then providing an account for the transition that projected the next activity, such as "it says we got to add the milk" (Goodwin & Cekaite, 2018). Examples from projects involving number talk include:

- "Okay so our cranberry juice"
- "All right so let me see what the temperature is"
- "So it says we need – Can you tell me what number this is?"
- "Now we need to do our vegetable oil"
- "Look can you do me a big favor and break these up and we'll see how many there are"
- "Hey let's count how many we made"

Goodwin and Cekaite (2018) documented that middle-class parents in the United States and Sweden used this same formulation to mark transitions in daily life and launch children's completion of everyday routines, such as getting ready for bed or preparing to leave the house, as well as subprojects within these activities (e.g., brushing teeth, putting on shoes). Within the cooking sessions, parents also typically closed projects with a boundary marker (e.g., "Okay", "All right", "Yep") or assessment (e.g., "Good job", "Awesome").

Given that cooking is a goal-directed and hierarchically organized activity, I also considered how recipe-related tasks fit together when establishing the boundaries of the

extracts. While executing a recipe[9] requires implementing a temporally ordered series of written steps, these steps often necessitate multiple courses of action that are implied rather than explicitly stated in the recipe. For instance, the Dirt Cups recipe (i.e., chocolate pudding with crumbled Oreos and gummy worms) in the intervention cookbook consisted of nine steps. Steps such as "Combine PUDDING MIX and MILK in a large bowl" require implementing at least three projects: 1) adding the pudding mix to the bowl, 2) adding the milk to the bowl, and 3) mixing the pudding mix and milk together until they are well combined. And, these projects often involve several subprojects (e.g., retrieving milk from the fridge, determining how much milk is needed, locating an appropriate measuring cup to use, pouring milk into the measuring cup) that vary in the extent to which they were instantiated within talk (e.g., a family might verbalize the action of pouring the milk into a measuring cup more than the action of retrieving the milk from the fridge, a family might spend minimal time establishing how much milk is needed but spend considerable time locating the correct numeral on the liquid measuring cup).

When possible, I followed the families' lead in demarcating the boundaries of number talk projects. However, if there was ambiguity, I considered the hierarchical organization of the activities being carried out and made decisions based on what would give enough context and coherence for understanding the number talk enacted. *Transana* allows for moving between demarcated extracts and the full transcript of the interaction,

[9] During most of the cooking sessions, families used a written recipe. Even when they did not have a physical recipe available, the parent still orchestrated the preparation of the food item through a series of temporally organized steps.

meaning it was possible to easily gather information about the larger interactional environment within which number talk projects occurred as the analysis proceeded.

While parents generally launched the projects within which number talk occurred, there were also examples of children launching numeracy-specific projects. Given that the latter occurred much less frequently, they received less attention in the present study but will be an important direction for further analysis. Within projects launched by parents, the number talk occurring could have been enacted by parents or children. It was also common for children to pursue their own courses of action within projects launched by parents (e.g., eating ingredients, smelling ingredients or batter). These projects pursued by children were often subsumed within or occurring at the transition between projects launched by parents; they were often a brief component of the larger activity underway but they sometimes stalled or thwarted the project the parent was pursuing. When applicable, the analysis presented in this dissertation attended to children's pursuit of alternative projects. This would be a fruitful direction for further analysis.

Establishing Focus on Task-Relevance

As I reviewed the transcripts, I looked out for parent and child participation in number talk. When a project with number talk was identified, I created a "clip" of that portion of the transcript and recording based on the parent's demarcation of the boundaries between that project and the preceding and subsequent projects. For the initial six transcripts, I documented each number talk project in a research memo within *Transana*, grouping projects together based on what the family was doing and how number talk functioned within the project (Miles et al., 2014).

Through this process, it became evident that the number talk projects implemented varied in the extent to which they were relevant to the task of completing the recipe. In some number talk projects, parents and children were working to complete tasks that moved the recipe forward. In other projects, parents and children were engaged in a pedagogically-oriented numeracy activity that was irrelevant for completing the recipe. Based on these observations, I decided to classify the number talk projects identified based on their task-relevance. *High task-relevance* was defined as:

> "Projects in which the family is engaged in the instrumental tasks of completing the recipe (i.e., physical manipulation of ingredients and materials for the purpose of accomplishing a recipe task) and the number talk moved the recipe forward. These sequences involved a degree of risk for the success of the recipe (i.e., precision is needed to ensure the recipe 'worked out)."

In converse, *low task-relevance* was defined as:

> "Projects in which the family is engaged in an explicit numeracy activity that did not involve carrying out instrumental tasks of completing the recipe. The number talk did not move the recipe forward, and there was little risk for the success of the recipe. Within these projects, parents and children were oriented to the teaching, learning, or displaying of numeracy knowledge or skills, which was evident in the presence of Initiation-Response-Evaluation (IRE) sequences and explicit demonstration of numeracy concepts."

This focus on task-relevance appeared warranted given that the families enacted different activities and largely engaged with different domains of numeracy within the projects classified as having high task-relevance compared to the projects classified as having low task-relevance. Additionally, the task-relevance of a project seemed to contribute to how sequences of number talk progressed between parents and children, with children displaying more resistance to numeracy within projects with low task-relevance.

Building Corpus of Number Talk Projects

After deciding to compare number talk projects based on their task-relevance, I proceeded with building the corpus of number talk projects by working through the remaining transcripts. Given the frequency of number talk projects in the initial six transcripts, I decided it would be sufficient to draw from the first two available audio recorded cooking sessions provided by each family (as well as the two video-recorded interactions). Each number talk project launched by parents was classified as having high task-relevance, low task-relevance, or task-relevance that was hard to classify. Numeracy projects launched by children were collected in a separate collection. Within these categories, the projects were grouped based on similarities and projects with interesting turn design or sequence organization were flagged. While building the corpus, I took note of observations in a research memo, presented preliminary findings during data sessions, and reviewed relevant CA literature.

Establishing Focus on Numeracy Pedagogy

After reviewing the 62 transcripts, I worked to further narrow my analytic focus and establish criteria for determining which extracts would be included in the analysis.

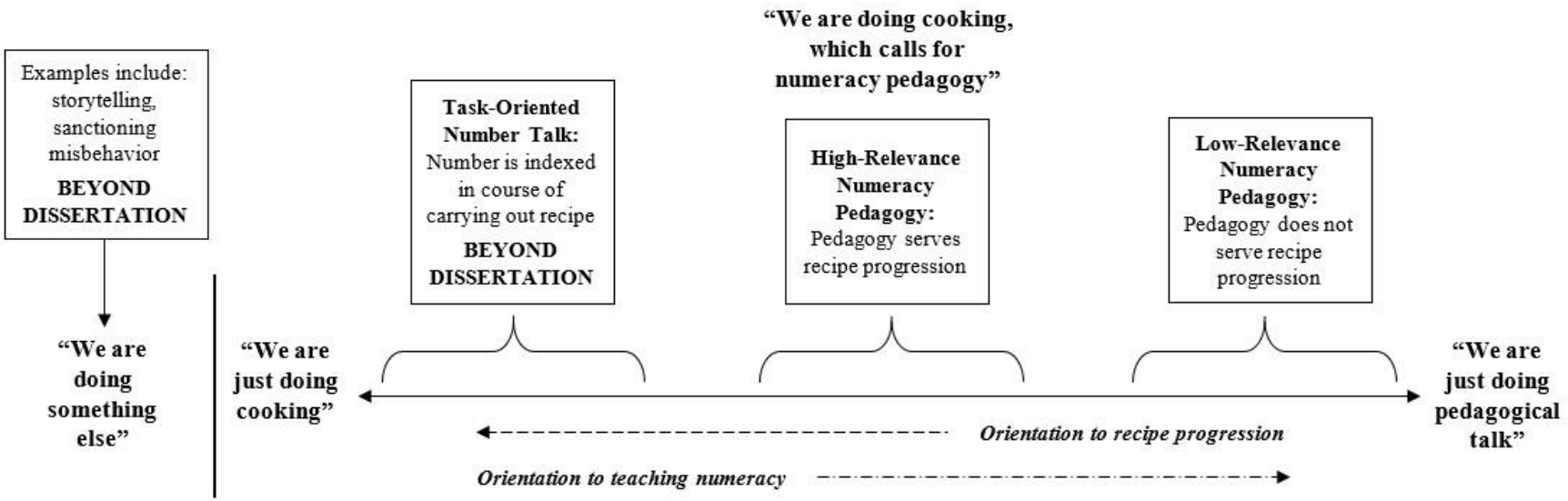
At this point, I recognized that differentiating number projects into the categories of high task-relevance and low task-relevance treated task-relevance and pedagogy as antithetical when, in fact, the projects classified as having high task-relevance varied in the extent to which they were pedagogical. Additionally, I struggled to determine how to proceed with number talk projects that were neither relevant to the recipe nor involved numeracy pedagogy. To address this, I diagramed the distinct categories of number talk observed in the data to clarify their distinctions and to establish clearer exclusion criteria. This led to the development of Figure 3.

I identified three primary categories of number talk projects: task-oriented number talk, high-relevance numeracy pedagogy, and low-relevance numeracy pedagogy. Definitions and examples of these categories of number talk projects are provided in Chapter 4. I categorized number talk projects as pedagogical if parents:

- Invited or directed children to contribute numeric information (i.e., respond to known-answer questions) or perform numeracy tasks (e.g., count, subtract sets);
- Performed or demonstrated numeracy tasks;
- Provided explanation of numeracy concepts or skills; or
- Explicitly and repeatedly drew the child's attention to numeric information.

Figure 3

Continuum of Family Number Talk Observed during Cooking as Participation in a Home Learning Intervention



Note: **1)** Number talk was categorized at the level of the project or action sequence (rather than at the utterance or family level). **2)** A project was defined as pedagogical if parents invited or directed children to contribute numeric information (e.g., respond to known-answer questions) or perform numeracy tasks (e.g., count); performed or demonstrated numeracy skills; or provided explanation of numeracy concepts or skills. **3)** The activity of cooking intrinsically involves number. Thus, parents frequently used numeric language in the course of executing recipe tasks and inviting children's physical participation in the completion of these tasks. When this occurred without pedagogical prompts or explanations of numeracy concepts, these sequences were categorized as task-oriented number talk. **4)** While families varied in the degree to which they were oriented to recipe progressivity and to numeracy pedagogy, they tended to have action sequences that fell within different categories. The activity—in terms of both the goal-oriented nature of cooking and the requirements of specific recipes—pulled for variability in the types of projects involving number talk that occurred. **5)** Variability was also evident within projects. Pedagogical sequences often contained turns similar to those occurring in task-oriented number talk. Projects characterized as high-relevance pedagogy sometimes contained pedagogy that was less relevant to the task at hand. Low-relevant pedagogical sequences also varied in the extent to which they were removed from recipe tasks. **6)** Families did other types of pedagogical talk (e.g., letters, vocabulary, colors, shapes) during the cooking sessions. This sometimes occurred during number talk sequences—both task-oriented and pedagogical.

Given that the overall context of these interactions was participation in a home learning intervention designed to encourage parent-child engagement in number talk, I ultimately focused the analysis on families' participation in numeracy pedagogy. Specifically, the analysis examined the activities enacted through and the sequence organization of high- and low-relevance pedagogical projects. This allowed for comparing numeracy pedagogy that served the purpose of advancing the recipe with numeracy pedagogy that was irrelevant to the primary goal of the overall activity.

Based on the decision to focus on numeracy pedagogy, I did not analyze the task-oriented number talk projects in depth. However, task-oriented projects were used as counterexamples to explicate the function of numeracy pedagogy within the cooking sessions. As depicted in Figure 3, number talk projects that were tangential or peripheral to completing the recipe or engaging in pedagogical talk about number were excluded from the analysis.

Table **2** summarizes the criteria used for determining the boundaries of what number talk projects were included in the present analysis.

Table 2

Summary of the Inclusion and Exclusion Criteria for the Present Analysis

Central focus	Projects launched by parents during which the family participated in numeracy pedagogy
Minimally addressed	Task-oriented number talk projects
Excluded	Number talk projects in which the family is doing an activity other than completing recipe tasks or engaging in numeracy pedagogy; number talk occurring in absence of a clear project; numeracy projects launched by children

Identifying and Analyzing Patterns in Numeracy Pedagogy

After organizing the corpus of number talk projects into task-oriented number talk, high-relevance numeracy pedagogy, and low-relevance numeracy pedagogy, I worked to identify and analyze patterns in how families enacted numeracy pedagogy. This involved organizing high- and low-relevance projects into more refined categories based on the activities implemented through the project, the position of the project within the larger cooking session, the turn design of parents' initiations within numeracy pedagogy, the sequence organization of numeracy pedagogy (e.g., whether children readily responded to parent initiations), and the affordances of the specific activity families were implementing (e.g., how much of a particular continuous ingredient the family was measuring out). I carefully reviewed the projects within the refined categories, cataloging similarities and differences between projects and identifying extracts that were useful for demonstrating different patterns in the data.

Elaborating Findings through Writing

The final stage of the analysis was elaborating the emergent findings through writing. At this stage, I identified the specific extracts I would use to demonstrate the differences between task-oriented, high-relevance, and low-relevance projects as well as the activities families implemented through numeracy pedagogy. I selected extracts that would demonstrate nuances in how families constructed these activities through IRE sequences. Through writing, I articulated how general patterns in the data were instantiated in context-specific ways in individual extracts and analyzed the sequence organization of these extracts.

CHAPTER 4: RESULTS

To explain the organization of this chapter, it is useful to walk through the two research questions addressed in the present dissertation and explain how the answers to these questions correspond with the section headings the reader will encounter below. The first research question was: ***what were parents and children doing when they talked about numeracy?*** To answer this question, I considered three distinctive but interconnected levels of action and activity occurring within the projects identified as involving family number talk. These levels of action are different lenses for understanding what parents and children were doing when they engaged in number talk. Given that these levels of action are interconnected, I have organized the results such that higher-level headings (e.g., "Task-Oriented Number Talk") identify the least granular lens for understanding what the families were doing and lower-level headings address what families were doing with greater granularity (e.g., "Measuring Out Continuous Ingredients"). I describe each of these layers of action below:

1. *To what extent did number talk prioritize cooking versus pedagogy?* This high level of action addressed if the projects were classified as task-oriented number talk, high-relevance numeracy pedagogy, or low-relevance numeracy pedagogy. As will be described in more detail shortly, in a general sense, the three categories of number talk projects were differentiated based on whether or not families' number talk was 1) instrumental to completing a recipe task and 2) pedagogically oriented (e.g., engaging children in knowledge display; demonstrating numeracy

concepts or skills). This chapter is divided into three primary sections, with each section focused on one of these types of number talk.

2. *What specific cooking or pedagogical activities were the families constructing through numeracy pedagogy or when they were engaged in numeracy pedagogy?* The projects classified as high-relevance numeracy pedagogy and low-relevance numeracy pedagogy were analyzed in more detail than the projects classified as task-oriented number talk. This intermediate level of action considered what activities parents and children enacted through high-relevance and low-relevance numeracy pedagogy (e.g., measuring out continuous ingredients, numeracy projects). In some cases, families implemented cooking activities or constructed pedagogical activities through their use of numeracy pedagogy. In other cases, families participated in numeracy pedagogy within a larger cooking activity or literacy-oriented pedagogical activity. Within the separate sections on high-relevance and low-relevance pedagogy, I describe the primary activities the families enacted as they engaged in that category of numeracy pedagogy, with each activity addressed in an individual section.
3. *Within what types of interactional sequences was number talk embedded?* This lowest level of action addressed the sequence organization of number talk, especially numeracy pedagogy, within the cooking sessions. As the results will demonstrate, initiation-response-evaluation (IRE) sequences were ubiquitous within both high- and low-relevance numeracy pedagogy. The function of these sequences and how they unfolded differed based on whether they occurred in projects classified as high- or low-relevance numeracy pedagogy and the specific

activity the family was constructing. I address this level of action as I present the analysis of each of the transcript extracts included in the chapter, meaning the sequence organization of numeracy pedagogy is discussed throughout the sections on task-oriented number talk, high-relevance numeracy pedagogy, and low-relevance numeracy pedagogy.

The second research question examined in the present dissertation was: ***how did different aspects of the cooking activity afford different kinds of number talk?*** The analysis demonstrated that variations in the recipe, ingredients, and cooking tools used shaped the affordances for numeracy pedagogy. These aspects of the cooking activities influenced each of the levels of action described above. They influenced whether it was relevant to engage in high-relevance pedagogy or in specific cooking activities within a cooking session. They also shaped the opportunities available for engaging in low-relevance pedagogy and influenced the interactional work parents needed to engage in to make specific low-relevance activities relevant. The recipe steps, ingredients, and cooking tools also shaped the sequences of numeracy pedagogy families constructed, such as what actions were implemented through IRE sequences and what domains of numeracy (e.g., numeral identification, counting) families engaged with. Like the sequence organization of number talk, I discuss how the recipes, ingredients, and cooking tools shaped the affordances for numeracy pedagogy throughout the chapter.

The next section provides an overview of the three categories of number talk projects identified in the cooking sessions. Then, each category is addressed in a separate section. The chapter ends with a brief summary of the differences between high and low-relevance numeracy pedagogy that the analysis identified.

Overview: Three Patterns in Family Number Talk

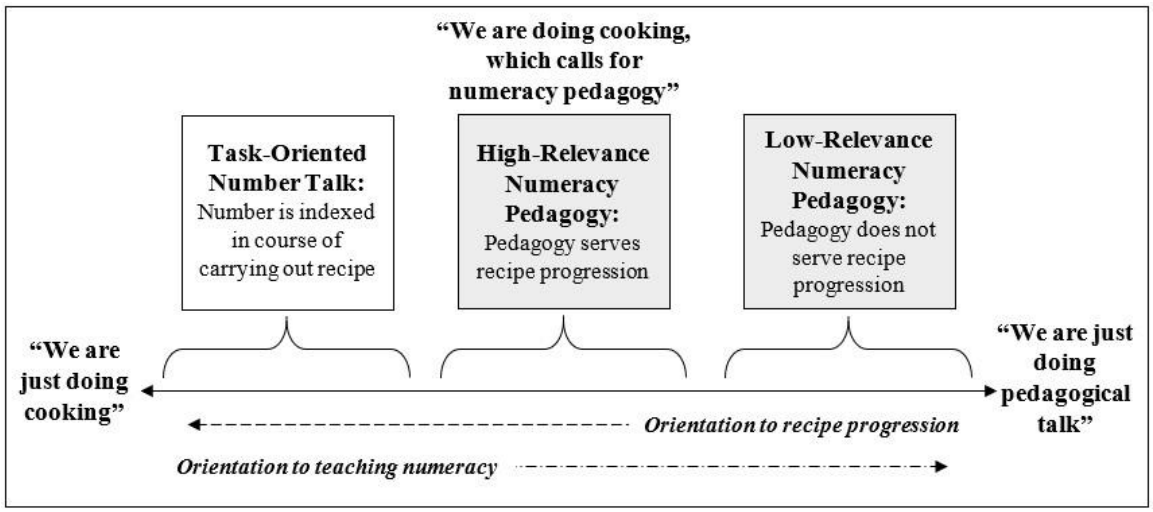
I observed three primary patterns in how parents and children engaged in number talk within the cooking sessions: task-oriented number talk, high-relevance numeracy pedagogy, and low-relevance numeracy pedagogy. These patterns were distinguishable based on the activities the families were constructing and the turn design, function, and sequence organization of the number talk enacted.

Figure **4** displays how the number talk projects implemented existed along a continuum[10]. On one end, within task-oriented number talk projects, parents or children used numeric language in the course of completing a recipe task. During these projects, the families did not engage in pedagogical talk about number; rather, parents' number talk was more strongly oriented to cooking than teaching numeracy. Falling in the middle of this continuum, within high-relevance pedagogical projects, parents and children participated in numeracy pedagogy within the context of moving the recipe forward. Within high-relevance projects, numeracy pedagogy invited children to participate in planning the course of action needed to perform a recipe task or to use their numeracy knowledge to implement the task. On the other end, within low-relevance pedagogical projects, parents and children engaged in pedagogical talk about number that was unrelated to completing the recipe. These projects were strongly oriented to teaching—or having children display— numeracy knowledge and skills.

[10] Note that these categories also exist along a continuum. While high-relevance projects had greater task-relevance compared to low-relevance projects, within these categories, families engaged in number talk that had higher or lower relevance to the task of completing the recipe. And some projects were harder to classify than others. This evident variability within categories is not unique to qualitative methods of analysis and actually presents greater limitations for quantitative coding of interactional phenomenon given the requirement of stricter boundaries between codes (Stivers, 2015). Within this dissertation, I present examples that are generally prototypical of the primary patterns that emerged.

Figure 4

Continuum of Family Number Talk Observed during Cooking Activities



Below, I differentiate between these three categories of number talk projects in greater detail and outline the primary activities enacted through projects classified as high- and low-relevance numeracy pedagogy.

Task-Oriented Number Talk

Key Finding: Within task-oriented number talk projects, number was a brief component of a larger action trajectory in which the family implemented a recipe task. In these projects, the families' number talk was not pedagogical.

Projects were classified as task-oriented number talk when parents or children used numeric language in the course of completing a recipe task without displaying an overt pedagogical orientation (e.g., the parent did not demonstrate or explain numeracy concepts or ask the child known-answer numeracy questions).[11] Within task-oriented

[11] This is not to say that task-oriented number talk does not promote young children's development of numeracy skills or that pedagogical number talk does advance children's numeracy skills. That is a distinct empirical question beyond the scope of this dissertation. Rather the purpose of this dissertation is to examine the interactional practices families used to engage in number talk, specifically numeracy pedagogy, and the function of these practices within the cooking sessions.

projects, number talk was often limited to a single interactional turn, with the participants' use of numeric language being only a brief component of a larger cooking action trajectory. Through their use of task-oriented number talk, parents and children enacted specific actions—making a request, delegating responsibilities, launching a new project—that were instrumental for navigating the joint activity of completing the recipe. Implementing joint activities, like completing a step of a recipe, requires not only executing physical actions but also managing the ongoing interaction: keeping things moving forward, negotiating responsibilities, recruiting others' participation, and repairing interactional trouble (e.g., misunderstanding, conflict; Bangerter & Clark, 2003). Task-oriented number talk was turns-at-talk in which it was relevant and instrumental to index number and quantity in the course of organizing, coordinating, and executing the implementation of a recipe task. Table 3 provides examples of parent turns-at-talk occurring within task-oriented projects and calls attention to common types of actions parents implemented through number talk turns within these projects.

Table 3

Examples of Parent Turns within Projects Classified as Task-Oriented Number Talk

Action	Example
Environment 1: Number Talk was Intrinsic to Recipe	
Launch next project, stating quantity of ingredient to add	>Next on the list.< (1.0) Half teaspoon of ↓gro:und cinnamon
Narrate the task of preheating oven	>So let's go ahead and turn our oven on like it says to three seventy fi:ve.< =>So it will be ready to cook.< ((sound of buttons being pushed from "like" to "So"))
Read recipe out loud to children	OKA:y >Let Me Read The< Instructions: BAke for Ten to Twelve Minutes or until bo:ttoms and si:des are gol:den bro:wn.
Recruit child's participation in carrying out a recipe action	°↓Al:↑right° (7.0) >Three-quarters of a cup< =>Go ahead< =>Can you pour that in the bowl?<

Environment 2: Number Talk became Relevant during the Activity of Cooking Together	
Provide instruction on recipe task	>So what we're gonna do< is take a spoonful and that's enough to make one cookie
Correct child's technique of carrying out recipe task	Al: >eh eh aye< cut one time on that side. And then- one time on the other side.
Make request to engage a withdrawn child in activity	>Can you help us< Bethanie? >Can you put one on the tra:y?< >You don't wanna help?<
Appease child as informs that cookies are not yet baked	I think we're >gonna let it cook< for maybe five more minutes and then that's it.
Delegate tasks equally between two siblings	Okay Ava (.) you do one egg And ↓>Ella do one egg<.
Make an assessment related to quantity or amount	↓An::d (.) >I think we have enough pancake #batter for# like<↓ (.) two: da:ys
Perform a noticing of a potential problem	↑Uh ↓oh >you missed putting< cheese on one of them.↓ What should we do?

In what interactional environments did families engage in task-oriented number talk?

Key Finding: In some task-oriented projects, parents and children implemented recipe tasks that intrinsically involved number (i.e., number was written into the recipe). It was common within these projects for parents to make the number intrinsic to the recipe (e.g., duration of cooking task, amount of ingredient needed) explicit for the child. It was during implementing these same types of recipe tasks that families participated in high-relevance numeracy pedagogy. Thus, task-oriented number talk and high-relevance numeracy pedagogy were two different approaches to executing recipe tasks when number was intrinsic to the recipe.

To uncover the function of task-oriented number talk turns within the cooking sessions, it is necessary to examine the interactional environments in which they are embedded (Maynard, 2013). The interactional environment of a turn is its position within the sequential unfolding of the interaction: how is the turn responsive to the prior turn, what next actions does it project in the subsequent turn, and how are these turns situated within larger action trajectories (Hoey & Kendrick, 2017; Levinson, 2013). Within task-

oriented projects, there were two primary interactional environments in which families engaged in number talk. In the first, the families were completing a recipe action that intrinsically involved number, such as using a measuring cup or preheating the oven, and the participants'—particularly the parents'—number talk stemmed directly from the task they were executing. In the second, the participants' number talk was enacted to address matters arising as a recipe task was carried out rather than emanating from what was written into the recipe. These two types of number talk turns were not mutually exclusive but instead both could occur within a single task-oriented project, and they could also both occur within high- and low-relevance pedagogical projects alongside pedagogical talk about number. The examples presented in Table 3 are organized based on whether they occurred in the first or second interactional context.

Before turning to discuss high- and low-relevance pedagogical projects, it is worthwhile to provide additional explanation about the task-oriented number talk that occurred when number was intrinsic to the recipe task underway. This will be useful for explicating the function of numeracy pedagogy within high-relevance pedagogical projects. When families completed a recipe task that intrinsically involved number within a project classified as task-oriented, the parent usually engaged in number talk as they did one of the following: launching the project, reading the relevant recipe step, narrating their own actions, or orchestrating children's physical participation. For instance, when implementing projects aimed at measuring out continuous ingredients and adding them to a cooking vessel, parents often labeled the amount needed at some point within the project. Extract 3 provides an example of a task-oriented project in which the family measured out one teaspoon of salt and added it to their mixing bowl. The mother and her

son were preparing Fun Pancakes with Mix-Ins using the treatment version of the intervention cookbook.

Extract 3: Mom and her son (5 years) on his birthday [2723-1_263]

```
1  Mom:    →   No:w we've gotta do o:ne tea[s p o o n  ]
2  Child:                                  [((sneezes))]
3  Mom:        Ooh bless you
4  Child:      ((sneezes))
5  Mom:        Bless you. (1.4) ↓Kay now let's wipe your hands down↓
6              (1.6) N'r:ight. No:w >this one's tricky< so Mama's gonna
7              hel- have to #help you a little bit# okay? (.6)
8          →   We're doing one teaspoon of #salt#
9              Okay (.) >Okay<= ((sound of tapping overlaps with talk))
10 Child:      =>Can I< help? ((sounds like mouth is covered))
11 Mom:        ↑Yep now you can add it.
12             (1.1) ((ringing from something hitting metal or glass))
13 Mom:        °↓Yep.°
```

The parent launched the project of measuring out the required amount of salt in line 1 by stating, “Now we’ve gotta do one teaspoon”. As she said “teaspoon”, the child sneezed, resulting in an insert sequence to tend to his sneeze. The parent transitioned back to completing the project with “N’right. Now this one’s tricky so Mama’s gonna hel- have to help you a little bit okay?”. She then reissued and extended her first turn with “We’re doing one teaspoon of salt”. The child’s request to help (“Can I help?”) in line 9 and the parent’s response (“Yep now you can add it”) suggests that the parent filled the teaspoon with salt before the child dumped the contents of the teaspoon into the pancake batter.

The first four examples in Table 3 provide other instances of this type of task-oriented number talk. These examples and the number talk turns in Extract 3 not only facilitated the forward movement of the recipe by, for instance, initiating the transition to a new project or recruiting children's participation in carrying out a recipe action, but also made the numeracy intrinsic to the recipe task explicit for the child. Through these turns, the parent seemed oriented not to teaching the child numeracy but instead to socializing the child into the cultural practice of cooking by making the numeric information inherent in the recipe evident to the child.

As illustrated in Extract 3, children's roles within task-oriented projects were typically limited to observing parents complete a recipe task, such as preheating the oven, or performing physical actions involved in completing a recipe task, like dumping the contents of a measuring cup or spoon into a cooking vessel. In the case of Extract 3, the child's exclusive role was performing the final physical action involved in implementing the recipe task. This may be due, in part, to the affordances of this particular project. In lines 6 and 7, the parent displayed an orientation to possible risks in measuring out the salt in her account for why she and not the child was going to fill the teaspoon: "this one's tricky". Interestingly, the parent's use of third person ("so Mama's"), her self-repair of "gonna hel-" to "have to help you", her inclusion of "a little bit", and solicitation of agreement from the child ("okay?") all work to construct her role in measuring out the salt as her providing limited assistance to the child. In other words, the design of this utterance minimized the role she would play in implementing the project and constructed her ensuing action not as imposition on the child's autonomy and competence but rather

as a requirement of the task that was beyond her own control (Beach, 1995, Land & Kitzinger, 2007; Schegloff, 2007).

This point is important because it highlights how aspects of recipe tasks appeared to influence whether parents used task-oriented number talk or engaged their child in numeracy pedagogy. It was within similar interactional environments in which number was intrinsic to the recipe task that families participated in high-relevance numeracy pedagogy. In other words, projects classified as task-oriented number talk and high-relevance numeracy pedagogy were two distinct approaches to constructing recipe tasks when number was built into the activities completed, with the defining difference being the absence or presence of numeracy pedagogy.

While parents may differ in their readiness to make use of available opportunities for engaging children in numeracy pedagogy, Extract 3 illustrates how the specific circumstances of the project, like the properties of an ingredient, may afford or limit family engagement in high-relevance numeracy pedagogy. In this example, the dyad needed to measure out one teaspoon of salt, an ingredient that can substantially influence the taste of food. While we do not know how this family stored their salt, within the United States salt is often sold in containers that require a pouring action, which given its small granules can make the task of measuring out a single teaspoon challenging and possibly messy. The parent does not make her specific concerns known but she displays an orientation to the risk involved in this cooking task and her organization of the task prioritizes attending to this risk.

Another aspect of this specific cooking project that shaped its affordances for numeracy pedagogy is the actual amount needed and the measuring tool required: one

teaspoon. Beyond identifying the numeral in the recipe, the opportunities for numeracy pedagogy are minimal. Underscoring this point, the parent and child in Extract 3 participated in high-relevance numeracy pedagogy during other projects in which they measured out ingredients as they prepared their pancake batter. For instance, they worked to find "1 cup" on a liquid measuring cup when measuring out one cup of milk and tracked the quantity of tablespoons as they measured out two tablespoons of sugar and two tablespoons of oil.

These two issues raised by Extract 3—the interactive work parents and children engaged in to tend to issues of control and competence and the role of affordances in shaping numeracy pedagogy—are touched on throughout this chapter. I now turn to defining and providing examples of high-relevance numeracy pedagogy.

High-Relevance Numeracy Pedagogy

Key Finding: By definition, high-relevance numeracy pedagogy functioned to facilitate children's participation in recipe tasks and served to move the recipe forward. IRE sequences deployed within these projects prompted children to identify numeric information the family needed to plan out the physical actions required of a task or to use their numeracy knowledge to implement the task.

Projects were classified as high-relevance numeracy pedagogy when the families engaged in pedagogical talk about number as they completed a recipe task and the numeracy pedagogy facilitated children's participation in the completion of the task. The recipe tasks families implemented through high-relevance projects intrinsically involved number and required some degree of precision to avoid unfavorable outcomes for the recipe. Extract 4 provides an example of numeracy pedagogy that occurred during a high-relevance project in which the mother and daughter measured out 1-cup of cranberry juice to add to their blender. They were preparing the Berry Smoothie recipe using the

treatment version of the intervention cookbook. These eight lines occurred at the beginning of the project with the parent's identification of the next ingredient they would add to their blender. Observe how the parent's initiation in line 4 functioned to elicit the child's verbalization of numeric information—how much cranberry juice they need to add—that was required for carrying out the recipe task.

Extract 4: Mom and her daughter (3 years) [1101-1_197]

1	Mom:		↓Oka:y↓ (.) >so our< cranberry juice =↓We nee::d↓
2			>Can you look back< >Can you remind me again<
3	Child:		°↓Yep.°
4	Mom:	I→	↓How much cranberry juice↓
5	Child:	R→	On:e
6	Mom:	E→	On:e ↑cup.
7	Child:	R→	°↓One cup↓°
8	Mom:		*C u p* Cup.

After launching the project ("Okay so our cranberry juice"), the parent said "We need" before proceeding to make a request of the child. Given the parent's talk in line 1, her request in line 2 can be understood as her asking the child to look back at the recipe ("Can you look back") and remind her ("Can you remind me again") of how much cranberry juice they need to add to their blender. The child accepted the request with "Yep", and the parent then issued the initiation "How much cranberry juice". The child provided the response "One" in the next turn, presumably identifying the numeral in the first line of the ingredient list: "1 cup CRANBERRY JUICE." In her evaluation turn in line 6, the parent provides a modified repeat of the child's response that included the unit of measurement: "One cup" (Stivers, 2005). Through this modified repeat, the parent

provided feedback that a complete fitted answer to a "how much" question includes a unit of measurement. This made it relevant for the child to repeat "One cup" to repair her prior turn to provide the complete second pair part implicated by the parent's initiation (Tarplee, 2010). Underscoring the pedagogical nature of this sequence, the parent proceeded to spell the word cup in line 8.

As was prototypical for high-relevance projects, the IRE sequence in Extract 4 solicited the child's participation in identifying numeric information needed for completing the recipe task. In fact, the parent's request in line 2 constructed the child's identification of the numeral "1" as assisting the parent by providing her with information they needed and that the parent did not remember. In using the modal form "Can you…" to make her request, the parent displayed an expectation that the request would be fulfilled but also an orientation that fulfillment was contingent on the child's capacity and willingness to do so (Craven & Potter, 2010; Curl & Drew, 2008; Rauniomaa & Keisanen, 2012). Following this request, the initiation in line 4 worked to scaffold the child's fulfillment of the parent's request. While the parent could have easily determined this information herself and was quite possibly looking at the recipe, the parent's request invited and her initiation facilitated the child's participation in identifying numeric information needed to implement the project. This request followed by initiation sequence framed the child's knowledge display in line 5 as purposeful to the project of measuring out the cranberry juice and, given the modal form of the request, as something the child had agency to opt into. While the parent claimed epistemic authority through her modified repeat in her evaluation turn in line 6 (Mehan, 1979; Tarplee, 2010; Stivers, 2005), her request for the child to use the recipe to "remind" her how much was needed

granted ultimate epistemic authority to the recipe and constructed the project as a collaborative effort.

Like in Extract 4, parents' initiations within high-relevance pedagogy overwhelmingly prompted children to identify or locate a numeral in the recipe or on a measuring tool or appliance. IRE sequences within these projects simultaneously functioned to:

- Prompt and evaluate children's display of numeracy knowledge (e.g., knowledge of the numeral 1); and
- Generate and corroborate numeric information needed for completing the recipe task (e.g., "one cup").

Together, these two functions of IRE sequences in high-relevance projects have the effect of facilitating children's participation in planning the actions the family will take to implement a recipe task and use their numeracy knowledge instrumentally to carry out the task. Given this, these sequences have the potential of affording parents with the opportunity to provide academic instruction about numeracy and practical instruction on using numeric information within the context of cooking. High-relevance numeracy pedagogy, therefore, not only solicited numeric information needed for moving the recipe forward, but also socialized children into both cultural routines for engaging in pedagogical talk and cultural practices of cooking with recipes, measuring tools, and cooking appliances.

What activities did the families enact through high-relevance pedagogical projects?

> ***Key Finding:*** Families enacted two primary activities through projects classified as high-relevance pedagogy: 1) measuring out continuous ingredients (e.g., flour, milk, macaroni) and 2) operating digital cooking implement (e.g., timer, oven, or microwave).

The majority of projects categorized as high-relevance pedagogy involved the family measuring out continuous ingredients, such as flour, milk, or macaroni, using measuring cups or measuring spoons. A second notable but less frequent activity occurring during high-relevance projects was using the buttons and digital display of an appliance to set a timer, preheat the oven, or melt an ingredient in the microwave. Whether families engaged in these activities during the cooking sessions was driven primarily by the recipe the family was completing. For instance, making pancakes often involves measuring out several continuous ingredients but there is usually less of a need to set a timer or preheat the oven. Conversely, making pizzas involves preheating the oven and perhaps setting a timer to monitor bake time but does not often require precise attention to the quantity of each ingredient. And while baking chocolate chip cookies typically involves measuring out ingredients, preheating the oven, and setting a timer to monitor bake time, a fruit salad can be made without engaging in any of these activities. I will describe and provide an example of each of these activities below.

Measuring Out Continuous Ingredients

In the high-relevance projects implemented to measure out continuous ingredients, parents deployed IRE sequences to facilitate the children's participation in one or more of the following:

- Identifying the amount of the ingredient called for by the recipe (as we saw in Extract 4);
- Selecting the appropriate measuring tool to use or determining how to use a particular measuring tool; and
- Delegating and performing the physical actions of measuring out and adding the ingredient to the intended cooking vessel.

Through these IRE sequences, parents invited the child to use their numeracy knowledge to plan out the actions required for implementing the project or to participate in measuring out the ingredient (e.g., by watching for a liquid to reach the correct measurement unit on a liquid measuring cup or tracking the addition of two or more measurement units, such as two cups or three tablespoons). When a recipe involved measuring out continuous ingredients, it often called for measuring out several different ingredients, providing opportunities for high-relevance numeracy pedagogy involving different quantities and measuring tools.

In these projects, parents largely directed the children's participation in planning out the task based on the requirements of the recipe and the affordances of the measuring tools available. For instance, rather than launching an open-end discussion of the tools available, parents generally launched targeted IRE sequences that projected an intended tool and course of action, engaging the child in locating or verbalizing the numeric information needed to identify an effective path forward. In this way, the constrained structure of IRE sequences (Bottema-Beutel et al., 2020; Sterponi & Fasulo, 2010) allowed parents to engage children in solving real problems of the recipe (e.g., how much they needed to add of each ingredient, how to correctly add two cups of milk using a 1-

cup measuring cup) while maintaining parents' control over the interaction. This constrained structure appeared instrumental for keeping the interaction moving forward and managing the possible risks of involving young children in cooking.

The combination of the properties of the ingredient (e.g., wet, dry), the amount needed, and the measuring tools available usually implicated the use of a particular tool, making a particular course of action relevant. As described above, parents launched IRE sequences that involved the child in identifying this course of action. Thus, these three aspects of the recipe shaped the affordances for numeracy pedagogy. For instance, if the family was to use a dry measuring cup or spoon (i.e., a single unit), the IRE sequences enacted typically functioned to facilitate the selection of the appropriate tool, with parents prompting children to locate the measuring cup with the correct numerals or compare the size of several measuring cups. However, parents sometimes identified the appropriate measuring cup and had the child label the numeral representing its unit of measurement. If the family was to use a liquid measuring cup (i.e., multiple units), the IRE sequences enacted typically functioned to involve the child in identifying the maximum unit or locating a smaller unit on the measuring cup.

When families needed to measure out two or more whole units (e.g., 2 cups, 3 tablespoons) one unit at a time or using a measuring cup with a smaller maximum unit than the total amount required, this provided opportunities for the family to enact numeracy pedagogy involving counting or arithmetic; numeracy domains that were relatively rare in high-relevance projects. For example, measuring out two cups of an ingredient with a 1-cup measuring cup is a different activity than measuring out two cups of the same ingredient using a 2-cup measuring cup. Most notably, the former but not the

latter facilitates breaking the total amount required (i.e., 2 cups) into discrete, countable units (i.e., 1 cup) or actions (i.e., filling measuring cup twice). While using a 2-cup measuring cup to measure out two cups requires identifying or locating the numeral 2 on the measuring cup, using a 1-cup measuring cup requires identifying or locating the numeral 1, determining how many times they will need to fill the cup to achieve the same quantity, and possibly counting to track as the units were added. Likewise, using a 2-cup measuring cup to measure out 3 cups makes discussion of arithmetic relevant (i.e., "two plus one").

Extract 5 provides an example of a mother facilitating her daughter's participation in determining how much baking powder they need to add to their pancake batter. The family is preparing the Fun Pancakes with Mix-Ins recipe using the treatment version of the intervention cookbook. This example was noteworthy for involving counting and arithmetic.

Extract 5: Mom and her daughter (4 years) [1307-1_92]

```
1  Mom:    I→ And the::::n (.) what does this say?
2          R→ (2.4) Tw[o : ] (.3) tea:spoons of ba:kin pow:der
3  Child:  R→          [Two-]
4  Mom:    I→ So what's: [ (.) >so what's] two plus two< =>We gonna
5  Child:                 [Right h e : r e]
6  Mom:    I→ dou:ble the recipe< =>What's two plus two<
7               (.3)
8  Child:  R→ °E:[qual:s°]
9  Mom:    I→     [L o o: k] look ↓two:: plus two
10              (.2)
11 Child:  R→ E:quals (.5) one two >three- Four.<
```

12 Mom: I→ >So two plus two is how much:

13 Child: R→ F:our:

14 Mom: E→ ↑Good jo↓::b=

15 Child: =↑Like I am↑

16 Mom: Ye:ah: (.8) Like ↑yo:u are↑ (1.5) So >we're gonna do

17 two< tea:spoons: (.) we're gonna do four teaspoons of

18 ↓ba:kin(.) so:da↓ =I mean ba:kin pow:der

The parent launched this project with the boundary marker "And then" and the initiation "what does this say?", presumably prompting the child to identify the numeral in the following line in the ingredient list: "2 teaspoons BAKING POWDER". After a gap of over two seconds, the parent began to label the numeral and the child joined in with her in saying "Two". In line 4, the parent issued a new initiation, "So what's (.) so what's two plus two". The parent, then, provided an account for this initiation, explaining "We gonna double the recipe", before immediately repeating the initiation ("What's two plus two"). After a beat of silence, the child quietly said, "Equals", signaling to the parent she was working to provide a response. The parent's next turn in line 9 overlapped with this turn and reissued the initiation, likely—though I have no evidence of this without a visual recording of the interaction—directing the child to count her fingers ("Look look two plus two"). The child began her response with "Equals" before counting to four and adding extra emphasis on the number "four" with stress and increased volume.

Following the child's counting, the parent launched a final initiation, "So two plus two is how much" with additional stress on "how much". The parent's use of "So" signaled that the child's preceding counting was relevant for solving this arithmetic equation. The child responded "Four" and the parent evaluated her response and closed

the numeracy sequence with "Good job". The child's next turn ("Like I am") extended the sequence, resulting in the parent's response, "Yeah (.8) Like you are." Here, the parent offered a more complete closing to the implied but never fully made explicit project they have undertaken in these 18 lines: identifying how many teaspoons of baking powder they needed to add to their batter if they wanted to double the recipe. The family then proceeded to measure out the baking powder.[12] In some of the projects that followed, the parent continued to present the child with arithmetic initiations to include her in determining how much of each ingredient they needed to add.

Extract 5 provides an example of a parent issuing an arithmetic initiation using an academic equation ("What's two plus two") in the context of involving the child in solving a real problem presented in the course of completing the recipe. While the initiations deployed in this example are known-answer questions as is typical of IRE sequences, the parent issued them not just to have the child display her numeracy knowledge, but instead to have her display her numeracy knowledge for the instrumental purpose of identifying how much to add of an ingredient. The projects to measure out continuous ingredients in this cooking session were unique in that something the family brought to the activity—the intention to double the recipe—afforded high-relevance numeracy pedagogy that engaged the child in arithmetic. Given that this information was not provided by the recipe, the mother had to also calculate this sum. While she could do this quickly on her own, she used IRE sequences to involve her child in doing this arithmetic, sharing the responsibility of organizing the recipe task with the child.

[12] It is a bit unclear why but the parent ultimately decided to add just three teaspoons of baking powder, saying "All right so maybe we'll just do three tablespoons =I mean three teaspoons. We won't put as much".

Operating Digital Cooking Implements

During the cooking sessions, the families sometimes used a digital cooking implement to set a timer, preheat the oven, and use a microwave. These tasks involved interacting with the numerals on the digital display or buttons of an appliance. These activities were classified as high-relevance pedagogical projects when parents did one or more of the following[13]:

- Prompted the child to identify numerals in the recipe or on food packaging to determine the required cook time or temperature (e.g., "Let's look at these numbers", "Can you read that number?", "Do you know what number that is?")
- Prompted the child to identify or repeat numerals on the display or buttons of an appliance (e.g., "What do the red numbers say?", "Say three-fifty")
- Prompted the child to locate and push buttons with particular numerals on an implement to set a timer or start the microwave (e.g., "Now press two zero zero")
- Counted up as the button was pushed to increase the number on the oven's display when preheating the oven (e.g., "Three-sixty. Go up again. Three-sixty-five. Three-seventy. Three-seventy-five.")

These activities ranged from relatively brief exchanges to more elaborate endeavors. For instance, during one cooking session in which the parent and child made chocolate covered strawberries, the parent facilitated the child's involvement in setting the cook

[13] These activities were also observed in projects classified as task-oriented number talk. Within task-oriented projects, these activities were often carried out exclusively by parents with parents narrating their own physical actions or informing children of the duration of a recipe task. Occasionally, parents orchestrated children's participation in the physical action of pressing buttons on appliance by instructing them to push a particular button without engaging the child in pedagogical talk (e.g., "Press this. Press it again").

time on the microwave for two minutes and stopping the microwave every 30 seconds to stir and check on the progress of the chocolate.

Extract 6 provides an example of a high-relevance project through which the mother and child—with some assistance from the child's father—set a timer to monitor the bake time of their pizzas. The mother and daughter in this example—one of the families in the treatment group—had been working on making a pepperoni "star pizza" and "four pizza circles" (i.e., rectangles of dough with toppings rolled up) using pre-prepared pizza dough. It is unclear if the family is using a particular recipe. This exchange occurred after they have prepared the pizzas and were getting ready to put them in the oven. The two IRE sequences deployed in Extract 6 facilitated the child's participation in identifying the numerals "2" and "0" to set the timer for twenty minutes.

Extract 6: Mom, Dad, and their daughter (3 years) [1412-2_541]

```
1  Mom:        All right >how long does it sa:y ↓to put it in< (.4)
2              #the oven for#↓ (1.7) ↑I: ↓thi:nk
3              (1.0)
4  Dad:        [°Bout (twelve) minutes°]
5  Mom:        [ (                  ) ] >I think it's twenty minutes<
6              =>Come on let's go set the timer< (.2) [Come on]
7  Child:                                             [O k a y]
... ((7 lines omitted))
8  Mom:        >Daniel can you pick her up so she can put tw- to put
9              twenty?< Okay (.) ↓we got to do the timer for twenty
10        I→   minutes↓ >So press ↑the two:↑<
11             (.8)
12 Child:      °Two::°=
```

13 Mom: I→ =>The number two< =>Where's the number two< (.3)

14 E→ £Ye:s smart girl£ >Okay oh< (.3) u:ms kitchen timer

15 ((beep)) =>Now press the number two< (3.1) ↑Two↑ (.8)

16 °You have the two?°

17 (2.0)

18 Dad: Press harder.=

19 Mom: =Press harder. (.3) You got the right number. (.2)

20 ↓All right let Mommy help you↓ ((beep)) Two.

21 **I**→ =>Now the number zero< =>Where's the zero<

22 (.7)

23 Child: R→ Ri:ght there.

24 Mom: E→ ↑Ye:ah: gir:::l↑

25 (.7) [((beep))]

26 Mom: [P r e s s] it hard. =>There you go<

27 >We got to start it.< >Hold on.< Wait. Let's put this in

28 the ↑oven. It's hot.↑

29 Child: ↑Yeah!↑ I want t- to close it.

30 Mom: =>You can close it< =>Close the oven< [(2.1)]((bang))

31 Child: [°(okay)°]

32 Mom: A:nd >now press the start button< (.) on ↑the

33 stove That's the start right ther:e↑ (1.4) ((beep))

34 There we go. ↑Now our pizza's coo:king:↑ ((singsong))

35 Child: Ye::s!

36 (.3)

37 Mom: ↓M'kay↓

The mother launched this project by asking, “All right how long does it say to put it in (.4) the oven for”. This question did not appear to be directed at anyone in particular and the mother ultimately provided her own answer (“I think it’s twenty minutes”[14]). She, then, recruited the child’s participation in setting the timer (“Come on Let's go set the timer”) and, after the omitted turns[15], requested the father’s assistance with “Daniel can you pick her up so she can put tw- to put twenty?”. This request repeated the bake time and projected the role the child would play in implementing the task. The mother then marked the start of setting the timer with “Okay” and informed the child, “we got to do the timer for twenty minutes”, further emphasizing “twenty” but now including the unit “minutes”.

In line 10, the mother launched the first IRE sequence with an initiation (“So press the two”) to prompt the child to locate and press the first numeral needed to set the timer. After a pause, the child quietly said, “Two”, displaying she was actively working to fulfill the parent’s directive. The mother pursued a response with “The number two Where’s the number two”. After another short pause, the mother said, “Yes smart girl”, with smiley voice and by emphasizing “Yes” with stress and elongation of the vowel. The child’s response to this initiation was nonverbal and the mother’s animated evaluation simultaneously confirmed the child’s nonverbal response and praised her. In

[14] It is interesting that while the mother indexed the recipe or instructions for the dough as the authoritative source of information regarding bake time (“how long does it say”), communicated uncertainty with her pauses, and the child’s father provided a response (“Bout (twelve) minutes”), the mother’s response to her own question (“I think it’s twenty minutes”) indexes herself as the source of this information, rather than rather constructing it as a collaborative decision or attributing it to an external authority like a recipe. It is possible the father said “Bout twenty minutes”; nevertheless, the mother does not construct her decision for how to move forward as mutual.

[15] In the lines omitted, the parent told the child to bring the phone with her (perhaps what they are using to record), expressed disagreement with the father, and pursued the child’s participation (“Let’s go. Come on”).

the turns that followed, the mother and father provided instruction and affirmation to direct the child to push the “2” button, with the mother ultimately pushing the button herself (“All right let Mommy help you”).

In line 21, the mother launched the next step in setting the timer (“Now the number zero”) and prompted the child to locate the “0” button with the initiation “Where's the zero”. After a pause, the child responded “Right there”, and the parent provided the enthusiastic evaluation, “Yeah girl”. This time the child was able to press the button. Next, the mother initiated the action of putting the pizzas in the oven (“Hold on. Wait. Let's put this in the oven” and warned the child of the safety risk of the oven (“It’s hot”). The child eagerly asserted her interest in contributing to the physical actions of putting the pizza in the oven by requesting to close the oven (“I want t- to close it”). The project ended with the parent directing the child to press the start button and the mother and child expressing excitement that their pizzas were cooking.

In this example, the mother’s initiations prompted the child to use her existing numeracy knowledge to implement the action of setting the timer—an important task in safeguarding against the potential risk of burning their pizzas. Interestingly, the IRE sequences functioned to include the child in the task even when she physically struggled to fulfill the required physical action of pressing a button. In this example, the child could more fully demonstrate her own competence through participating in numeracy pedagogy than through the physical actions required for completing the task. The mother also oriented to the child’s identification of the numerals “2” and “0” as more significant than the child’s completion of the physical actions of the recipe, suggesting she valued the child’s numeric contributions more than her physical contributions. This is evident not

only in the mother's completion of the action of pressing the "2" button, but also in the design of mother's second initiation in line 21 and the mother's differential responses to children's actions in the sequence.

While the mother's first initiation in line 10 prompted the child to "Press the two", her initiation in line 21 prompted the child to find the numeral "0" ("Where's the zero"). The design of her second initiation may be due in part to her prior pursuit of the child's identification of the numeral "2" ("The number two Where's the number two") and in part to the child's struggle to press the first button, but nevertheless constructed locating the numeral as the central duty for the child. More notably, while the mother responded with enthusiastic evaluation turns after the child located the numerals ("£Ye:s smart girl£" and "↑Ye:ah: gir:::l↑"), her acknowledgement of the child's completion of the physical actions of pressing the "0" button ("=>There you go< "), shutting the oven door ("A:nd >now press the start button<"), and pressing of the start button ("There we go.") were more muted.

This suggests that in addition to facilitating children's participation in planning and implementing recipe tasks by prompting them to draw on their existing or emergent numeracy knowledge, parents' deployment of IRE sequence in high-relevance projects can function to grant children opportunities to instrumentally contribute to tasks and display their competence as actors even when the physical actions prove to be beyond their current abilities.

Low-Relevance Numeracy Pedagogy

Key Finding: By definition, low-relevance numeracy pedagogy did not serve recipe progression but instead engaged children in displaying, rehearsing, and, in some contexts, advancing their numeracy knowledge and skills. IRE sequences deployed within these projects overwhelmingly prompted children to count present objects, such as discrete ingredients and cooking tools.

Projects were classified as low-relevance numeracy pedagogy when the families engaged in pedagogical talk about number that was largely irrelevant to or unnecessary for implementing recipe tasks. Instead of facilitating recipe completion, these projects were oriented to engaging children in displaying, rehearsing, and perhaps advancing their numeracy knowledge and skills. The numeracy pedagogy occurring within low-relevance projects overwhelmingly involved counting objects—either as an end or as a means for engaging in advanced numeracy tasks, such as arithmetic and magnitude comparison.

While disconnected from the goal of completing the recipe, low-relevance numeracy pedagogy was afforded by the presence of countable sets of discrete entities, namely ingredients and cooking tools, as the families worked to complete their recipes. The numeracy tips provided in the treatment version of the intervention cookbook largely encouraged low-relevance numeracy pedagogy by suggesting families practice counting, arithmetic, estimation, and subitizing with small sets of discrete ingredients or engage in other counting that was inessential for completing recipe tasks.

Unlike high-relevance pedagogy that by definition occurred as the families completed recipe tasks, low-relevance pedagogy occurred in a variety of positions over the course of the overall activity that could generally be classified as: the beginning of the session; the end of the session; during a pause within or between recipe tasks; and during waiting periods in which there were no recipe tasks available for the child or the entire

family to complete. Additionally, some low-relevance pedagogy was layered onto a recipe task despite being unnecessary for completing the recipe task. In the latter case, the pedagogy did not facilitate children's participation in the recipe task but instead prompted the child to practice counting or more advanced numeracy skills as they completed the task. In some cases, the child deftly managed pedagogy while completing a recipe task, but in others, the pedagogy stalled progression of the recipe task as the family paused to attend to child mistakes or resistance.

Extract 7 provides an example of low-relevance pedagogy occurring at the beginning of a cooking session. Among families who displayed a stronger pedagogical orientation—evident in their participation in several high- or low-relevance pedagogical projects in each of their cooking sessions, it was common to begin and conclude the cooking activities with low-relevance numeracy pedagogy. In this example, the parent prompted her daughter to count the cups they would use to make Dirt Cups (i.e., chocolate pudding with crumbled Oreos and gummy worms) using the control version of the intervention cookbook. The child's brother, two of her cousins, and her aunt are also present during this project and contribute later in the activity. Prior to this project, the mother introduced herself and everyone present. She then said, "And we're gonna be making dirt cake. Amelia has the recipe" before proceeding with the first line of the project.

Extract 7: Mom and her daughter (4 years), child's older brother and two cousins (9, 11, 13 years), and aunt are present [1316-3_24]

```
1  Mom:    I→ >We're gonna< start with >first Amelia< (.) how many
2             cups do you have here Bunny? =>You have to count them<
3  Child:  R→ O:ne t:wo (.) three:
```

4 Mom: E⟶ Whoa! =You missed one. [>Start over again.<]

5 Child: R⟶ [((l a u g h s))] O:ne two

6 three four >five six seven eight nine ten<. ((counts

7 briskly with steady voice, enunciating each number))

8 Mom: E⟶ That last cup is not part of the activity

In the first two lines of this extract, the parent initiated numeracy pedagogy by prompting her daughter Amelia to count. After marking the transition to the first project ("We're gonna start with first Amelia), she asked, "how many cups do you have here Bunny?" and then immediately provided the directive, "You have to count them". Amelia responded by counting—the fitted response to the parent's initiation. After Amelia counted to three, the parent interrupted her counting sequence with "Whoa! You missed one" before prompting Amelia to "Start over again." Given Amelia's counting mistake, it became relevant for the parent to provide an evaluation before Amelia completed her responsive turn. With this evaluation, the parent reissued the initiation, and Amelia responded by counting to ten. The parent closed the sequence with the evaluation, "That last cup is not part of the activity". The parent treated skipping an item in the set as beyond the bounds of a sufficient response to a counting initiation, requiring Amelia to restart her count in order to provide an adequate second pair part. In contrast, the parent simply acknowledged Amelia's inclusion of an additional cup in her counting sequence before proceeding to transition to a new project.

While this counting project was afforded by the presence of multiple cups and by the larger context of participating in a study called "Cooking and Learning Together," it did not serve a purpose in terms of the ultimate goal of the activity: completing the recipe. Despite the presence of other family members, the parent constructed this project

as a standalone numeracy task specifically for Amelia, her preschool age child participating in the study, marking the cooking session as first and foremost a pedagogical and performative activity (Tarplee, 2010). As was prototypical for low-relevance pedagogy, this extended IRE sequence functioned to have the child display and rehearse her counting skills. In prompting the child to display her knowledge, particularly with the directive "You have to count them", and then evaluating the child's counting with "You missed one. Start over again.", the parent positioned herself as having the entitlement and epistemic authority to direct the course of the activity, expect the child's compliance with her pedagogical initiations, and evaluate the child's knowledge displays (Heritage & Heritage, 2013; Kent, 2012a, 2012b; Mehan, 1979). In this way, low-relevance numeracy pedagogy worked to socialize children into a particular configuration of parent-child relationships, one in which there was an asymmetry in authority that made it interactionally permissible and relevant for parents to prompt and evaluate children's performances of knowledge (Tarplee, 2010).

What activities did families enact through low-relevance pedagogical projects?

> ***Key Finding:*** There were three primary ways that families constructed low-relevance numeracy activities—most of which involved counting present objects: 1) parent asked a "how many" initiation within an ongoing recipe or literacy-oriented pedagogical project, 2) parent launched a standalone numeracy project, and 3) parent layered low-relevance counting onto a recipe task.[16]

[16] A fourth activity that was less frequent within the data was parent-child joint reading of the recipe or larger cookbook. This activity usually occurred at the beginning of the cooking session, though families occasionally read other recipes in the intervention cookbook during waiting periods to explore what they might cook in the future. These sequences were distinct from how the families used the recipe during high-relevance projects. In high-relevance projects, the parent might engage the child in using the recipe to identify numeric information needed for completing a specific recipe task (e.g., temperature, cooking duration, quantity of ingredients needed). During these low-relevance projects, the families' use of the recipe was less about moving the recipe forward and more about orienting the child to the cooking activity. These activities took different forms including: 1) parent and child read materials and ingredient lists together, with child identifying numerals, parent reading text, and child repeating, 2) parent read materials

The predominant numeracy activity enacted during low-relevance pedagogical projects was counting. Specifically, parents prompted children to count and, overwhelmingly, their prompts directed children to count present objects, such as discrete ingredients and cooking tools. Children's counting within low-relevance projects was sometimes in service of answering arithmetic or magnitude comparison initiations. There were three distinct activity contexts in which parents elicited low-relevance counting or other domains of numeracy from children. First, parents prompted counting during ongoing recipe or literacy-oriented pedagogical projects through the use of "how many" initiations. Second, parents launched numeracy projects in which the overall purpose of the action trajectory was to have the child perform a pedagogical numeracy task that frequently involved counting. In this case, the numeracy pedagogy constituted the activity rather than being embedded within an activity that had purposes beyond pedagogical talk about number. Third, parents directed children to count as they completed a recipe task but the counting was unnecessary or irrelevant for completing the task. I will discuss each of these activity contexts in more detail below.

"How Many" Initiations during Ongoing Recipe or Pedagogical Projects

A primary way in which parents initiated low-relevance numeracy pedagogy was by asking children a "how many" question about a set of objects during an ongoing recipe or literacy-oriented pedagogical project. While there was variation, a few consistent patterns emerged in how parents designed these "how many" initiations, with the specific set to be counted typically identified in the prompt:

---

and ingredient list and child checked off if they had gathered the material or ingredient, and 3) parent read recipe and family engaged in pedagogical talk about number.

- How many [set] do we/you have? (e.g., “How many strawberries do we have?”, “And how many blueberries you have?”, “How many ingredients do we have?”, “How many wooden spoons do we have (.) while we’re at it?”)
- How many [set] did I/you/we [action]? (e.g., “How many pieces of toast did I put in the toaster?”, “I mean how many chocolate chips did you put on there?”, “Okay how many pieces did we just cut it up into?”)
- How many [set] are there? / How many [set] is this/that? (e.g., “How many ingredients are there right here?”, “How many slices is this?”, “So how many pieces of bread is that?”)
- How many [set]? (e.g., “How many eggs?”, “So how many bananas?”)

Given that low-relevance numeracy pedagogy was irrelevant for completing the recipe, it is pertinent to examine the contexts in which it became interactionally relevant (despite not being recipe relevant) for parents to launch “how many” IRE sequences. A fundamental tenet of CA is that talk is organized into interlocking sequences in which subsequent turns are designed to perform actions implicated by the prior turn (e.g., Drew, 2013; Raymond & Sidnell, 2014; Sterponi et al., 2015). When speakers pursue a course of action that is disconnected from the preceding talk, they need to account for or signal this departure in how they design their turn (Drew, 2013). Thus, parents needed to launch “how many” IRE sequences in a way that was connected to the prior talk or displayed a transition to a new course of action. Analysis of the cooking sessions suggests that it became interactionally relevant for parents to ask “how many” questions at any point in which a countable set was or the items in a set were indexed or explicitly referenced. As we will see below, sets were often indexed 1) during labeling sequences in which parents

prompted children to label a discrete ingredient (e.g., eggs, blueberries) physically present or depicted in the intervention cookbook and 2) through a family member performing or directing a child to perform a physical action that involved a countable set (e.g., choosing a mixing spoon from drawer, putting two pieces of bread in toaster, cutting produce into smaller pieces, adding pizza sauce to English muffin halves). Within these contexts, it was common for parents to begin their "how many" initiation with a boundary marker, such as "okay", "so", and "all right" that signaled the transition to numeracy pedagogy, and this was more elaborate when the "how many" initiation constituted a greater departure from the prior talk (e.g., "All right kiddo let's see. Now how many people are in our family?").

Overwhelmingly, the predominant response to a "how many" question involving a present countable set was for the child to count the set. Thus, these questions functioned to launch IRE sequences through which children performed and parents evaluated the counting of a present set of objects. In some projects, parents followed a "how many" initiation with a counting prompt either immediately, after a beat of silence, or after child vocalizations like "Hmm" and "I don't know". These counting prompts were often formulated as directives (e.g., "Count them", "You have to count them", "Count the cookies"), and can be thought of as the parents elaborating their initiation and pursuing the child's provision of a fitted second pair part to complete the sequence initiated by their "how many" first pair part (Schegloff, 2007).

After parents and children completed the initial "how many" IRE sequence, they either continued the project underway or the parent launched additional numeracy IRE sequences, typically through "how many" questions, arithmetic prompts (e.g., "And if I

take one away, how many is left?" One plus one equals what?"), magnitude comparison prompts ("Do we have more strawberries or more blueberries?"), or prompts to say a number in Spanish or to count in Spanish (e.g., "Do you know how to say two in Spanish?" "Can you count in Spanish?").

I will present two examples of parents deploying "how many" initiations during ongoing projects. In the first—Extract 8, the parent and child enacted a single IRE sequence in the course of an ongoing recipe task. In contrast, in Extract 9 In the course of the project, the parent launched two "how many" initiations, with the parent deploying an IRE sequence to have the children count in Spanish following the first "how many" initiation. Extract 9 provides examples of how IRE sequences are completed when there are two young children present, an illustration of how an extended series of topically connected IRE sequences unfolded, and variations in the interactional work a parent accomplished with her evaluation turns.

Extract 9, the parent and her two young daughters engaged in an extended pedagogical sequence at the beginning of their cooking session.

Example of a brief pedagogical pause to count during a recipe task. The mother and daughter in Extract 8 were preparing Easy Personal Pizzas using the treatment version of the intervention cookbook. This example occurred approximately 14 minutes into the cooking session after the child had already added sauce and cheese to some of their 14 English muffin pizzas. In this project, the parent directed the child to put sauce on the remaining pizzas.

Extract 8: Mom and her daughter (4 years) [1918-1_396]

```
1  Mom:        Her:e (.) put sauce on these two.
2              (1.1)
```

```
3  Child:       (°Yummy yummy cheese and sauce°)
4  Mom:         Here (.) you >gotta put sauce< on those.
5               Oh (.) you have these three to do. (.7)
6          I→   >HOw MAny DOn't< HAve Sauce =COunt It.
7               (.6)
8  Child:  R→   °O::ne two:: three::°=
9  Mom:    E→   =Good job. So we need to put sauce on it.
```

This project began with the parent directing the child to put sauce on two English muffins ("Here (.) put sauce on these two"). In line 4, the mother issued a second directive for the child to put sauce on the remaining English muffins ("Here (.) you gotta put sauce on those"). She followed this up with "Oh (.) you have these three to do", displaying this as new information to the parent and a repair of her prior indication that the child had two more to complete (Schiffrin, 1988). This utterance indexed a set of objects—the three English muffins that do not have sauce—and the mother launched an IRE sequence with a "how many" initiation immediately followed by a directive to count ("How many don't have sauce =Count it"). The child responded by counting to three, and the parent then provided the evaluation "Good job" before bringing the child back to the task of putting sauce on the remaining English muffins.

In general, adults and children orient to the initiations that launch IRE sequences as known-answer questions, with children displaying compliance, hesitance, or resistance with providing an appropriate knowledge display and adults positioning themselves as having epistemic authority to assess children's knowledge display through their evaluation turns (e.g., Heritage & Heritage, 2013; Mehan, 1979; Sterponi & Shankey, 2014; Tarplee, 2010). In this example, the pedagogical and performative nature of the

parent's initiation in line 6 is all the more evident given that the parent already labeled the quantity of English muffins without sauce in line 5 ("you have these three to do"). The fitted answer to the parent's initiation is not only already known by the parent but also has already been verbalized within the exchange. Thus, the parent's initiation and subsequent explicit directive made evident the asymmetry in control and authority between the parent and child and claimed entitlement to expect the child to comply by providing the appropriate knowledge display (Kent, 2012a, 2012b; Mehan, 1979; Tarplee, 2010).

In addition, the initiation and directive in line 6 uncover a tension in this sequence between recipe completion and numeracy pedagogy. In this brief sequence, the parent issued four—explicit or implied—directives for the child to finish putting sauce on the English muffins, suggesting a strong orientation toward completing the recipe task. However, the parent paused the progress of the recipe task to have the child count a set for which the parent had already verbalized this numeric information in the sequence. Thus, the child's counting performance momentarily delayed a recipe task that the parent was directing the child to complete, positioning the parent as the arbitrator of when a pause in recipe progressivity was permissible and as having the entitlement to control the child's actions within the activity. While the IRE sequences in low-relevance projects, in general, functioned to have the child display their counting skills when counting was irrelevant or unnecessary for completing the recipe, this function is especially salient in this example in that the numeric information was already verbalized and the counting display momentarily stalled the recipe project the parent was pursuing.

Example of an extended pedagogical project with numeracy pedagogy.

Parents sometimes began the cooking sessions with literacy-oriented pedagogical activities and launched "how many" initiations and other numeracy prompts within these sequences. These activities often began as labeling sequences in which the parent had the child label present ingredients or graphics depicted in the intervention cookbook. In addition to having the child label ingredients and respond to numeracy prompts, the parents often had children display other domains of early academic knowledge, like letters, colors, and shapes. These projects demonstrate how an initial IRE sequence can open the door to additional, topically-related IRE sequences, resulting in an extended pedagogical activity constructed through a series of IRE sequences (Bottema-Beutel et al., 2020; Mehan, 1979). In addition to occurring at the beginning of a cooking session, these extended pedagogical sequences could occur—though usually in a more abbreviated form—later in the session. For instance, one parent concluded the session by having the child tell "the people listening" the steps she took to make Dirt Cups, launching a series of IRE sequences to guide the child in providing a narrative account of the activity. As part of this activity, the parent had the child count how many gummy worms she had added to her cup.

In Extract 9, the mother and her two daughters, Ella and Ava, engaged in an extended pedagogical sequence at the beginning of their cooking session. They were gearing up to make Chocolate Chip Cookies using the control version of the intervention cookbook. This sequence began a minute into the recording after the family introduced themselves, identified what they would cook (Mom: "What are we gonna do today?... What kind of cookies?"), and discussed the audio recorder (Mom: "This is an audio

recorder. It's not a video recorder."). The project undertaken during this pedagogical sequence was labeling each of four the ingredients they needed to complete the chocolate chip cookie recipe[17]. In the course of the project, the parent launched two "how many" initiations, with the parent deploying an IRE sequence to have the children count in Spanish following the first "how many" initiation. Extract 9 provides examples of how IRE sequences are completed when there are two young children present, an illustration of how an extended series of topically connected IRE sequences unfolded, and variations in the interactional work a parent accomplished with her evaluation turns.

Extract 9: Mom and sisters Ella (5 years) and Ava (3 years) [2204_2403-2_48]

```
1  Mom:        Oka:y so:: let's figure out what ↑materials we need.
2         I⟶   >What do you think we need< to make ↓chocolate chip
3              cookies↓
4              (1.1)
5  Ella:  R⟶   ↑Ch:↓i:↑ps: ((sassy voice))
6  Mom:   E⟶   Chocolate chips? Ye:ah that's one t[hing
7  Ava:   R⟶                                     [Chocolate
8              ↑ki::↓::↑ps: ((sassy voice))
9  Mom:   E⟶   Ye:ah
... ((9 lines omitted: parent gets chocolate chips))
```

The project began with the parent launching the activity of identifying what materials they needed to complete the activity. In line 2, the parent initiated a labelling sequence with "What do you think we need to make chocolate chip cookies". Ella's

[17] The chocolate chip cookie recipe in the intervention cookbook used cake mix to simplify the steps required.

response of "↑Ch:↓i:↑ps:" led to labeling the four ingredients called for by the recipe. The parent's evaluation turn repaired the child's response ("Chocolate chips?"), affirmed her response ("Yeah"), and signaled her response was incomplete ("that's one thing"). Ella's younger sister, Ava, then issued a modified repeat of the two prior turns ("Chocolate ↑ki::↓::↑ps:"), copying her sister's sassy intonation and tone. The parent, then, affirmed Ava's response with the evaluation, "Yeah". In the omitted lines, the parent retrieved the chocolate chips and prompted the children to label the chocolate chips ("What is this?"). The sisters continued to repeat the need for chocolate chips and Ava moved to continue the labeling sequence ("We need we need What is this?").

The sequence then proceeded with the parent deploying an IRE sequence to have the children identify the second ingredient.

```
10 Mom:    I→  Oka:y a::nd (.2) what is t:his?
11 (Ava):  R→  ↑Cup↓cake
12 Mom:    E→  It's cake mix:
13 Ella:   R→  [Cake mix]
14 Ava:    R→  [Cake mix]
15 Mom:    I→  Oka::y  a[ :   :   :   n   d]
16 Ava:    R→           [>And we need some<] (.) (sauce) (1.3)
17              We need s:[o : m e ]
18 Ella:   R→            [↑E:↓:↑:]gg=
19 Mom:    I→  =A:nd what are the::se?
20 Ella:   R→  E::GGs
```

In line 10, the parent prompted the children to label the box of cake mix ("Okay and (.2) what is this?"). One of the children—possibly Ava—responded "Cupcake". In her

evaluation turn, the parent provided the correct answer “It’s cake mix”. Given the parent’s correction, it was, then, relevant for Ella and Ava to repeat “Cake mix”, which they did simultaneously. In line 15, the parent marked the transition to the next ingredient with “Okay and”. Given the context within this ongoing labeling sequence, this turn can be understood as an initiation to identify the next ingredient. Both Ava and Ella responded, with Ella labeling the eggs and with Ava perhaps referencing the vegetable oil. In response to the children’s turns, the parent issued a more focused initiation (“And what are these?”) in line 19 to have the children identify the eggs. The parent perhaps issued this constrained initiation due to the children’s disparate answers or Ava’s drawn out and possibly tangential response (“And we need some (sauce) We need some”).

Through the IRE sequence to label the eggs, the family indexed a countable set of discrete ingredients, making it interactionally relevant for the parent to provide a “how many” initiation in line 21. While the parent does not provide a separate evaluation turn following Ella’s response, “Eggs”, before launching the next IRE sequence, the parent’s question, “Ava how many eggs is that” indirectly affirms the accuracy of Ella’s response (Bottema-Beutel et al., 2020).

```
21 Mom:    I→ >Ava how many eggs is that.<
22 Ava:    R→ U:m one two.
23 Mom:    E→ T:wo::
24 Child:       °°Two?°°
```

The parent directed this “how many” initiation to Ava after Ella labeled the eggs in lines 18 and 20, perhaps to redirect Ava’s attention back to the unfolding pedagogical sequence or create an opportunity for her to contribute. Ava responded by counting to two (“Um one two”), and the parent provided an evaluation turn that repeated the last

number in the counting sequence (“Two”), emphasizing the quantity of eggs present and providing the cardinality response to her “how many” question. One the children, then, quietly repeated “Two” with rising intonation.

The parent continued the focus on numeracy by asking the children “Do you know how to say two in Spanish?” in line 25.

```
25 Mom:         Do you know how to say two in Spa:nish?
26 Ella:        [Ye:ah]
27 Ava:         [Yeah ]
28 Mom:    I→   How you say it
29              (1.7)
30 Ava:    R→   D:ie:z cuatro-
31              (.2)
32 Mom:    E→   °No° you got to count from ↑the beginning↑ U:no:
33 Ella:   R→   OKay [u :]no di:ez:
34 Ava:              [Ep-]
35 Mom:    E→   U:no: (.1) dos:
                (.2)
36 Ava:    R→   Uno do:s:
37 Mom:    E→   YE::↑[ah
38 Ella:   R→         [↓Okay (.4) Uno (.2) dos
39 Mom:    E→   Ye::ah good gir::l (.9) You're a bi:lin:gual
... ((12 lines omitted: labeling sequence to identify vegetable oil))
```

After the sisters responded with “Yeah”, the parent launched the next IRE sequence with “How you say it”. Ava responded with “Diez cuatro” or “Ten four” in English. The parent provided a corrective evaluation turn that first rejected the response (“No”), gave

instruction on how to issue a correct response ("you got to count from the beginning"), and provided the first number in the counting sequence to prompt the children's counting ("Uno"). Here, Ella cut in to provide a response "Okay uno diez", and the parent provided the correct answer ("Uno (.1) dos" with stress on "dos") to her initiation "How you say it". After a short gap, Ava repeated the correct response, which the parent affirmed with an enthusiastic and elongated "Yeah". Overlapping with this evaluation, Ella then repeated the counting sequence. The parent closed the sequence with an evaluation, "Yeah good girl (.9) You're a bilingual". In the omitted lines, the parent proceeded with the labeling sequence, launching an IRE sequence to prompt the children to label the vegetable oil ("And do you know what this is?"). The sisters displayed interest in the vegetable oil, responding with an assessment of its appearance (Ella: "It looks like soda and water"), disgust (Ava: "Ew I don't want that soda"), and request to smell the oil (Ella: "I want to smell it").

In line 40 below, the parent pushed to continue the pedagogical sequence by launching a second "how many" initiation to prompt the children to count the four ingredients ("So how many ingredients do we hav-"). The act of identifying each ingredient indexed this higher-order set (i.e., the "ingredients") that was first indexed with the parent's initiation in line 2 ("What do you think we need to make chocolate chip cookies") and explicitly referenced in lines 40, 43, 44, and 57.

```
40 Mom:    I→ >So how many ingredients [do  we  hav- ?<]
41 Ella:                               [I want smell it]
42 Mom:       You can't really smell it. It doesn't smell like
43         I→ anything. HOw MAny ingredients do we ha:ve
44            [      (.8)       ]>in order to make the chocolate chip<
```

```
45 Ava:          [°I can smell it°]

46 Mom:    I→    Can you count?

47 Ava:          Ew

48 Ella:         Yeah

49 Mom:    I→    How many?

50 Ella:   R→    .hhh T:wo:

51               (.4)

52 Ava:    R→    [Tree:]

53 Mom:    E→    [O::ne]

54 Ava:    R→    Three:

55               (.2)

56 Ava:          [ >(WAnt!   I WAnt)<  ]

57 Mom:  I/R→    [How many ingredients?] [O:ne two:]

58 Ella:                                 [NUHNUHNUH]  >NO NO< I count

59         R→    I:t's (.6) ↑fo:ur?

60 Mom:    E→    Ye:ah it is four ingredients
```

Ella interrupted the parent's initiation in line 40 by continuing to pursue the alternative project of smelling the vegetable oil. After blocking—or at least downgrading the value of—Ella's proposed course of action, the parent worked to pursue the children's counting of the ingredients, issuing three more initiations ("How many ingredients do we have to make the chocolate chips", "Can you count?", and "How many?"). This pursuit of a response is typical in adult-child IRE sequences when children do not readily move to provide a second pair part (e.g., Filipi, 2009; Mehan, 1979; Sterponi & Shankey, 2014; Zemel et al., 2011). It is interesting that the parent's third initiation ("Can you count?") used the modal form, allowing for the possibility of contingencies that might prevent the

children from providing a fitted second pair part (Craven & Potter, 2010; Curl & Drew, 2008; Rauniomaa & Keisanen, 2012).

With each additional initiation the parent issued, the absence of a fitted second pair part is further marked, increasing the pressure for the children to respond (Schegloff, 2007). The parent managed the asymmetry in authority and control between herself and her daughters that is instantiated through her pursuit of compliant provision of a second pair part, by using this request form that allows for providing a yes/no answer rather than the sought-after counting sequence. The modal form for making a request is typically used in interactional environments in which an interlocutor claims entitlement to expect their request to be fulfilled, such as with close family and friends, as opposed to with a supervisor or coworker (Craven & Potter, 2010; Curl & Drew, 2008; Rauniomaa & Keisanen, 2012). And yet, the parent might have employed a directive, as many parents do when a second pair part is not forthcoming, which would have maximized the asymmetry between the parent and her children by expressing entitlement to expect compliance (Kent, 2012a, 2012b). Thus, through downgrading from a "how many" initiation, which makes relevant the response of counting, to a "Can you count?" request, the parent increased the pressure for the children to count while minimizing her exertion of control and avoiding a potential power struggle.

Ella responded with "Yeah" to the parent's "Can you count?" and "Two" to the parent's "How many?". Ava followed Ella's turn in line 50 with "tree", which she repaired to "three". Overlapping with Ava's "tree", the parent provided corrective feedback in line 53 by providing the first number in the counting sequence "One". Both children, then, shouted over the parent's reissuing of the initiation ("How many

ingredients?") and attempt to provide the fitted response ("One two") in line 57. Ella's insistence on counting won out and she responded with the cardinal statement "It's four?". The parent, then, affirmed this response ("Yeah"), labeled the quantity ("it is four ingredients"), closing the numeracy sequence she initiated in line 40 and the larger labeling sequence initiated in line 1.

While line 60 closed the project of labeling the four ingredients, the family continued participating in pedagogical talk and discussing orienting information regarding the recipe for another 3 minutes and 20 seconds, at which point the parent launched the first joint recipe step of opening the cake mix. During these subsequent sequences, the family tried the chocolate chips, described the taste and color of the chocolate chips, counted how many chocolate chips each child grabbed in English and then Spanish, identified the materials needed for the recipe, discussed preheating the oven and what would happen to the cookies in the oven, and finally began to read the directions for carrying out the recipe.

Extract 9 demonstrates how some of the families constructed the activity of "Cooking and Learning Together" by engaging in extended pedagogical sequences before initiating the completion of the recipe task. These pedagogical projects define the activity of cooking with preschoolers as quite distinct from other sociocultural constructions of cooking activities, by relying on school-like ritualized interactional routines (Bottema-Beutel et al., 2020; Gardner, 2013; Mehan, 1979). Additionally, while IRE sequences frequently unfolded over more than three turns when the cooking sessions involved a single parent-child dyad, especially when parents provided corrective feedback in the third turn, making it relevant for the child to reissue their response turn, we see that IRE

sequences become more complicated when two young children contribute. Nevertheless, they continue to function to prompt children's display of knowledge and evaluate children's response, enveloping the children in a sequence that the parent launches and closes, directing the course of the exchange and keeping the interaction moving forward.

Numeracy Projects: Constructing Standalone Numeracy Activities

The second approach parents took to enacting numeracy pedagogy in low-relevance projects was constructing a standalone numeracy activity for young children to display, rehearse, and potentially advance their numeracy skills. Given that the opportunities for high-relevance pedagogy within a particular cooking session were limited by the affordances of the recipe, with some recipes (e.g., fruit salad) providing minimal opportunities for high-relevance pedagogy, parents who were oriented to maximizing the opportunities for engaging their child in numeracy had to construct activities that allowed for this. Moreover, since the affordances for counting, particularly counting larger sets, was limited in high-relevance, engaging children in counting required capitalizing on moments when larger quantities of discrete ingredients were available. I observed five primary types of numeracy projects, with counting projects occurring most frequently and with only a few examples of the latter three types occurring in the cooking sessions:

- *Counting Projects*: The parent introduced counting as a distinct activity within the cooking session and prompted the child to count ingredients, materials, or their final recipe product ("While I get the vegetable oil can you open and count how many eggs we have in the carton?", "Hey let's count how many we made", "Let's

see if you can count these correctly") or to produce a set of objects ("I need one pile right over here of four chocolate chips").

- *Estimation Projects*: The parent prompted the child to estimate a quantity. These came in three flavors[18]: the parent either invited the child to estimate 1) the quantity of a large "uncountable" set, 2) the quantity of an already present "countable" set, or 3) the hypothetical quantity of a set that was not yet in existence. In the case of the latter, the family would go on to produce and count the set.
- *Arithmetic Projects*: The parent constructed an addition or subtraction problem for the child usually related to a discrete ingredient or their final product (e.g., "So we have three pancakes, right? And I take one, how many is it?", "So if you take two away, which we did, how many are left?").
- *Magnitude Comparison Projects*: The parent presented the child with two small sets and prompted the child to count each set and identify which had more (e.g., "Which one has more chocolate chips?", "Okay which side has more berries?").

[18] Based on the observations available in the data reviewed, it appeared that the first two contexts could present troubles for the interaction. Examples of parents prompting children to estimate the quantity of a large "uncountable" set were along the lines of guessing the quantity of marbles in a jar when it is not possible to count the objects to determine the correct answer (e.g., "Zamaya? How much macaroni do you think is in here?"). This activity presented interactional trouble in the sense that the family had a harder time completing the IRE sequence. Young children's response to these initiations were very inadequate—not at the right magnitude of quantity (i.e., ones or tens instead of hundreds)—and they were not able to edit their response in a way that got them closer to the likely quantity. Additionally, the parent did not have the answer or a way of getting the answer, so they were not able to close the sequence beyond offering their own guess (i.e., Zamaya tried to pursue the correct answer after her initial guess of "Uh six" was not accepted: "Maybe ten? Maybe ten? … Did I guess it?"). In the cases of parents prompting children to estimate a present countable set (e.g., "And how many eggs do you think are in each one?", "How many pancakes do you think we made in total?"), children typically responded with counting and appeared to have trouble figuring out how to provide the fitted answer the parent was pursuing. In at least one example, this resulted in confusion and ultimately resistance when the parent subsequently prompted the child to count the set.

- *Equal Distribution Projects*: The parent prompted the child to distribute a food item equally and then count how many each person received (e.g., "Can you make sure we have the same amount?... Can you give us each the same?... How many do we each have now?"). There were also examples of families discussing how many cups they would get out of a smoothie or how many cookies they would need to make if each family received one. These later examples sometimes occurred as standalone numeracy activities or followed a "how many" initiation in an ongoing recipe or literacy-oriented project.

It appeared that arithmetic, magnitude comparison, equal distribution, and some estimation projects were constructed by parents to provide an alternative and more novel context for children to practice counting.

Extract 7 above provides an example of a counting project occurring at the beginning of a cooking session. In that case, the parent prompted the child to count the cups they would use to make their Dirt Cups and this occurred separate from any recipe task. While all low-relevance numeracy projects were irrelevant for the task of completing the recipe, parents sometimes constructed numeracy projects that connected numeracy pedagogy to a prior or forthcoming recipe action. We see this in Extract 10: the parent constructed an estimation project that involved the child estimating how many pieces a bell pepper would give them before she led him through cutting the bell pepper and, then, prompted him to count the resulting pieces. The mother and son in this example—a family in the treatment condition—were cutting up vegetables to make a stir-fry. The dyad did not appear to be using any particular recipe. In their prior projects in

this cooking session, they counted their heads of broccoli, cut the florets into pieces, and counted the resulting quantity of pieces before washing them.

In addition to illustrating an extended numeracy project that the parent tied to a recipe task, Extract 10 provides another example of a parent needing to pursue the child's provision of a second pair part following a counting initiation. While the parent initially had to work to elicit the child's counting, he ultimately extended the sequence, counting again to confirm they did in fact cut more pieces than he estimated and responding more readily to the parent's subsequent numeracy initiations.

Extract 10: Mom and her son (3 years) [1816-1_361]

```
1  Mom:          Okay so now (.) you >get to cut ↑the pepper↑< ↑Remember
2                (.) you have to set it down on the counter. (.2) Put it
3                down on a counter and m- cut away from your fingers.
... ((6 lines omitted: parent gives instruction on cutting))
4  Mom:          >Now one big piece is gonna give us< several smaller
5           I→   pieces. =>↑How many pieces↑ do you think it's gonna give
6                us?< =Can you take a guess? (.6) How many?
7                (.7)
8  Child:  R→    Um s:ix:
9  Mom:    E→    Six. ↑Okay let's see if it can give us six pieces↑
... ((16 lines omitted: parent talks child through cutting pepper))
```

In line 1, the parent launched the project of cutting the pepper into smaller pieces ("Okay so now (.) you get to cut the pepper") and proceeded to provide the child with instruction on how to cut effectively and safely. The parent, then, began to establish the basis of the ensuing estimation project, explaining "Now one big piece is gonna give us several smaller pieces". In lines 5-6, the parent issued an estimation initiation with "How many

pieces do you think it's gonna give us?" followed immediately by "Can you take a guess?". After a notable gap, the parent pursued the child's response with "How many?". After another gap, the child responded "Uh six". In her evaluation turn, the parent repeated "Six" before projecting the numeracy pedagogy to come with "Okay let's see if it can give us six pieces". Interestingly, this worked to construct a numeracy activity that had built in uncertainty that was shared by both the parent and the child. The exchange continued with the parent talking the child through cutting the pepper.

After they finished cutting the pepper into smaller pieces, the parent launched a counting initiation in line 10 ("So now let's count how many pieces of pepper we cut".)

```
10 Mom:    I→ So now let's count how many pieces of pepper we cut.
11            (.3) Let's count. You count. (.6) Go ahead. (.1)
12            You- (.4) >Count how many< pepper- pieces of peppers
13            we have.=
14 Child:  R→ =One (.) two (.) three (.) °four (.) five (.) six (.)
15            seven° (.) ↓eight=
16 Mom:    E→ =↑O:↓:h (.) so we thought we were >gonna have<↑ s:ix
17            ↓p:ieces. (.1) That was your es- [edu]cated ↑g:uess (.1)
18 Child:                                      [Six]
19 Mom:       But we actually have ↑e:ight:↑
```

The child did not readily respond, resulting in the parent issuing four additional counting initiations to pursue a fitted second pair part to her initiation. First the parent repeated "Let's count", which framed the counting as collaborative even though she is working to get the child to count on his own. She then increased the response pressure on the child when a response was not forthcoming with additional directives: "You count", "Go

ahead", and "Count how many pepper- pieces of pepper we cut". The child responded by counting the eight pieces that resulted from his cutting of the pepper. The parent's evaluation in lines 16, 17, and 19 presented the difference between the child's "educated guess" ("Oh so we thought we were gonna have six pieces") and the actual quantity of pieces they cut ("But we actually have eight"), marking this as new information with her "Oh" (Schiffrin, 1987) and, in the process, indirectly affirming the accuracy of the child's counting.

It is worth noting the parent's use of pronouns within the exchange so far, and how they display an orientation to managing the asymmetries in control and competence between the parent and child as the parent worked to construct the numeracy activity as collaborative. Previous research has demonstrated that within asymmetrical interactions (e.g., doctor-patient, parent-child), the individual with the greater authority will sometimes use personal pronouns in strategic ways to manage the asymmetry, either minimizing the appearance of their authority, often without actually disrupting the power differential, (Robertson et al., 2011; Skelton et al., 2002) or elevating the competence of the person with less authority (Ochs, 1992). In line 1, the parent began with "Okay so now you get to cut the pepper," which positioned the child as being granted with an important responsibility. In lines 5 and 6, the parent used "you" again to prompt the child to make a guess ("How many pieces do you think it's gonna give us? Can you take a guess?"), but she also used "let's" and "us" (e.g., "Okay let's see if it can give us six pieces"), to display affiliation with the child and to construct the activity as a collective exploration. In line 10, the parent repeated the use of "let's" in her initiation for the child to count and, now, used "we" to refer to the action of cutting the pepper ("So now let's

count how many pieces of pepper we cut"). When the child did not begin to count, the parent again used "Let's count", before making explicit her entitlement to exert control over his actions with the directives "You count" and "Count how many pepper- pieces of peppers we have" (Kent, 2012a, 2012b). Thus, while the parent was working to get the child to count on his own, she began by using collective language that framed the counting as collaborative, mitigating her exercise of control. But given this may have provided the child with a way out of responding, the parent ultimately upgraded to a directive that made clear her expectation that the child count on his own.

In line 20, the child provided an account for the discrepancy between his guess and the actual number of pieces, saying "We made accident".

```
20 Child:      U:M (.2) I think that we have tuh- We made accident
21             [(      )]
22 Mom:        [>We made] an accident< Okay. =Hold on. >Let me wipe
23             your nose.< (.9) You think we made ↑an accident↑ with
24             the num↑ber [that we] guessed?
25 Child:                  [Y e a h]
26 Mom:    I⟶  Okay >you gonna ↑recount it again↑<
27 Child:  R⟶  One two three four (.) five (.2) ↑six (.2) seven (1.2)
28             HEH HEH ((Chuckles))
29 Mom:    E⟶  E::ight
30 Child:      (               ) ((Screams something unintelligible))
31 Mom:        HA HA HA ((Laughs)) S:o we actually cut one big piece of
32             red pepper into e:ight smaller pieces (.2)
33             )↑That's okay.↑=
34 Child:      =Aye:ah:=
```

35 Mom: =>We thought we were gonna make six but it actually made

36 eight pieces<

37 Child: S:ix:

After an insert sequence in which the parent wiped the child's nose, the parent asked, "You think we made an accident with the number that we guessed?", offering her understanding of the child's turn in line 20. In line 26, she said "Okay you gonna recount it again" either proposing a course of action for the child to take or verbalizing a course of action he appeared ready to take. Regardless, this launched a new IRE sequence, with the child responding with counting. The child started out counting more quickly than he had before in line 14. As he approached the end of the sequence he slowed down. Rather than providing the final number in the sequence, the child laughed loudly, signaling his understanding that there are eight pieces. The parent completed the counting with "Eight", affirming the accuracy of his counting. Here the child shouted an unintelligible utterance and the parent responded by laughing and issuing the 'solution' ("S:o we actually cut one big piece of red pepper into e:ight smaller pieces") to the estimation activity she initiated in line 4 ("Now one big piece is gonna give us several smaller pieces"), with similar stress across the two turns. The mother then attended to the intensity of the child's reaction to this information with "That's okay".

In line 38 below, the parent initiated an arithmetic initiation ("So if I take away two (.4) if I take way two how many pieces are left?"), constructing an IRE sequence that offered the child the opportunity for his guess of "six" to be a correct answer.

38 Mom: **I**→ It made eight pieces =So if I take away t:wo: (.4)

39 if I take away two how many pieces are left?

40 (.4)

41 Child: R→ >Tis eh< ((Giggles)) Six!

42 Mom: E→ Awe:some! Good jo:::b Six. =Now can you confir:m your

43 **I**→ es:tima:ted guess? Let's ↑count

44 Child: R→ >One- two- three- four-< (.) six- >EHH heh heh< (.) HEH

45 ((laughs)) ↑Six

46 Mom: E→ Awe:so:me! Good jo:::b. ↑High five↑ You- are- so::

47 ha:ndsome and smar:t. (.5) Great jo:b!

The child responded with "Six". After the parent praised the child ("Awesome! Good job") and affirmed the accuracy of the response ("Six"), she launched a final counting initiation ("Now can you confirm your estimated guess? Let's count") that labeled the child's response in line 41 as an "estimated guess". The child briskly counted to four before pausing, seeming to realize there are in fact six pieces now. The parent closed the IRE sequence as well as the entire estimation project with the enthusiastic and elaborate evaluation "Awesome! Good job. High five You are so handsome and smart. Great job!".

In Extract 10, the parent constructed an extended numeracy project that she tied to the child's completion of a recipe task. The parent's use of an estimation initiation resulted in a pedagogical sequence that introduced uncertainty that the parent could use to frame the child's counting in lines 14 and 15 as providing new information to her. This retroactively constructed the IRE sequence launched in line 10 as a true prompt for information, rather than as a test question for which the parent already had the answer. In line 38 through 47, the parent and child collaborated on constructing an IRE sequence through which his guess made in line 8 could be considered correct, providing another example of how numeracy pedagogy made it relevant for the families to engage in interactive work to affirm children's competence. Perhaps the child's "incorrect" guess

and his emotional response to it created the context in which the parent provided such exuberant praise in lines 46 and 47.

While the parent had to issue several directives to prompt the child's counting in these turns, he readily responded to the parent's subsequent numeracy initiations. In fact, the child's eagerness to count within this type of activity was seen later in the same cooking session. In a later project to cut a different pepper, the parent said "I think this one's gonna be (.) into three pieces" before instructing the child to cut the piece in two places. The child counted to two as he cut the piece and then geared up to count the set, saying "So we have- Look". At this point, the parent launched an IRE sequence with "How many pieces did you cut?". The child readily responded by counting and extending the sequence past the parent's evaluation turn ("Three pieces Awesome") with "We have three pieces".

Layering Low-Relevance Counting onto Recipe Task

The final approach parents took to construct low-relevance numeracy activities was layering irrelevant and unnecessary—in terms of completing the recipe—counting onto a recipe task. Unlike the estimation project in Extract 10 in which numeracy pedagogy was enacted before and after a recipe task was completed, within these projects, parents directed children to count as they completed a recipe task. Unlike the counting we might see in high-relevance projects, the counting in these sequences did not serve a purpose in terms of completing the recipe. For instance, having a child count pepperoni as they place them on a pizza or count strawberries as they fill a 1-cup measuring cup does not provide numeric information that is instrumental for making a

pizza or smoothie. Furthermore, the precise quantity added is unlikely to have any substantial effect on the final product.

In some cooking sessions, parents' prompts for children to count as they completed a recipe action, such as adding sauce or pepperoni to English muffin pizzas, became repetitive, with the parent having the child count the same action and quantity several times. This particular activity was encouraged by one of the recipe steps in the Easy Personal Pizzas recipe in the intervention cookbook: "Spread 2 spoonfuls of pizza or spaghetti SAUCE onto each of the muffins". The treatment version of the cookbook further emphasized this activity with the numeracy tip: "Have your child count as they add two spoonfuls of sauce to each of the muffins". While this numeracy activity was written into the recipe steps, parents did not frame prompts to count as children added sauce or pepperoni to their pizzas as particularly relevant to the task (e.g., providing an account for why this was useful or important). Additionally, in the observations analyzed, parents usually had children add more than two scoops, increasing the difficulty of the task.

By and large, parents' initiations for children to count as they performed a task resulted in children providing a variety of incorrect responses: providing numbers out of sequence (e.g., "one two four", "three eleven"), counting backwards (e.g., "two one"), counting without one-to-one correspondence, (e.g., "one two three four five six" when they only performed the action twice), not continuing to count as the child continued the action (e.g., counting the first couple of actions but not the later actions), and provision of unfitted answers (e.g., a child responded with "cheese" and later "pepperoni" to the question "and what comes after four?", which the parent asked when the child did not

provide the next number in the sequence). These incorrect responses were common even when the child correctly counted as they went on some occasions or correctly counted to the same number or higher numbers when counting stable objects in another context. When the family was counting something that could become a stable set (i.e., strawberries and chocolate chip cookies but not pizza sauce), parents often prompted the child to start over at the beginning to identify the next number in the sequence or eventually had the child count the set once the recipe task was completed and the full set was created. Sometimes children initiated counting from the beginning in order to identify the next number in the sequence.

From a cognitive standpoint, these incorrect responses are not particularly surprising given the additional cognitive load required for managing counting while performing another action and keeping track of which number comes next in the sequence following longer pauses (Nguyen et al., 2017). Parents often treated these incorrect responses as the child being silly (e.g., "The number five, silly monkey"), distracted (e.g., "Are you following directions?", "You're not counting", "Look at it please and focus"), or uncooperative (e.g., "Can you please count in the right order?", "No don't make up stuff that's not there."). In fact, within these cooking sessions, there appears to be evidence that children instrumentally provided incorrect responses during counting—both when counting as they performed an action and when counting stable objects—to guess when they were uncertain and to resist parents' prompts to count. At times, what appeared to begin as sequencing errors due to the challenges of counting while performing a recipe action morphed into more overt resistance as parents continued

their efforts to pursue a correct counting sequence. This will be demonstrated through the example below.

Extract 11 provides an example of a numeracy project in which the parent prompted the children to count each strawberry as she filled up a 1-cup measuring cup. The mother and daughter were preparing the Berry Smoothie recipe using the treatment version of the intervention cookbook. This version of the cookbook included the numeracy tip: “Count the strawberries one-by-one when adding them to the measuring cup”. This is the same family as Extract 4. After they added cranberry juice, the parent guided the child in reading the following line in the ingredient list, “1 cup frozen STRAWBERRIES”, by prompting the child to identify the numeral, and then saying, “What word is that? Do you remember? Cup”. The parent then said, “One cup of strawberries” and “So let’s open our strawberries”.

In line 1 of Extract 11, the parent launched the distinct activity of having the child count as she filled the measuring up with strawberries. Initiations that prompted children to count as they performed a repetitive action (i.e., putting a strawberry in a measuring cup) created a dynamic where each additional action both continued children’s progress toward completing the larger project and issued a new response that if incorrect warranted corrective feedback from the parent. Throughout the incremental completion of the larger project, parents could launch intermediate initiations to facilitate the child’s accurate counting of the set as it gradually grew in size, one new item at a time. We see this unfold in this example.

Extract 11: Mom and her daughter (3 years) [1101-1_251]

```
1  Mom:    I→ >Okay now we're gonna< count how many strawberries it
2             takes to fill up this cup.
```

3 Child: R→ Okay (3.7) °O:ne: (2.0) hhmhh ((laughs)) (1.0) eh t:wo:°

4 (3.0) fou:r

5 (.4)

6 Mom: E→ Th:ree::

7 Child: R→ Th:ree: (3.1) e:le:ven=

8 Mom: E/I→ =↑Eleven? ↓Wait. Let's go back. ↓Use your finger↓

9 (.2)

10 Child: R→ °O:ne [(.4)] t::wo: thr:ee f:our°=

11 Mom: E→ [Mmhm] =F:our. ↑Awe:some.

After the parent's initiation in lines 1 and 2 ("Okay now we're gonna count how many strawberries it takes to fill up this cup"), the child began to count with fairly long pauses within each number in the sequence, presumably to remove the next strawberry from wherever they were stored. Here is another example of a parent using collective language, "we", when issuing an initiation for the child to fulfill. After labeling the third strawberry as "four", the parent corrected the child, saying "Three". The child repeated "Three" and after the longest pause yet said "eleven". In line 8, the parent rejected this response in the sequence, saying "Eleven?" with apparent incredulity in her tone. The parent then issued the initiation, "Wait. Let's go back. Use your finger", prompting the child to count the four strawberries she had placed in the measuring cup. After the child correctly counted to four, the parent provided an evaluation in line 11 that affirmed the final number in the sequence ("Four") and a descriptive evaluative ("Awesome"; Bottema-Beutel et al., 2020).

With this evaluative turn, the parent closed the counting of the first four strawberries, making it relevant for the child to continue, in her subsequent turn in line 13, the activity launched by the parent's primary initiation.

```
12                (2.0)
13 Child:  R→  F:i:ve [(1.4)] (2.6) °↓eleve:n° ((mumbles "eleven"))
14 Mom:                [Mmhm:]
15         E→  ↑>Why do you want everything to be eleven?<↑ ((laughs
16         I→  during talk)) Fi:ve. =>What comes after fi:ve?<
17             =O:ne [>two three four< fi:ve]
18 Child:  R→         [>Two three four< fi:ve] (.) si:x:
19 Mom:    E→  ↑Thank ↓you.
```

The child correctly responded with "Five", which the parent affirmed with "Mmhm". The child then quietly mumbled "Eleven", signaling some uncertainty about the next number in the sequence and awareness of the inadequacy of "eleven" as the next response. Here, the parent laughed while asking, "Why do you want everything to be eleven?". She then launched a new intermediate initiation affirming the last correct number in the sequence "Five" and prompting the child with "What comes after five". She then proceeded to count one through five. The child joined her on "two" and following a short pause after "five", provided the next response in the sequence "six". The parent responded with the evaluation "Thank you". In the context of this pedagogical project, this "Thank you" displayed recognition of the child's compliance, and portraying the child's previous response of "eleven" as untoward.

In line 20, the child again continued the ongoing activity by adding an additional strawberry and attempting to provide the next number in the sequence.

20 Child: R→ Si:x

21 Mom: E/I→ >That was six so this one's< (.4) >One two three four

22 R→ five ↑si:x< (.5) ↓se:ven

23 (2.7)

24 Child: R→ ↓Ni(h):(h)ne ((laughs during talk))

25 Mom: E→ Eight.

26 Child: R→ Eight?

27 Mom: E→ ↓Mm↑hm

However, the child repeated "Six" here, resulting in the parent's corrective evaluation ("That was six") and issuing of an intermediate initiation ("so this one's"). After a notable beat of silence, the parent counted from one to six. Following a slightly longer pause, the parent provided the correct response ("seven"). The child then continued with adding the next strawberry to the measuring cup. Here she said "Nine" while laughing with lower intonation, suggesting uncertainty with her response. The parent corrected the child by saying, "Eight". The child responded by repeating "Eight?" with rising intonation. The parent affirmed the accuracy of this response.

After a beat of silence, the child moved to end the sequence by saying "And that's it." in Line 29.

28 (.5)

29 Child: >↑And that's it.↑<

30 Mom: °(Okay)° ↓>Well we can probably<↓ squee:ze one or two

31 more (.4) So: we were at (.) ↑eig[h t] =>One two

32 Child: [°(One)°]

33 Mom: I→ three four five< s[: i x] [se:ve:n:] [ei:gh]t:=

```
34 Child:                          [°six°] [°seven°] [(ngh)]
35              =>I wanna dump it [in]< ((whines))
36 Mom:    I→                    [↑A] couple more↑ (.2) Ei::ght
37              (.2)
38 Child:       ↓>I wanna< hold i:t:↓ ((whines))
39              (1.1)
40 Mom:    R→ N:i::n[e ]
41 Child:  R→        [ne]: (.6) >That is<↓gon be↓ a lo::t (.8)
42 Mom:    I→ ↓>How much is that<↓ (.3) N:i::[n e ]
43 Child:  R→                                  [°↓O]:ne t:wo: three
44              four fi:ve [si:x]↓
45 Mom:                    [Here] >let's take it ou:t<
```

However, the parent—being the one that launched this numeracy project and having the authority to determine its closure—blocked the child's attempt to close the sequence with "We can probably squeeze one or two more". After a beat of silence in which the child did not resume her counting sequence, the parent moved to resume the counting sequence, saying "So we were at eight" and counting from one to eight to prompt the child to provide the next number in the sequence. Prior to the parent's counting, the child may have quietly voiced "one" and she joined the parent in saying "six" and "seven" before making a vocalization on "eight". Instead of providing the fitted second pair part, here the child made a complaint, "I wanna dump it in", moving again to close the counting sequence. The parent persisted in pursuing her agenda to add "A couple more", before reissuing "Eight" to prompt the child's provision of a second pair part. After a gap, the child again issued another complaint ("I wanna hold it").

After a longer beat of silence, the parent provided the second pair part “Nine”, which the child joined in on. Then, the child again pushed back again on the parent’s agenda of adding more strawberries, making the assessment “This is gon be a lot”. When the child did not continue the counting sequence, the parent issued a new intermediate initiation “How much is that” to prompt the child to provide the next number in the sequence. After a beat of silence, the parent pursued a response from the child by providing the previous number in sequence (“Nine”). The child responded by starting over to count from one. At this point the child had added ten strawberries to the measuring cup—the total amount that they would add. The activity of counting all the strawberries, launched by the initiation in line 1, remained open at this point because the final strawberry had not been counted (Schegloff, 2007).

So far in Extract 11, the parent had provided more extensive scaffolding than seen in the previous extracts. This is in part due to the challenges created by the activity of counting as the set was produced. For each additional strawberry the child added to the measuring cup and counted, it was interactionally relevant for the parent to evaluate the child’s new response. While this was also the case when children were counting a stable set of objects, as was seen with Extract 7, it was generally easier and faster for children to achieve a sufficient counting sequence. When counting, each additional item counted in the set introduced the possibility of the child making a “mistake”, shifting the child’s response from “sufficient” to “insufficient”. Given this inherent characteristic of counting within the constrained structure of IRE sequences and the prevalence of counting in low-relevance projects, low-relevance numeracy pedagogy presented families with additional

challenges for securing a fitted answer to parents' initiations and bringing IRE sequences to a close.

Until the child's move to in line 29 to close the sequence ("And that's it."), she had been more or less cooperating with executing the counting sequence prompted by the initiation in line 1 and completing the intermediate IRE sequences the parent launched to scaffold her counting. In the sequence above she began to display more resistance to the continuation of the sequence, providing complaints and an assessment to pursue closing the sequence. Nevertheless, the child moved to count the strawberries in line 43 and 44, displaying her attempt to provide a second pair part. In line 45, the parent said, "Here let's take it out", transforming the activity of counting the strawberries as they were added to the activity of counting the stable set of ten strawberries on a plate. In line 48 and 49, the parent gave an account for her action of removing the strawberries from the cup that elevated counting as a priority within the larger activity and veiled the parent's exertion of control with the use of "we": "Because we have to make sure we count them all properly =That's part of the activity". From here, the child displayed more substantial resistance to counting and the parent responded by pursuing compliance.

```
46                (.4)
47 Child:         (W:h::y)
48 Mom:           >Because we have to make sure we< cou:nt them all::
49                pro:per:ly =That's part of the activity (2.8) ((sound of
50           I→   frozen strawberries being poured onto plate)) G:o (.6)
51 Child:    R→   G:o o:ne: t:wo: three °four n' fi:ve° ((singsong voice))
52 Mom:      E→   Fi::ve
53                (.4)
54 Child:    R→   Fou:r (1.0) th:ree °two one°
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55 Mom: E→ hmhm Sa(h)van(h)nah ((starts laughing and continues
56 through saying child's name)) (.4) Okay. U:se your
57 I→ pointer finger =Remember. (.5) ↓How much is it↓
58 Child: R→ O:neuh t:wo: =>That looks like a< (.) a milk. (1.3)
59 °Kiss° (.8) A k:iss (.6) A [(.2)] [k:iss]
60 Mom: [> A] [k:iss]< >A Hershey
61 kiss?<
62 Child: Ye:ah:
63 Mom: I→ ↓Ye:s. (.2)
64 Child: R→ One: °t:wo three (.7) >one Hershey kish< ((says "one
65 Hershey kiss" in back of throat))
66 Mom: E→ >↑Not a Her↑↓shey ki:ss↓< >Come on< >Count the
67 strawberries<
68 Child: R→ •O:::neh ↓t:wo: ↓th:ree four five >six seven eight
69 nine ten eleven twelve<↓ ((slurs last three numbers))
70 Mom: E/I→ ↑Sa::↓vvy. >↑We can't put um in until we count them
71 correctly↑<= ((a bit of singsong voice))
72 Child: R→ =O:ne:h
73 Mom: E→ ↑L:ook at it↑
74 Child: R→ O::ne: (.2) t:w::o (.6) thr:ee: (.3) fo:ur::: (.4)
75 fi::ve: (.3) (°si:x°) (1.6)
76 Mom: E→ ↓Se[ven.
77 Child: R→ [ven (1.0) ei::ght (.5) ni:::ne (.3) t:en

In line 50, the parent launched a new initiation for the child to count the strawberries with "Go". In the course of the sequence above, the child gave five

insufficient responses before she correctly counted—with one instance of parent scaffolding—all ten strawberries. In each of these five responsive turns before her final counting sequence, the child displays resistance using a different strategy. First, in line 51, the child began a counting sequence with "Go o:ne: t:wo: three" before mumbling in a singsong voice "four n' fi:ve". While it is somewhat unclear with her lowered volume, the child's use of the derivative of "and" (n') and her rhythmic voice quality might suggest she was moving to end the sequence prematurely. In some counting sequences, children in this data displayed an orientation to cardinality by emphasizing the final number in the sequence. One of the ways children did this was by inserting "and" in between the second to last and final number in the sequence. After the parent repeated and clearly enunciated "Fi::ve" to prompt the child to continue the sequence, there was a beat of silence and then the child counted backward.

The parent responded by laughing and laughing through saying the child's name. Then seemingly to regroup and enact a more serious tone, the parent said "Okay. Use your pointer finger =Remember." After a beat of silence, she reissued the initiation to count the strawberries with "How much is it" with lowered intonation. Here, the child launched her second insufficient counting sequence, beginning again at "one". She counted to two, with extra emphasis on the ending of "one". Then, immediately after "two", the child pursued an alternative project by providing an assessment of one of the strawberries: "=That looks like a (.) a milk. (1.3) Kiss (.8) A k:iss (.6) A k:iss". The parent repeated "A kiss", overlapping with the child's final attempt to articulate her assessment, and then issued a repair through the appendor question "A Hershey kiss?" (Stivers, 2010). The child confirmed with "Yeah" and the parent moved to close the

insert sequence launched by the child's assessment with "Yes", making it relevant again for the child to provide the second pair part the parent was pursuing.

The child responded with her third insufficient response, this time counting to three, pausing, and then saying in a funny voice "one Hershey kiss" (pronounced more like "kish") as if it was part of the counting sequence. The parent responded with "Not a Hershey kiss" before increasing the pressure for compliance with "Come on Count the strawberries". Here, the child responded with her fourth insufficient response, by counting from one to twelve without one-to-one correspondence, both a frequent counting mistake among young children (Nguyen et al., 2017) and a common strategy that children in this sample used to display resistance following an initiation to count. In this counting sequence, the child drew out "one" adding extra emphasis at the end, began lowering her intonation on "two" and "three", used a low staccato voice on "four" and "five", before picking up her tempo and slurring "ten eleven twelve".

Upgrading the pressure for compliance from her previous initiation ("Come on Count the strawberries"), the parent responded by saying the child's nickname ("Sa::vvy.") in a disapproving tone and "We can't put um in until we count them correctly" using a higher intonation and slight singsong voice. The child began a fifth counting sequence, saying only "one", before the parent issued the directive "Look at it", cutting this fifth insufficient—from the perspective of the parent—response short. The child then responded by counting from one to ten in a slow deliberate voice, elongating the sounds of each word. From the recording, it is unclear what exactly happened at the number "six", which the child seemed to say very quietly. The parent came in at "seven",

with the child completing the word with her. The child then finished her deliberate count to ten.

Throughout this exchange, the parent exercised her entitlement to expect compliance by continuing to pursue a correct counting sequence, but maintained a relatively light, upbeat, and somewhat playful tone. Nevertheless, the parent issued a warning that the cooking would not continue until "we count them correctly" in lines 70 and 71, clearly communicating her willingness to stall the cooking activity as long as needed until the child produced a correct counting sequence. This elevated pedagogy as a primary priority within the cooking activity, framing performances of correct counting as a necessary component of its successful completion. The parent managed to enforce compliance, while mitigating it somewhat with her tone and use of "we".

This may be in part due to the fact that the child managed to display a move toward compliance without actually providing the sufficient response in each of her five attempts. Previous analysis of children's resistance to parent directives that require an embodied response has demonstrated that children sometimes respond to directives by displaying what has been termed "incipient compliance", in which the child displays an embodied demonstration of moving toward complying, while either delaying actual compliance or voicing verbal resistance (Kent, 2012a). While previous research has shown that parents tend to respond to child resistance with an immediate upgrading of their directive (Craven & Potter, 2010), resistance that occurred after a display of incipient compliance was shown to led to the de-escalation of the exchange (Kent, 2012a). In addition, incipient compliance created space between parents' directives and children's ultimate compliance, allowing children to treat their compliance as

disconnected from the directive and less of an impingement on their autonomy (Kent, 2012a).

While not directly comparable to the present data, the child in this example, as was the case in other examples in the present data, put off providing a correct counting sequence while still displaying an effort to comply by providing a verbal response that involved counting. By not being completely unresponsive, the child enacted a display of compliance while continuing to subvert the expectation that the child would perform a correct counting sequence. For instance, in lines 58 and 59, the child displayed an attempt at compliance by beginning a counting sequence, before proceeding to make her assessment that a strawberry looked like a Hershey kiss. By initiating her assessment immediately after "two" and uttering "That looks like a" rapidly, the child displayed that her assessment was a parenthetical noticing that she is inserting into the counting sequence, delaying the completion of the sequence but not foreclosing willingness to comply (Hepburn & Bolden, 2017).

In addition, some of the child's insufficient attempts introduced ambiguity—arguably strategically—regarding the extent to which the child was refusing to count correctly and the extent to which the child was struggling to accomplish a correct counting sequence. For instance, the child did not display an overt stance of resistance through her trailing off at number "five" in line 51 or counting backward in line 54. Like her counting without one-to-one correspondence in lines 68 and 69, this could be construed as counting errors rather than resistance, or in the very least as silliness, especially with the funny voice the child employed in lines 68 and 69. By using a funny voice in line 64, for example, when she said "One two three (.7) one Hershey kish", the

child performed silliness rather than an outright refusal to comply. The parent's laughter when saying the child's full name ("Sa(h)van(h)nah") in line 54, her exaggerated "Not a Hershey kiss" in line 66, and her singsong voice in lines 70 and 71 suggest that both the parent and child are carefully treading this line between exerting or resisting control and performing playing at exerting or resisting control. This has been seen in another analysis of a pedagogical interaction that turned into a compliance sequence between an adult and child (Sterponi & Shankey, 2014).

After the child correctly counted to ten, the parent provided the positive assessment "Awesome" in line 78, closing the sequence launched by her initiation in line 1. She then marked the transition from this sequence to a new course of action with "Okay".

78 Mom: E⟶ ↑Awe:↓so:me =Okay [(N o w)]

79 Child: [>Now I can<] ↑dump it

80 in↑((singsong voice))

81 Mom: Now you can dump them in.

82 (.8)

83 Child: You need to put them back inside because you °(dump

84 em)° (.6) these out to a pla:te.

85 Mom: °I kno:w (.8) ↓Because we have to count th:em↓°

In line 79, the child cut off the parent's launching of a new action with "Now I can dump it in" with a repetitive singsong quality. She said this slightly more quietly, almost to herself, expressing slight annoyance. The child then upgraded this display of irritation by rebuking the parent in lines 83 and 84, saying "You need to put them back inside because you dump em (.6) these out to a plate" with emphasis on the last word. The parent

responded by saying “Because we have to count them”, repeating her previous claims in lines 48 and 49 (“Because we have to make sure we count them all properly”) and lines 70 and 71 (“We can’t put um in until we count them correctly”). These turns displayed the parent’s orientation that pedagogy was a necessary and primary component of the activity and that cooking was a vehicle for having the child count.

After they added the strawberries, this dyad moved onto adding the next ingredient: the blueberries. They looked at the recipe to determine how much blueberries were needed: “One cup”. The parent then asked, “Okay do you want to count the blueberries?”. The child responded, “Nope. I don’t want to”, to which the parent laughed and said, “Well we have to”. Then, after an almost three second gap, the parent changed course, saying “Or let’s =How about we do this. We’ll fill it up and then we’ll see how many”. The project proceeded with the parent constructing a magnitude comparison numeracy project that involved the child counting two sets—one with seven blueberries and one with three blueberries—to determine which had more. In this sequence, the child continued to display resistance but ultimately complied.

In these projects and other similar examples, the child’s resistance led to the parent’s pursuit of compliance. In this way, pedagogy could become a site for parents to socialize child compliance. While the most frequent response to parent initiations was timely cooperation, child resistance to counting was relatively common within the families in the treatment condition, perhaps because their parents prompted more counting—namely low-relevance counting—which required significantly more from children than identifying a numeral and perhaps because parents were more strongly oriented to pedagogy as being a primary—if not *the* primary—goal of the activity.

Among these families, particularly when preparing a recipe that had more minimal opportunities for high-relevance numeracy pedagogy, like a smoothie or fruit salad, parents often displayed a more rigid stance for how pedagogy needed to unfold. First, parents displayed an orientation that the child needed to be the one to count. After all, in low-relevance contexts, parents' prompts to count were irrelevant for completing the recipe and functioned to have the child display their counting skills, so the relevant second pair part was not just counting, but for the child to perform counting. Second, the parent displayed an orientation that the activity needed to be carried out in a particular way. For example, in Extract 11, the parent insisted that they add ten strawberries and that the sequence could only end after the child counted all of them with minimal help from the parent. Together, this constructed an interactional environment in which pedagogy was disconnected from and in competition with the activity the child signed up to participate in: cooking. While it was more common for children in these contexts to delay responding and to delay compliance, it was very rare for children to not ultimately comply with providing a fitted second pair part to a parent initiation; in these rare sequences, the parent generally opted not to pursue a response from the child.

Comparing High-Relevance and Low-Relevance Numeracy Pedagogy

In conclusion, the present study observed two primary patterns in how sequences of numeracy pedagogy unfolded during the cooking sessions: high-relevance pedagogy that moved the recipe forward and low-relevance pedagogy that did not serve recipe progression. Table 4 summarizes the primary differences between these two patterns of numeracy pedagogy that were discussed in this chapter.

Table 4

Comparison of High-Relevance and Low-Relevance Numeracy Pedagogy

	High-Relevance	Low-Relevance
Definition	• Pedagogy moves recipe forward	• Pedagogy does not move recipe forward
Function of IRE sequences	• Facilitated children's participation in planning the course of action needed to perform a recipe task or to use their numeracy knowledge to implement the task; Involved child in solving real problems of the recipe, while allowing parent to maintain control and keep things moving forward	• Prompted children to display, rehearse, and, in some contexts, advance their numeracy knowledge and skills; primarily engaged child in counting present objects
Position in activity	• As recipe tasks are completed	• Beginning of session • End of session • Pause within or between recipe tasks • Unnecessary pedagogy layered onto recipe task • Waiting period
Activities	• Measuring out continuous ingredients • Operating digital cooking implement (i.e., timer, oven, microwave)	• "How many" initiation during ongoing recipe or pedagogical project • Numeracy projects: Counting, Estimation, Arithmetic, Magnitude Comparison, Equal Distribution • Layering Low-Relevance Counting onto Recipe Task
Role of Affordances	• Recipe made activities relevant and shaped the opportunities for engaging in numeracy pedagogy	• Afforded by presence of countable sets of ingredients and cooking tools • Given limits to opportunities for high-relevance within any particular recipe, parents who were oriented to maximizing opportunities for pedagogy needed to capitalize on affordances for low-relevance numeracy activities
Common initiations	• Identify a numeral (e.g., "Do you know what this number is?", "How many cups do we need?",	• "How many" initiations (e.g., "How many ingredients do we have?", "Okay how many pieces

	"What's that number?", "How much blueberries?", "What does that say?") • Locate a numeral (e.g., "Can you find the number one?", "Where's the one that says one slash two?", "Do you see where the two is?"	did we just cut it up into?", "So how many pieces of bread is that?", "How many eggs?") • Counting prompts following a "how many" question (e.g., "Count them", "Count the cookies", "You have to count them")

CHAPTER 5: DISCUSSION

Given the importance of young children's math skills for their later academic achievement (e.g., Duncan et al., 2007; Nguyen et al., 2016), there has been increasing attention to children's early numeracy experiences at home (e.g., Elliot et al., 2017; Huntsinger et al., 2016; Galindo & Sonnenschein, 2015). A primary focus of previous research has been parents' use of number talk during play, math-specific activities, and everyday routines (e.g., Eason et al., 2021; Levine et al., 2010; Ramani et al., 2015). In addition to correlational research that has found associations between parent number talk and children's prospective math skills (e.g., Casey et al., 2018; Susperreguy & Davis-Kean, 2016), a recent experimental study found causal evidence that parent number talk promotes children's early cardinality knowledge (Gibson et al., 2020).

However, previous research has primarily operationalized parent number talk as discrete, decontextualized instances of environment input, overlooking how parents and children collaboratively and incrementally construct numeracy conversations. Moreover, the field has given minimal attention to how parents engage children in number talk when they are working to teach numeracy skills. These limitations of the extant literature pose challenges for developing guidance and resources for promoting family engagement in numeracy that are based on the realities and true complexities of parent-child

interactions. The present study sought to address this gap by using CA to examine the sequential organization of parent-child number talk during cooking, with a focus on how parents and children participated in pedagogical talk about numeracy. The parents and children cooked together within the context of participating in a home-based math intervention, providing an opportunity to analyze how they interacted and engaged in number talk within an overtly pedagogical context.

In this chapter, I will interpret the three primary findings of the present study, before discussing the implications of the results for studying family number talk and developing resources for promoting families' engagement in early numeracy. The chapter will end with a description of the limitations of the present study and directions for future research and practice.

Discussion of Findings

Distinct Ways of Engaging in Number Talk and for Distinct Purposes

The results of the present study demonstrate that parents and children use numeric language and engage in numeracy conversations in distinct ways and for distinct purposes within the course of an activity. First, analyzing the task-oriented number talk projects revealed that it becomes interactionally relevant to use numeric language in the course of parent-child activities to enact a multitude of actions (e.g., delegating tasks between siblings, requesting to taste ingredients, providing instruction on completing a recipe task). Within these interactional environments, parents' and children's number talk was

usually a brief component of a larger course of action, but nevertheless a valuable linguistic resource for managing the joint activity of completing a recipe. The families also used numeric language in the course of other activities that were excluded from the present analysis: sharing what happened at school, reminiscing about a past experience, sanctioning child misbehavior, and so on. The relevance and utility of number within these parent-child interactions is unsurprising given that, despite great diversity in how languages index quantities, number is a pervasiveness dimension in the majority of human languages and within English, in particular (Acquaviva, 2017; Corbett, 2006).

In addition to the wide-ranging actions that can be implemented through individual number talk turns, this dissertation found that parents' and children's use of number talk could be differentiated based on whether it was relevant for completing the recipe and whether it was pedagogically oriented. Comparing the projects classified as task-oriented number talk, high-relevance numeracy pedagogy, and low-relevance numeracy pedagogy illuminated three distinct patterns in what the parents and children were doing together in terms of how they were talking about numeracy, what specific recipe or pedagogical activity they were constructing, how the sequence positioned children vis-à-vis parents, and how children were being socialized into cultural practices for cooking or pedagogy.

For instance, within interactional environments in which number was intrinsic to the recipe, parents' use of task-oriented number talk made this intrinsic numeric information explicit for the child. These interactional turns functioned both to keep the cooking activity moving forward and to socialize children into the cultural practice of cooking. Within these task-oriented projects, children's participation was limited to

performing physical actions like pouring ingredients into a mixing bowl and parents' number talk contextualized those physical actions within the activity of cooking. In other words, in the example presented in the previous chapter, the child was not dumping any random amount of salt into the bowl, but instead the parent had carefully measured out a very specific amount—one teaspoon—using one particular measuring tool. The parent made this information salient to the child, communicating cultural knowledge about the practice of cooking within their ecocultural context. However, parents' use of high-relevance numeracy pedagogy within these same interactional environments invited children to share responsibility for using numeric information intrinsic to the recipe to plan out and implement recipe tasks, constructing the activity as more collaborative and allowing children to display greater competence within a typically adult activity.

Research has largely taken two approaches to coding and analyzing number talk. First, some researchers have treated number talk as if it is a monolithic interactional behavior. While they may code number talk based on domain or complexity, their analysis is focused on examining correlations between total number talk—measured at the word or utterance level—and children's math skills (e.g., Gürgah Oğul & Aktaş Arnas, 2020; Levine et al., 2010; Leyva et al., 2017; Mutaf Yıldız et al., 2018; Susperreguy & Davis-Kean, 2016). The results of the present study suggest this approach overlooks the reality that number talk is not a single interactional behavior but serves several different interactional functions and can be used to construct different activities and distinct ways of interacting. The second approach examines associations between more specific number talk codes, often related to the complexity or domain of numeracy, and children's math skills (e.g.; Casey et al., 2018; Elliot et al., 2017; Gunderson &

Levine, 2011; Ramani et al., 2015; Son & Hur, 2020). The results of this dissertation suggest that coding by numeracy domain or complexity is insufficient for understanding what families are doing through their number talk and how they are going about doing it. For instance, while counting was more common in low-relevance pedagogy, in large part due to the affordances of the recipes, there were examples of high-relevance counting. Parents' prompts for children to count served different purposes and often unfolded differently within these two activity contexts, based on whether the counting was instrumental for completing a recipe task.

Expanding upon previous research, the present study found that the extent to which number talk was task-relevant and pedagogically-oriented was consequential for how parents and children participated in numeracy conversations, with more extended numeracy exchanges occurring within pedagogical projects but not task-oriented projects. Moreover, unlike low-relevance projects in which parents prompted children to rehearse their numeracy skills in ways that were disconnected from the goal of completing the recipe, high-relevance projects invited children to use their existing or emergent numeracy skills to plan out and implement recipe tasks. These high-relevance projects provided families with contextually meaningful opportunities for parents to provide feedback on children's numeracy skills and demonstrated the real-world significance of math.

There is reason to believe that pedagogically-oriented number talk that engages children in using, rehearsing, and advancing their numeracy knowledge would be particularly beneficial for their math learning. Previous research suggests that parents' efforts to engage children in formal numeracy activities in which they explicitly teaching

math skills (e.g., practice simple arithmetic) were stronger predictors of children's numeracy skills, like counting, number identification, arithmetic, and magnitude, than participation in more informal math activities, like reading counting books; playing with puzzles, blocks, board games, and card games; and watching tv or videos with math content (Huntsinger et al., 2016; Skwarchuk et al., 2014). It may be that parents do not frequently engage in pedagogical number talk within informal math activities, while the overt pedagogical nature of formal numeracy activities elicits numeracy pedagogy, affording opportunities for parents to provide scaffolding and instruction that advances children's skills. A recent study did, in fact, find that parents engaged in more math talk about fractions within the context of a formal learning activity (e.g., worksheet and manipulatives) compared to a guided play activity (e.g., storybook with prompts, relevant play materials) and a free play activity (e.g., play materials alone), and asked more math questions during the formal learning activity and guided play activity than in the free play activity (Eason & Ramani, 2020).

Moreover, aligned with Montessori and Reggio Emilia philosophies of early education, research has documented cognitive and social-emotional benefits of project-based and authentic learning experiences for young children (e.g. Aral et al., 2010; Halvorsen et al., 2012; Hertzog et al., 2007; Meacham & Atwood-Blaine, 2018; Revell et al, 2020). This research suggests that high-relevance pedagogy that engages children in numeracy in instrumental ways within the context of real-world activities may be more advantageous for young children's engagement, motivation, and learning than low-relevance pedagogy.

Recipe, Materials, and Participants Shape Affordances for Numeracy Pedagogy

The present study demonstrated that the affordances available for numeracy pedagogy during a particular cooking session were due to the amalgamation of the following factors:

- What the research team provided families (i.e., intervention cookbook with tips, larger activity context that was explicitly pedagogical);
- What families selected to cook (i.e., the recipe, which called for specific recipe tasks, quantities, and ingredients);
- What families had available (i.e., the specific measuring tools and cooking implements they owned); and
- What parents and children brought to the interaction (e.g., the intention to double recipe, the quantity of English muffin pizzas they decided to make, the parent's desire to have her children count in both English and Spanish because the family is bilingual, the child's energy around his guess being incorrect).

Previous research has found that the larger activity and interactional context of parent-child interactions contribute to how families engage in math talk and the relation between parent math talk and children's skills (Eason & Ramani, 2020; Thippana et al., 2020). For instance, Eason and Ramani (2020) found that, overall, parents and children who were provided a formal math activity used a greater frequency and diversity of math words than dyads who were provided a guided play activity or free play activity, with dyads engaging in more math talk during the guided play activity than a free play activity. Both the formal math activity and guided play activity made the math relevance of the activity more salient and evoked parents to ask their child more math-specific questions (Eason & Ramani, 2020). This research suggests that the activity context

influences the salience of the available affordances for math talk and the likelihood parents take advantage of the affordances available.

The present study was unique in that it allowed for examining how variations in the same activity shaped the affordances for numeracy pedagogy, with some affordances being more salient—in fact, written into the recipe—and instrumental for completing the activity (i.e., affordances for high-relevance pedagogy). Within the cooking sessions, the recipes determined whether there were opportunities for the family to engage in high-relevance numeracy pedagogy. Within the most common high-relevance activity, measuring out continuous ingredients, the combination of the properties of the ingredient (e.g., wet or dry), the amount required, and the measuring tools available shaped what domains of numeracy were relevant for planning and executing the task of adding the ingredient to the intended cooking vessel. Thus, the recipes shaped the affordances available to families during different recipe projects within the same cooking sessions as well as during different cooking sessions.

On the other hand, low-relevance pedagogy was afforded by the presence of countable sets of discrete ingredients and cooking tools. The treatment version of the intervention cookbook made these affordances more evident to families than the control version of the intervention cookbook, but making use of these affordances generally required pausing the cooking activity or layering low-relevance counting on a recipe task, which may have been less appealing for some families or in some interactional moments. The most frequent method that parents used to engage children in low-relevance pedagogy was issuing "how many" initiations during ongoing recipe or pedagogical projects. This seemed to be afforded and interactionally relevant whenever a set of

discrete ingredients, actions, or materials was indexed, and thus, relatively easy to pull off. However, if parents were oriented to maximizing family engagement in pedagogy, they tended to launch distinct numeracy activities in which they had children count larger sets available (e.g., whole carton of eggs) or constructed activities around sets they produced for their child to count.

Previous research has also demonstrated that there are greater between-family differences in the frequency of parent number talk when the affordances for math are less salient. For instance, Thippana et al. (2020) observed parent-child dyads playing together at home for 10 minutes on three occasions using video conferencing. They coded whether families were participating in math-related play activities (e.g., board games, puzzles, building) and determined the frequency of parent number word use (Thippana et al., 2020). They found that while parents of boys and parents with higher educational attainment use more number words during non-math activities compared to parents of girls and parents with lower educational attainment, there were no differences in parent number talk within math activities based on parent education and child gender (Thippana et al., 2020).

Similarly, Vandermaas-Peeler et al. (2009) observed low-income and high-income parent-child dyads during two activities: reading a storybook related to shopping and engaging in dramatic play with a pretend grocery store. They coded two different types of participation in math talk: sociocultural exchanges in which parents or children engaged in number-related discussion of money and buying goods and mathematical exchanges in which dyads engaged in numeracy tasks such as numerical identification, cardinality, comparison, and arithmetic (Vandermaas-Peeler et al., 2009). Across both

activities, there were no differences between low-income and high-income dyads in their participation in sociocultural exchanges; however, high-income dyads engaged in more mathematical exchanges than low-income dyads. Based on the results of these two studies, it would be reasonable to expect greater between-family heterogeneity in low-relevance numeracy pedagogy, at least for families in the control condition, than task-oriented number talk and high-relevance numeracy pedagogy, given that task-oriented number talk and high-relevance numeracy pedagogy occurred within activities for which number was intrinsic to the recipe.

Together, the present study and previous research suggest that activities provide different affordances for family number talk, with some types of activities, like cooking, providing variability in affordances across the activity. There is likely to be both within- and between-family variability in when and how families take advantage of affordances for numeracy based on the salience of the affordances and families' interactional priorities and constraints. In designing early math resources and interventions, it would be fruitful to carefully consider the affordances for numeracy pedagogy and provide guidance that makes affordances more salient.

IRE Sequences: Pedagogical Control as Resource or Liability?

The present study found that while IRE sequences were ubiquitous in both high- and low-relevance pedagogy, they functioned differently within these distinct interactional and activity environments. IRE sequences within low-relevance numeracy pedagogy functioned to prompt children to display, rehearse, and, in some contexts, scaffold children's numeracy knowledge and skills. This is the function most often associated with IRE sequences within formal school contexts (Brooks, 2016; Mehan,

1979). Within high-relevance numeracy pedagogy, IRE sequences functioned instead to prompt children to use their existing and emergent numeracy skills to plan and implement recipe tasks. This finding is aligned with previous research that has demonstrated that IRE sequences serve interactional functions beyond instruction (Bottema-Beutel et al., 2020; Cook-Gumperz, 1979; Fitneva, 2012; Wilkinson, 2013). For instance, Bottema-Beutel et al. (2020) found that a bilingual Spanish-English speaking mother used IRE sequences during observations with her 5-year-old autistic son to engage him in collaborative play and to engage him in playful labelling sequences around a particular topic.

Within both high- and low-relevance pedagogy, IRE sequences were constraining of interaction, with parents' initiations exerting control over the direction of the interaction and creating pressure for the child to provide a particular correct answer (Mehan, 1979). However, the implications of the constrained nature of IRE sequences were different within these two contexts. In high-relevance projects, the constrained nature of IRE sequences allowed parents to guide children toward identifying an effective path forward for measuring out a continuous ingredient or to facilitate their participation in implementing recipe tasks like setting a timer. The constrained nature allowed parents to share responsibility with their children for translating the recipe into actionable steps and for managing the risks involved in cooking, while keeping the activity moving forward and preventing any serious breakdown in terms of the interaction or recipe. In this way, the high-relevance IRE sequences enabled children to competently participate in an activity they might not otherwise be included in, using their emergent numeracy

skills in strategic ways to solve real problems and occasioning contextually meaningful moments for parents to provide academic instruction.

Given that IRE sequences in low-relevance pedagogy, by definition, were irrelevant for completing the overarching goal of completing a recipe, they exerted control within the interaction for the primary purpose of having children display their counting skills for the parent to provide feedback on. While children often displayed willingness or interest in participating in low-relevance pedagogy, these sequences could also veer into the territory of the parent working to enforce compliance, particularly when parents displayed a strong orientation to maximizing opportunities for children to practice counting. While high-relevance pedagogy often positioned parents and children as collaborators, low-relevance pedagogy largely positioned parents as teachers prompting and evaluating children's knowledge displays. These findings are aligned with previous research that demonstrates that the constraining structure of IRE sequences can be both a resource and a liability in interaction (Bottema-Beutel et al., 2020; Cook-Gumpertz, 1979; Sterponi & Fasulo, 2010; Sterponi & Shankey, 2014). It will be important for future research to examine the implications of this for young children's learning and participation.

Implications

Methodological: The Value of CA for Studying Number Talk

The methodological approach of the present study was distinct from previous research on number talk in three primary ways. First, in using CA, the analysis was focused on understanding how parents and children constructed sequences of number talk, attending to the moment-to-moment contingencies between parent and child talk

(Schegloff, 1989). Second, this dissertation examined number talk within the interactional and activity environments in which it was embedded, allowing for analysis of the function of number talk within parent-child interaction and of the larger activities constructed through number talk. Third, as is typical for CA research, the analysis involved examining how parents' and children's conduct during the interaction displayed their interpretation of each other's talk and the activities they were undertaking together (Raymond & Sidnell, 2014; Wootton, 1997).

The present study demonstrates that using this approach is valuable for understanding parent-child numeracy interactions and identifying distinct patterns in how families engage in number talk. Additional qualitative, microanalytic research on family participation in numeracy could be useful for refining quantitative coding of number talk and clarifying possible mechanisms underlying the relation between family number talk and children's numeracy skills.

Qualitative Analysis Can Help Refine Quantitative Coding

The inductive approach of the present study allowed for the analysis to be guided by how the parents and children participated in number talk and what their interactions displayed as important for this participation. This led to identifying differences in how numeracy pedagogy unfolded when it moved the recipe forward and when it was irrelevant for completing the recipe. This suggests that qualitative, interactionally-grounded analysis is useful for generating insights on family numeracy engagement that more deductive approaches may overlook and could guide future quantitative work. In addition to uncovering new directions for research on number talk, this dissertation also indicates that it may be worthwhile to reconsider the deductive categories used in past

quantitative coding of number talk. When conducting utterance-level coding of number talk, researchers frequently code the numeracy domains addressed by individual utterances. Aligned with the CA perspective that talk is a collaborative achievement (Raymond & Sidnell, 2014; Schegloff, 2007), the present study suggests that it could be valuable to align coding with how parents and children interpret the actions enacted through a number talk turn.

For example, the present study found that parents asked children "how many" questions in different interactional environments to elicit different actions from children: to prompt counting present objects (e.g., "How many don't have sauce", "How many ingredients do we have in order to make chocolate chips"), to prompt the identification of a numeral in the recipe (e.g., "How many tablespoons of honey does it say?"), and to prompt the child to make a guess (e.g., "How many pieces do you think it's gonna give us?"). While "how many" initiations served different functions within the cooking sessions, they were the primary vehicle the parents used to prompt children to count. Researchers using quantitative methods to code number talk typically code "how many" questions of this variety as cardinality prompts (Eason et al., 2021; Klibanoff et al., 2006; Ramani et al., 2015). These coding schemes typically treat utterances like "There are three strawberries" as equivalent to utterances like "How many strawberries are there?".

However, the present analysis showed that "how many" initiations when referring to a present set of objects were typically understood by parents and children as prompts to count. This was demonstrated by the fact that children overwhelmingly responded with counting and that parents pursued counting when it was not forthcoming. In contrast, parent initiations that explicitly directed children to count were less common (e.g.,

"Count your yogurts", "You have to count them"), which is aligned with the results of previous studies (Eason et al., 2021). Explicit prompts for children to count often occurred after a "how many" initiation or were designed using a combination of "count" and "how many" (e.g., "Hey let's count how many", "Can you count how many…?").

That being said, parents and children did sometimes display an orientation to cardinality. For instance, children sometimes designed their counting sequences in ways that emphasized the final number in the sequence through stress or volume, repeating the final number, or adding "and" before the last number in the sequence. Parents sometimes displayed an orientation to cardinality in their evaluation turn, such as when they repeated the final number in the sequence or made a statement about the quantity of the set. Thus, while "How many blueberries?" is not necessarily equivalent to "Count the blueberries", treating "how many" initiations as exclusively cardinality prompts overlooks the reality that they are a—if not *the*—primary vehicle that parents used to prompt child counting. If children understand these initiations as prompts to count and if parents orient to counting as the appropriate response, we might want to code and analyze "how many" initiations in a way that distinguishes them from statements of cardinal value and recognizes the role they play in directing children to count. Current quantitative approaches for coding number talk obscures the nuance of how families engage in number talk and the mutual dependencies between parent and child number talk turns.

Studying Family Participation in Number Talk Can Clarify Possible Mechanisms

Existing research on parent number talk has generally found that parent number talk predicts children's concurrent or prospective math skills. However, the studies described in the literature review largely identified that only some of their measures of

parent number talk predicted children's math skills or that number talk only predicted children's math skills under particular circumstances. For instance, Casey et al. (2018) found that mothers' support of cardinality (i.e., labeling the quantity of a set) during free play at 36 months but not their support of numeral identification and one-to-one counting predicted children's math performance at 4.5 years and first grade. Similarly, Son and Hur (2020) found that while caregivers' talk related to numbers (e.g., counting objects, numeral identification) during cooking were positively associated with children's concurrent math scores, their total math talk and their talk about operations and measurement were not associated with children's concurrent math scores. Conversely, caregivers' total math talk and their measurement talk predicted children's prospective math scores, but only when parents engaged in higher levels of talk that oriented children's attention to the task of completing the recipe (Son & Hur, 2020).

Moreover, some studies have not found correlations or found negative correlations between parent number talk and children's math skills (e.g., Leyva et al., 2017; Mutaf Yıldız et al., 2018; Zippert et al., 2019). For example, Mutaf Yıldız et al. (2018) found that parents' reports of how frequently their kindergartener engaged in numeracy activities at home was positively associated with their child's concurrent arithmetic skills, but their use of number talk during a 10-minute semi-structured video observation of them and their child playing with Legos and reading a storybook was negatively associated with children's concurrent arithmetic skills. Research has also found that the social context in which parents are observed determines if correlations between parent number talk is associated with children's skills. For instance, Thippana et al. (2020) found that while parent number talk at home during free play with their own

materials predicted children's performance on standardized math assessments, parent number talk during free play during a laboratory visit did not.

Making sense of these findings is challenging without knowing more about when, how, and for what purposes the parents and children participated in number talk during the observations. For instance, in what interactional and activity contexts were parents and children talking about different domains of number talk and for what purposes? What next actions do parent numeracy prompts make relevant and how is this different across numeracy domains? What kinds of child actions within the activities evoke parent number talk (e.g., errors, displays of numeracy competence)? How do parents and children engage in number talk similarly or differently within different social environments and during different activities? Answering these questions would be invaluable for understanding the function and meaning of number talk for families during different interactional and activity contexts.

In addition to the challenges of drawing conclusions based on the results of individual studies, the extant literature does not allow for drawing conclusions across studies. This is because the research designs, participants, measures of number talk, and assessments of children's math skills have varied across studies. For instance, Mutaf Yıldız et al. (2018)—who found that number talk was negatively correlated with children's arithmetic skills—defined number talk more expansively than other researchers, including talk about sorting objects by color, size, and shape and talk that indexes quantity without specific numerical language (e.g., both, little, double, half, a lot). Did the researchers find a negative correlation between parent number talk and children's math skills because they used this expansive operationalization of number talk

or because the researchers used arithmetic skills as their outcome measure? Or was it because within the activity context in which the families were observed, it was more relevant for parents to engage in number talk when children had less advanced arithmetic skills? Additionally, did these activity contexts reflect the ways the parents and children interacted on a daily basis? Or maybe it was because the participants were Belgian and the children's early experiences were different in significant ways from those of children living in the United States—the primary participants of previous number talk research? Perhaps parent participation in number talk within U.S. samples acts as a proxy for other factors that are important for children's development and wellbeing, resulting in a positive correlation, but the relation is different among these Belgian families?

Whether researchers identify associations between caregivers' number talk and children's outcomes likely depends on several factors, including:

- The measures of number talk used and the extent to which they meaningfully represent between-family differences in children's numeracy experiences
- The interactional and activity context in which number talk is observed and the extent to which this context is representative of children's everyday experiences
- The current skill level of the children, the relationship between children's existing skills and their participation in number talk, and the extent to which caregiver-child numeracy conversations engage children in their zone of proximal development
- The extent to which the caregiver observed interacting with the child engages him or her in numeracy or other learning activities in daily life
- The specific math skills assessed and the timing of when they are measured

- The resources and constraints families are experiencing that may exert influence on family interactions, child learning, and family wellbeing

Qualitative, microanalysis of family engagement in numeracy seems invaluable for untangling and clarifying the relation between family participation in number talk and children's math skills, in terms of refining how number talk is studied quantitatively; clarifying when, how, and for what purposes families engage in number talk; and uncovering how children construct numeracy knowledge through their interactions with caregivers. This qualitative, interactionally-grounded research is also necessary for translating the results of quantitative research into actionable guidance that caregivers can use in daily life to promote children's math learning.

Practical: Designing Learning Materials and Interventions

Two important takeaways of the present study are that home-based, early learning interventions task caregivers with getting their children to do things and that pedagogy requires interactive work to accomplish. Understanding how families engage with numeracy activities and make use of learning tips is necessary for developing effective, meaningful, and interactionally-grounded numeracy activities and interventions.

Reconsidering the Goals, Values, and Pressures of Interventions

The present intervention tasked parents with engaging their child in numeracy when cooking and provided tips that largely encouraged low-relevance pedagogy. This numeracy pedagogy was not purposeful for the activity of cooking together—the activity child assented to participate in, which sometimes led to competition between the interactional agendas of cooking and pedagogy and, thus, the interactional aims of children and parents. Parents in the treatment condition who displayed a strong

orientation to implementing the numeracy tips and maximizing opportunities for low-relevance counting sometimes found themselves in the position of enforcing children's compliance with providing the second pair part to an IRE sequence.

It is not totally clear what the implications of these sequences in which children displayed resistance and parents worked to achieve compliance. Is this simply the natural consequence of counting being hard? Are parents working to help their kids persevere during a hard task that is valuable for their long-term wellbeing and performance in school? Or could these dynamics be problematic for child motivation and school engagement? While the present dissertation did not address this, there were also examples in the data of children who were very eager to demonstrate their competence through numeracy and worked to assert their epistemic authority within interactions. Could consistent engagement in low-relevance pedagogy at school and home promote children connecting their self-worth to academic achievement and the evaluations of others, which might undermine their willingness to take risks in challenging situations? Were parents capitalizing on these moments of resistance to socialize compliance or proper school behavior in a way aligned with their socialization goals and values? Or did parents find themselves—partly due to the pressure of the intervention—in this position where they suddenly needed to enforce compliance? Were these sequences an artifact of the families' participation in the intervention or is this something they experience in their everyday lives? Answering these questions would be necessary for understanding the possible implications of these sequences for child learning and family interaction.

Nevertheless, as someone involved in developing the intervention, I do not feel comfortable with potentially contributing to parents feeling like they need to maximize

every moment for pedagogy or make pedagogy the main priority of cooking with their child. This raises questions about how to develop guidance for families that they can flexibly make use of for their own purposes and how to encourage pedagogy at home without making parents feel like they need to do as much pedagogy as possible. Families already experience considerable pressures in the current political and economic context to maximize their children's chances for success and 'cultivate' their potential (Ochs & Kremer-Sadlik, 2013; Vincent & Maxwell, 2016). The role developmental psychology plays in promoting highly child focused parenting and encouraging families to make downtime productive seems problematic. It would be worthwhile to reconsider the values underlying intervention work and the central focus in early math research on math achievement. Developing activities and materials in partnership with families, community leaders, and community-based organizations might be valuable for guiding intervention work, especially if this work is grounded in envisioning ways math could promote child, family, and community wellbeing beyond performance on standardized assessments.

Designing for task-relevance and affordances

The present study found that whether number talk was task-relevant or pedagogically-oriented was consequential for how parents and children engaged in number talk, the activities they constructed through number talk, and how IRE sequences unfolded between parents and children. Given that high-relevance pedagogy facilitated children's use of numeracy in strategic ways to solve real problems and implement tasks they cared about, it seems worthwhile for researchers to design math activities and interventions that afford high-relevance numeracy.

In addition, the finding that variations in the recipes, ingredients, cooking tools, and participant orientations shaped the affordances for numeracy pedagogy underscores the need for researchers to carefully consider the activity context when developing math activities and interventions. What are the affordances and constraints of the activity? Will pedagogy be a competing aim or can it meaningfully facilitate child participation in the activity? The results of the present study suggest that when an activity has an overarching goal, it may be particularly important to ensure that tips for engaging in pedagogy are aligned with that goal. However, there were also moments within the cooking sessions when families were waiting for their food to bake and were actively working to identify things to do together. These were moments when low-relevance pedagogy might be an opportunity for entertainment and interaction, rather than barrier to the forward movement of the activity.

One challenge of designing interventions with affordances in mind is that children's existing numeracy skills likely influenced if and how families made use of the affordances available for high- and low-relevance numeracy pedagogy. The families who participated in this intervention were recruited through academic-oriented preschool programs, which might suggest both that parents were already oriented to promoting their children's school readiness, that children's existing numeracy skills may be different than children experiencing different care arrangements, and that these children frequently participate in the types of pedagogical routines seen in this data. A challenge for developing effective learning activities and interventions is designing them such that parents and other caregivers can easily adapt them to individual children's zone of proximal development.

A more specific takeaway from the present study is that while preschool-age children may be able to count a stable quantity (four spoons sitting on a counter), they may find it much harder to count as they perform an action (count as they add five slices of cheese to a saucepan). There is evidence that parents tend to overestimate their children's numeracy skills (Zippert & Ramani, 2017), so they might benefit from information that helps them understand their children's existing numeracy skills, make sense of common numeracy errors, and identify strategies for working in their child's current zone of proximal development. For example, while having children count as they perform an action is likely beneficial for helping them gain fluency with the order of the counting sequence, they might need reminders of what number came before in the sequence. Rather than emphasizing counting, this could also be a good opportunity for asking arithmetic questions, like "So we have two. If we add one more, how many will we have?" or ordinal relations questions, like "So we've added four. What number comes after four?". It might also be valuable to share with parents the potential value of counting along with their child and demonstrating how they instrumentally use counting in their daily life, rather than feeling pressure to have their child perform counting.

Limitations

The primary limitation of the present dissertation is the reliance on audio data. Interlocutors draw on a range of embodied resources—gestures, gaze, facial expression, and body positioning—to enact meaningful social action during in-person interactions (Goodwin, 2006; Hengst, 2015; Mondada, 2013). Visual data is also valuable for understanding how interlocutors coordinate their bodies and manipulate objects in the course of constructing joint activity (Goodwin, 2006; Hengst, 2015; Mondada, 2013).

Several studies have demonstrated the importance of embodied action in young children's interactions with adults and other children (e.g., Cekaite, 2010; Dalgren, 2017; Filipi, 2009; Goodwin & Cekaite, 2018; Goodwin & Loyd, 2020; Kent, 2012b; Wootton, 1997). Relying primarily on audio data meant I had to make inferences about what was happening physically in the interactions as the families carried out cooking and pedagogical projects. Visual recording would have allowed for analysis of gaze, facial expression, gesture, and coordination of parent and child bodies, which may have adjusted my understanding of stretches of talk and provided more nuance to my analysis of control and collaboration between parents and children within the activities.

Additionally, the participants, particularly parents, may have adjusted their behavior to accommodate the fact that "the people listening" would only have access to auditory information. For instance, while children generally responded to "how many" initiations and counting prompts by counting out loud, there were some instances in which children responded by counting to themselves and parents insisted that their child count out loud. This tended to occur in sequences in which children were displaying resistance to counting. While parents may have wanted to monitor their children's counting, it is also possible that the expectation for children to count out loud was for the benefit of the researchers. In another context, parents might have been more accepting of children counting in their heads or quietly to themselves and only requiring children to count out loud if they provided an incorrect cardinal value at the end of their counting sequence. Thus, it is possible the mode of recording—in addition to the social pressures of being recorded while participating in an intervention—could have influenced how parents oriented to pedagogy, contributing to the performative feel of low-relevance

pedagogy and shaping how children responded. Nevertheless, asking families to audio record themselves had important practical advantages and allowed for collecting recordings on more occasions from a greater number of families.

This raises another limitation of the present analysis. The families were interacting within the particular context of participating in an intervention study in which parents were provided tips on how to engage their children in learning conversations, with families in the treatment condition receiving additional numeracy tips. This context likely shaped how the participants, especially the parents, interacted with their children and led to increased emphasis on pedagogy within some of the families or the use of more school-like pedagogical practices. Analysis of these interactions does not illuminate how the participating families might engage in number talk or pedagogical practices outside of the context of this intervention. Understanding families' everyday practices of engaging with numeracy and teaching children would be important for understanding children's early math experiences and for improving the cultural relevance of educational activities and resources.

It is important to note that families seemed to vary in the extent to which they used the intervention cookbook and the extent to which they oriented to the activity as a specialized, academic-oriented learning opportunity for their preschool child. It was common for the cooking activities to be a site for moral socialization and discussions of topics like safety, teamwork, and differences between adults and children. Some families engaged in minimal numeracy pedagogy, with parents opting instead to focus on demonstrating techniques of cooking, instilling proper cooking hygiene, and communicating the responsibilities involved in cooking for others. For other families, the

central focus of the cooking sessions was delegating tasks between siblings and managing children's expectations of fairness. This suggests that while the pressures created by the intervention influenced family participation, the extent of this may have varied by family given other interactional pressures and circumstances and based on what intervention cookbook the family received. Children's interactional agendas and priorities also shaped how the interactions unfolded, which perhaps were less influenced by the context of the intervention as parents' orientations to the activity.

It seems reasonable to assume that parents organized the cooking sessions based on both their own perceptions and beliefs about "good parenting" and their expectations of the researchers' perceptions and beliefs about "good parenting." Thus, while these interactions may not reflect what families do on a daily basis, the analysis does show one way that families can interact together and perhaps do interact within overtly pedagogical contexts. While additional research is needed, it is possible the interactional practices for engaging in pedagogy exhibited in the present data reflect how middle-class families, including middle-class families of color, might engage with school-provided materials or interact in other contexts that evoke dominant, school-like pedagogical practices. Additionally, this analysis provides some insights into how different families might approach these types of activities and contexts differently based on their priorities. It will be important for future work with this data to more systematically compare how families constructed the activity of cooking together based on the cookbook they received to evaluate the effect of the numeracy tips on family interactions. It will also be important for future work to situate qualitative, microanalysis of family numeracy interactions within their cultural, political, and economic contexts, using more ethnographic

approaches to understand how caregiver and child goals, priorities, and beliefs become instantiated in family interaction.

In addition, the present analysis, of course, cannot tell us how other families might have experienced this intervention or organized their participation in it. This dissertation was focused on analyzing how numeracy pedagogy, which was often implemented through IRE sequences, was organized and functioned within these interactions. While families varied in how much they engaged in numeracy pedagogy, parents tended to deploy IRE sequences in similar ways when they did select to enact numeracy pedagogy and these sequences tended to unfolded in similar ways between parents and children. Given the constraining structure of IRE sequences, which emerges interactionally rather than residing within individuals, there is reason to expect that if and when other families use this interactional practice for engaging children in pedagogy, they might do so in similar ways as the families participating in this intervention. However, other parents, particularly parents with less formal educational experience might have approached and organized the activity of cooking with a preschooler differently.

Moreover, children's existing numeracy skills likely influenced if and how families made use of the affordances available for high- and low-relevance numeracy pedagogy. As explained above, the families who participated in this intervention were recruited through academic-oriented preschool programs and the parents who signed up to participate this intervention and actually submitted audio recordings were likely already oriented to promoting their children's school readiness and may have had greater resources than other families. The participating children's existing numeracy skills may

be different than children experiencing different care arrangements and these children likely frequently participate in the types of pedagogical routines seen in this data. The usefulness of the tips provided in the treatment version of the intervention cookbook likely depended on their fit with children's existing skills and this fit or lack thereof likely influenced how the numeracy pedagogy unfolded and how other families might experience this intervention.

Future Directions

Examine When and How Families Engage in School-Like Pedagogical Practices

When the parents engaged their child in numeracy pedagogy during the cooking sessions they often used IRE sequences to do so. The results of the present study cannot illuminate the extent to which these families use school-like pedagogical practices in daily life, but it does indicate these pedagogical routines were known to them and part of their cultural repertoire. This is not surprising given that all the families were living in the United States, all the parents had graduated from high school with most having a college degree, and all the children were attending academic-oriented preschool programs. This dissertation also found that IRE sequences served distinct functions within high- and low-relevance numeracy pedagogy, which is aligned with previous research that demonstrates these pedagogical routines accomplish instrumental and interactional functions beyond child learning within caregiver-child interaction (Bottema-Beutel et al., 2020).

This raises the possibility that more school-like pedagogical practices, like IRE sequences, might be a resource that a diverse range of families may use in strategic ways when it suits their interactional needs and within particular interactional contexts (e.g., when being observed by researchers or school professionals; when engaging with overtly pedagogical materials, like homework or at a museum; when parents want to have more control over an interaction; when interacting with individuals with emergent or more limited communicative skills). It is important for researchers to study the everyday ways that families of diverse linguistic, cultural, geographic, and socioeconomic backgrounds engage their children in numeracy and pedagogy. But it is also important to recognize that families' interactions and cultural ways of being are not static and that caregivers engage with children differently within different contexts. For instance, one study found that how White, college educated parents interacted with their infant at 6 and 7 months during a 1-hour video observation was distinct from how they were observed to interact with their infant over the course of a 16-hour audio recording (Bergelson et al., 2018). While this underscores the importance of not extrapolating from brief video observations to make claims about children's everyday language environments, the 1-hour video observations may still be meaningful for understanding moments in children's lived experiences.

Given this, I am interested in examining when, how, and for what purposes families engage in more school-like pedagogical practices, including how they use the structure of IRE sequences to accomplish different interactional work and how they employ IRE sequences in ways that minimize or maximize asymmetries in authority and control.

Broaden the Focus of Number Talk Research

Research on number talk has largely examined associations between parent talk and children's math skills. Recent work has begun to explore how activity and social contexts influence parent-child number talk (e.g., Eason & Ramani, 2020; Thippana et al., 2020) and untangling the influence of parent number talk and of children's engagement in numeracy activities on children's math skills (e.g., Mutaf Yıldız et al., 2018; Thippana et al., 2020). These directions are promising because they begin to consider how individual families' participation in number talk might vary, rather than emphasizing only between family differences. The present study suggested that family participation in number talk varies both in the course of a single interaction and on different occasions, in part based on the opportunities and constraints of the recipe they were completing. This raises questions about how characteristics of the activity and context influence families' use of mathematical language and pedagogical talk.

Thus, there is a need for more examination of within-family variations in numeracy engagement both within the course of an interaction, on different occasions, within different activities, and over time. Systematic observations of family participation in math pedagogy under different conditions (e.g., more naturalistic to more structured; home vs lab vs public setting; dyadic vs multiparty contexts; within different activities—games, play, cooking, homework, bedtime) as well comparisons of how individual children engage in number talk with different caregivers would shed light on the affordances for numeracy pedagogy, the interactional function of number talk within different activities and contexts, and the interactional practices for engaging with numeracy evoked within different activities and interactional environments.

In addition to providing a more nuanced and comprehensive picture of children's early numeracy experiences, this would be useful for exploring how families experience different ways of engaging in numeracy: In what interactional and activity contexts do children and parents enjoy talking about numeracy? What interactional practices for engaging in numeracy do families find enjoyable? How does talk about numeracy relate to the overall goals of the activity? When does number talk allow children to develop competence in activities they find meaningful and when does it allow them to take on greater responsibility? When do parents and children display interest and motivation to engage in numeracy? What affordances enable caregivers to scaffold children's numeracy skills within their zone of proximal development?

By analyzing the interactive work involved in parent-child participation in numeracy pedagogy, the present study decentered the focus of the extant literature on math achievement. While it is important for young children to enter school prepared to tackle the math concepts they will encounter, perhaps the more important "outcomes" of family numeracy engagement are developing an appreciation of the value of math in everyday life, an interest in using math to solve problems, a sense of one's own competence in engaging with math concepts, and an enjoyment of taking on challenges. Future research should consider outcomes beyond math skills and achievement in order to prioritize enjoyment of math when designing resources for families.

Study Everyday Practices for Learning in Context of Cultural Values

There is a need for more ethnographic, culturally grounded research on how linguistically, culturally, geographically, and socioeconomically diverse families engage children in learning. It is also important to understand these practices in the context of

parents' priorities, values, and socialization goals; dominant and subversive cultural ideologies and anxieties; and the opportunities and constraints of families' life circumstances. Promoting children's math learning at home and in schools requires a deeper understanding of how diverse families interact with children, support their learning, and engage them in numeracy activities, so the strengths all children bring to school are valued and integrated into the curriculum.

Work for Systemic Change that Promotes Equity and Family Wellbeing

Individual-level interventions, like encouraging parents to engage in number talk, are unlikely to disrupt systemic inequities in children's access to resources and opportunities and in the stressors and traumas families experience. That is not to say they do not have value, but that they are insufficient for addressing the challenges facing families, particularly families living in poverty; Black and Indigenous families; and other families of color. Researchers studying child development should work to combat systemic racism and other forms of marginalization on campus, in their community, and at the broader political level. In addition, developmental psychologists should work to promote policies, like universal preschool, paid parental leave, and community mental health supports, that promote child development and ease the burdens on families.

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