THE EFFECTS OF PARENTAL BEHAVIORS AND PROSODY ON THE LANGUAGE AND COGNITIVE DEVELOPMENT OF INFANTS

A Dissertation

Presented to the Faculty of the Graduate School

of Cornell University

In Partial Fulfillment of the Requirements for the Degree of

Doctor of Philosophy

by

Tywanquila Lavarre Walker

August 2012

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Tywanquila Lavarre Walker, Ph. D.

Cornell University 2012

The prosody (i.e., acoustic variations in pitch, intonation, stress patterns, and rate of speech) of infant-directed speech is a salient communicative feature (e.g., Fernald, 1989) that aids in the cognitive and language development of infants (e.g., Kaplan, Bachorowski, Smoski, & Hudenko, 2002; Tamis-LeMonda & Bornstein, 2002). The way parents interact with their children also contributes significantly to infant learning and cognitive development (e.g., Riksen-Walraven, 1978; Tamis-LeMonda & Bornstein, 2002). Nevertheless, the detailed mechanisms that outline how prosody and parental behaviors (e.g., pointing to an object, touching the infant, smiling) guide infant learning remain less well understood. One approach to better understanding these mechanisms is to examine the caregiver's role during infant-caregiver interactions to determine which prosodic aspects of parental speech, and which accompanying behaviors, most influence infant vocabulary and cognitive development. Longitudinal and intervention studies indicate that level of caregiver responsiveness significantly impacts vocabulary development and rate of learning (Hart & Risley, 1995; Riksen-Walraven, 1978). However, real-time, moment-by-moment proximal interactions should also be examined in order to assess these specific mechanisms at the micro level.

Furthermore, given that many of our parental behaviors are shaped during

childhood (e.g., Serbin & Karp, 2003), before we can fully understand the mechanisms by which prosody and parental behaviors affect infant development, we must first understand how these mechanisms are acquired. An intergenerational approach to infant learning and cognitive development requires a study of infant-sibling interactions, which can be used as a first step to ascertaining how prosody and parental behaviors can lead to long-term positive developmental outcomes for infants. Therefore, the present dissertation extends the research by:

1) exploring the unique idea that older siblings may already be adopting their caregivers' speech and behavioral characteristics when interacting with infant siblings,
2) examining whether differences in maternal prosody result in differential levels of learning for infants; specifically on infant development of spatial vocabulary,
3) discovering which features of caregiver speech and interaction style are most effective in aiding infant learning and language development, and
4) utilizing the knowledge acquired regarding effective speech and interaction styles to develop an early childhood intervention program.

The results of this systematic investigation of parental behavior and prosody add to our knowledge of the relation between parental responsiveness and the subsequent cognitive development of infants. It may also be influential in guiding the way we design early childhood interventions for caregivers and at-risk children.

BIOGRAPHICAL SKETCH

Tywanquila Walker was born in Clarksdale, Mississippi and is a graduate of the Mississippi School for Mathematics and Science. After graduating *cum laude* from Vanderbilt University with bachelor's degrees in Psychology (Honors) and Spanish, she came to Cornell University to pursue a Ph.D. in developmental psychology. Tywanquila will join the faculty of Rochester Institute of Technology as an Assistant Professor in the Department of Psychology.

To my momma. Thanks for all of your love and support.

Be who you are and say what you feel,

because those who mind don’t matter

and those who matter don’t mind.

– Dr. Seuss

ACKNOWLEDGEMENTS

I would like to give a special thanks to Marianella Casasola for being my primary advisor and the chair of my committee, accepting me as a graduate student in her lab, and supporting me in my research endeavors. David Field, Rachel Dunifon, and Vivian Zayas, thank you for providing professional advice and ensuring that I looked at every topic from all angles. I thank Michael Goldstein, Jackie Davis-Manigaulte, Kenneth Reardon, and Arturo Sanchez for giving great feedback and helping me refine my dissertation studies. Pamela Cunningham, Sarah Hale, and Sarah Smith, thanks for handling all of the administrative tasks that keep the system running; I really appreciate you. To my wonderful friend Monique Hyacinthe and amazing fellow graduate students Catalina Iricinschi and Youjeong Park, thanks for always listening and being willing to lend a helping hand, day or night.

Last, but never least, I would like to acknowledge all of the research assistants who helped bring this research to fruition. Alexis Ritter, Anne Pai, Davina Chen, Emine Ozelkan, Erin Malley, Halley Siegal, Jessica Lake, Jill Hsia, Melanie Yee, Melissa Rieger, Samantha Fung, Sylvia Sable, Taijah Holder, and Tingting Wu, thanks for your dedication. I am especially grateful for the hard work of Tinting Wu, who worked tirelessly long after mere mortals would have given up – I could never thank you enough.

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Chapter 1: General Introduction

Traditionally, language has been studied in terms of how it can be used to transfer information. As Locke (2001) observed, language has the additional functions of regulating behavior and communicating emotional state. When we transmit information using words, the prosodic features of those words are also significant sources of communication. These additional functions of language can add to our knowledge of language development by helping us understand the functions of language and communication in various social contexts. In particular, the study of prosodic features can aid in our investigation of dyadic infant-caregiver interactions and the subsequent infant learning, which results from these interactions.

It has been well documented that parents do not rely solely on language when communicating with their infants. Rather, they use behavior and prosody (i.e., acoustic variations in pitch, intonation, stress patterns, and rate of speech; that is, those features that comprise infant-directed speech) to help convey the meanings of words (Goldin-Meadow, 1999; Fernald, 1989). Both behavior and prosody are salient communicative features that infants can use to infer meaning (Kaplan, Bachorowski, Smoski, & Hudenko, 2002; Tamis-LeMonda & Bornstein, 2002). However, despite their significance in aiding infants' acquisition of language, how prosody and maternal caregiving behaviors relate to infant language development is not as well understood as other aspects of cognitive development (e.g., speech milestones, word segmentation and infant-directed speech). Although the regulatory and communicative functions of caregiving behaviors are often studied, the predictive power of these behaviors is often overlooked. Of particular interest to the current research is whether prosodic and behavioral cues can be used as predictors of infant cognitive development.

For example, a child's first utterance is considered one of the greatest milestones in language development. Yet what role does the parent play in helping the child to improve her language skills? How can the manner in which a parent responds to a child's bid for attention help the child correctly map objects with their proper labels? What aspects of parenting behaviors are important for language development? And where do these behaviors originate? Are these behaviors intergenerational?

In terms of caregiving behaviors, studies by Tamis-LeMonda and Bornstein show that high levels of parental responsiveness are beneficial to infant learning (Tamis-LeMonda & Bornstein, 2002). Specifically, they found that promptness, contingency, and appropriateness impact the language learning of 9- and 13-month-old infants. Promptness is the latency of the caregiver's response to infant vocalizations. A contingent caregiver response is one that is dependent on the infant's behavior at a specific point in time during a period of shared attention (i.e., both the infant and the caregiver look at or point to the same thing). Appropriateness refers to a positive response that is relevant to the infant's behavior (e.g., an infant picks up a ball and the parent labels the toy as "ball"). Twenty-month-old infants whose caregivers responded less promptly, contingently, and appropriately when the infants were 9 and 13 months old had lower vocabularies at 20 months in comparison to infants with more responsive caregivers (Tamis-LeMonda & Bornstein, 2002).

These findings have a number of important implications. First, they show that the way mothers respond to their infants influences language learning. Secondly, the findings raise the question of whether these behaviors impact rate of infant learning as well. Thirdly, the findings raise the question of whether mothers learn these behaviors from their own parents. To explore this possibility, I examined maternal and sibling caregiving behaviors and assessed whether infants with responsive mothers also have responsive siblings. In order to construct a timeline of the intergenerational transmission of caregiving behaviors, these proximal mechanisms (i.e., promptness, contingency, and appropriateness) were studied in siblings of different ages.

Family Systems Theory

According to family systems theory, family members are part of an interdependent, interactive network in which the behavior of each individual modifies the behavior of other individuals in the family (Hetherington, 1994). Thus, research on familial interactions can have broad impacts on several communicative and social issues, including how caregivers affect their children's language development and how older children communicate with younger siblings (Zukow-Goldring, 2002). Currently, it is unclear when children begin acquiring caregiving behaviors or how these behaviors are manifested in interactions with others, particularly younger siblings. One key to determining how to prevent negative infant-caregiver relationships and enhance infants' cognitive development is to first understand when caregiving behaviors develop. Knowing the onset of caregiving behaviors would help identify a timeframe in which a positive caregiving intervention would be most helpful for at-risk families. Secondly, in order to create a clear picture of the relationship between prosody, caregiving behaviors, and infant cognitive development, it is important to explore all aspects of infant-caregiver and infant-sibling interactions; we must determine the most effective way to modify caregiving behaviors and teaching strategies so that they are maximally conducive to infant learning. Finally, through the exploration of these interactions, it is possible to design an early childhood intervention program for caregivers and infants in at-risk families. By combining our knowledge of which behaviors and prosodic features best aid the language and cognitive development of infants, we can develop an intervention program that is doubly beneficial in that it increases the parental responsiveness of low-income parents and enhances infant learning.

Problem Statement

Infant-caregiver joint activities have been identified as influential for infant language development. Specifically, caregivers' behaviors and prosody are salient learning mechanisms for infants. These mechanisms have been identified by using a global approach to infant learning, which measures the overall impact of dyadic interactions in terms of one stage of the infant's cognitive development. Yet, in order to assess these mechanisms at the micro level and sequentially assess where these behaviors come from and determine the best method to further the intergenerational transmission of positive, learning enhancing caregiving behaviors, moment-by-moment proximal interactions must be examined. The current research explores these aspects of maternal behavior with the goal of outlining which features of maternal speech and the accompanying behaviors aid infant learning and language development during infant-caregiver interactions.

Rationale and Significance

This approach to studying maternal speech and behaviors is three-fold. First, I explored the unique idea that older siblings are already adopting their primary caregivers' speech and play characteristics. Via observational learning, older siblings are introduced to caregiving behaviors. These behaviors are thereafter manifested during infant-sibling interactions. Next, I examined whether differences in maternal prosody result in differential levels of learning for infants. Although recent work has shown a link between prosody and infant language learning (e.g., Kaplan, Bachorowski, Smoski, & Hudenko, 2002), this study extends the research by examining how maternal speech characteristics influence infants' comprehension and production of spatial vocabulary. Specifically, I examined whether differences in maternal prosody and behaviors in a naturalistic play setting are linked to different rates of language development in infants. Finally, after I identified which features of caregiver speech and interaction style were most effective in aiding infant learning and language development, I devised an intervention for low-income families. Together, these three studies provide a systematic investigation into how prosody and interaction can aid both infants' learning and their acquisition of language.

Main Research Questions

What behavioral and prosodic components are children learning from their caregivers and how do we encourage caregivers to modify their behaviors to facilitate infant cognitive development?

1) *Study 1*: A Developmental Study
    a. What behaviors do we learn from our caregivers during childhood?
    b. When are the behaviors we learn during childhood manifested in our interactions with younger siblings (i.e., during infant-sibling interactions)?

2) *Study 2*: A Prosodic Study

    a. What features of infant-directed speech facilitate spatial vocabulary growth?

    b. What features of infant-directed speech account for individual differences in spatial vocabulary comprehension and production?

    c. What are the strongest predictors of the comprehension and production of spatial words?

3) *Study 3*: An Early Childhood Intervention Study

    a. If we can change learned behaviors, what is the best way to influence adult teaching behaviors so that infants most benefit from infant-caregiver interactions?

    b. Is a brief intervention that emphasizes the importance of infant-caregiver interactions effective enough to encourage caregivers to change the way they interact with their infants?

Chapter 2: Study 1

Infant-Sibling Interactions:

A Window to the Intergenerational Transmission of Caregiving Behaviors

Through observational learning, children actively imitate attitudes and behaviors that their parents may not have intentionally tried to teach them (Bandura & Huston, 1961). Over the last several decades, the strong association between unintentionally taught negative parenting behaviors and the continuity of these behaviors in future generations has become an issue of great concern to researchers, policy makers, and family and child practitioners (e.g., Neppl, Conger, Scaramella, & Ontai, 2009; Bailey, Hill, Oesterle, & Hawkins, 2009; DuMont et. al., 2008). As a result, research regarding the intergenerational transmission of caregiving behaviors has focused on abusive child-parent relationships and the generational effects of harsh parenting (Simons et al., 1991).

These studies show that there is intergenerational continuity in parenting behavior (Putallaz et al., 1998) and that mothers and fathers communicate their parenting beliefs indirectly through their parenting practices (i.e., beliefs about physical discipline are conveyed through threats and corporal punishment; Simons et al., 1993). However, one limitation of the traditional approach is the difficulty of determining the developmental trajectory of intergenerational transmission. For example, at what age do intergenerationally transmitted behaviors begin? How do we measure these changes in real time? Secondly, intergenerational methodologies primarily focus on the parent and not the real-time learning of the child.

On the other hand, intergenerational transmission studies which take into account the long-term effects that parenting behaviors have on children suggest that children use the negative parenting behaviors of their parents as models for their own parenting behaviors (Serbin & Karp, 2003). These studies generally focus on the behavioral and cognitive problems that result from learning negative behaviors and fail to address the mechanisms that lead to the transmission of these behaviors; nor do they address how constructive parenting behaviors affect children. Furthermore, because many intergenerational transmission studies focus on young adults (Chen & Kaplan, 2001) and are retrospective (Simons et al., 1991), they require individuals to think back to their childhood experiences and extrapolate the trajectory of their current parenting behaviors. Thus, it is difficult to assess the real-time processes by which caregiving behaviors are acquired. In contrast, the current study addresses these issues by using infant-sibling interactions as a mechanism for examining intergenerational transmission. Secondly, I focus specifically on constructive caregiving behaviors – an area of research of which we have limited knowledge.

According to social learning theory, children learn their behaviors from important adults with whom they identify (e.g., parents; Bandura & Huston, 1961; Bandura, Ross, & Ross, 1961). Given that social learning theory is applicable to the intergenerational transmission of parenting behaviors – and that children who live in a household with a parent and an infant sibling are provided with numerous opportunities to observe how the infant-caregiver dyad interact – the result of these observations should be manifested in proximal infant-sibling interactions in which the child models his or her caregiver. Proximal interactions are interactions that occur when participants occupy the same space and are able to see each other. During proximal interactions, participants are able to see, hear, and touch each other. Due to the physical nearness of participants, proximal interactions provide the opportunity to assess caregiver responses sequentially as they relate to the behavior of the infant. Furthermore, these responses are dependent on the actions of both the parent and the infant; the actions of one are influenced by the actions of the other. Because the caregiver's responses are in real-time (as opposed to retrospective), the mechanisms by which older siblings acquire caregiving behaviors can be studied in detail.

Proximal Interactions and Siblings

Unlike other categories of caregiving behaviors, proximal response behaviors can also be used to assess how siblings respond to infants. For example, the use of the categories authoritarian, authoritative, permissive, and neglectful (Baumrind, 1991) may be helpful for categorizing caregiving behaviors. However, as ways to define an infant-sibling interaction, use of these categories is inappropriate because they: 1) imply that caregiving behaviors are stable over time (i.e., there is no developmental change of caregiving behaviors) and 2) suggest that a sibling is responsible for disciplining an infant. In contrast, the proximal approach allows for changes in caregiving behaviors. It does not assume that caregiving behaviors are unidirectional and that only the caregiver's responses are important for analyzing caregiving behaviors. Instead, the proximal approach takes into account how the infant's behavior affects the caregiving response as well as how that response shapes the infant's subsequent behavior; it is a bi-directional model, which accounts for infant effects.

Three aspects of proximal parenting behaviors – promptness, contingency, and appropriateness – have been shown to impact the language learning of 9- and 13-

month-old infants (Tamis-LeMonda & Bornstein, 2002). Promptness is the latency of the caregiver's response to infant vocalizations. A contingent caregiver response is one that is dependent on the infant's behavior at a specific point in time during a period of shared attention. Appropriateness refers to a positive response that is relevant to the infant's behavior (e.g., an infant picks up a ball and the parent labels the toy as "ball"). This proximal approach can also be used to track the trajectory of the development of caregiving behaviors. Together, these three behaviors comprise what we will hereafter refer to as a responsive behavior (i.e., a responsive behavior is a caregiving response which is prompt, contingent, and appropriate to the infant's previous behavior).

During live interactions, the promptness, contingency, and appropriateness of sibling responses can be observed and thus provide more specific and reliable measures of the caregiving behaviors of siblings over time. Furthermore, these proximal mechanisms can be studied in children of different ages and used to construct a timeline of the intergenerational transmission of caregiving behaviors. By identifying the mechanisms of intergenerational transmission, one can determine which caregiving behaviors facilitate the learning of both positive and negative behaviors as well as how, and when, children of different ages use those mechanisms.

Responsive Behavior vs. Sensitivity and Warmth

Although a responsive behavior is prompt, contingent, and appropriate, that behavior may not necessarily qualify as a sensitive or warm behavior. Sensitivity requires caregivers to be contingent and appropriate, as well as attentive and consistent, during moments of infant distress (see e.g., Lohaus et al., 2001). Sensitivity is often required of primary caregivers whose responsibility it is to nurture and comfort crying infants. Similarly, warmth is characterized by high levels of affection that can occur during distress or non-distress situations. However, responsive, contingent parenting can occur in the absence of sensitivity or warmth (see e.g., MacDonald, 1992). Given that bouts of infant crying and distress were not expected, and that siblings are not usually required to comfort distressed infants, sensitivity and warmth were not measured in this study.

Links Between Prosocial Behaviors and Caregiving Behaviors

Investigations of preschoolers' interactions with infants suggest that there is a gradual onset of caregiving behavior. For example, children younger than 3 or 4 years generally have trouble attending to infant states and participating in multi-speaker turn taking interactions (Shatz & Gelman, 1973; Dunn & Shatz, 1989); at 18 months they are capable of sharing, helping, and comforting their siblings, but rarely respond in these ways (Dunn & Munn, 1986). By age 4, older siblings use shorter utterances and more simplified speech when communicating with infants (Shatz & Gelman, 1973). Furthermore, as children get older, they begin to display more prosocial behaviors towards their siblings.

Eisenberg et al. (1983, 1987) conducted a longitudinal study which showed that between the ages of 4 and 12 years, hedonistic (self-focused) reasoning decreases while direct reciprocity, role-taking, and approval-oriented reasoning increases. By age 9, children begin to use sympathetic reasoning and are more likely to consider situational factors when resolving moral dilemmas (Eisenberg et al., 1983, 1987). Given that children's display of prosocial behaviors increases with age, their ability to produce responsive caregiving behaviors should also be age related. Examining infant-sibling proximal interactions as they relate to prosocial and caregiving behaviors can be advantageous to the development of early childhood interventions and child abuse prevention programs because they serve as early markers for the intergenerational transmission of parenting behaviors. By studying infant-sibling interactions in a more in-depth manner, we can pinpoint when children begin to acquire caregiving behaviors and track the development of these behaviors over the course of a lifespan – from childhood to adulthood.

Multiple Sources of Caregiving Behaviors

In addition to having many opportunities to observe infant-caregiver interactions, the age of the sibling, the children's genders, and amount of sibling caregiving that parents expect may affect the development of caregiving behaviors. For example, siblings from mixed-sex dyads with traditional parents exhibit the most sex-typed behaviors. Similarly, same sex dyads whose fathers express more traditional attitudes about gender may reinforce sex-typed personalities (McHale, Crouter, & Tucker, 1999). In both older brother-younger sister dyads and older brother-younger brother dyads, the younger siblings are more involved in housework than their older siblings if the father is traditional (McHale, Crouter, & Tucker, 1999).

Furthermore, the types and amounts of caregiving behaviors displayed by older siblings may depend on how much caregiving is expected of the sibling. Parents who expect their children to serve as caregivers give 5- to 8-year-old children clear training instructions about caregiving (Zukow-Goldring, 2002). Children who participate in a daycare program, however, may learn about the caregiving expectations and behaviors of adults other than their parents. Therefore, daycares could be another source of information that affects sibling caregiving.

The Current Study

Given that children model the behaviors of their caregivers (Serbin & Karp, 2003; Leaper, 2002; Leaper, 2000), the current study focused on the intergenerational transmission of caregiving behaviors via observation of infant-sibling and infant-caregiver interactions. More specifically, we examined whether sibling behaviors resemble those of their parents when they communicate with infants. We also investigated infant-caregiver and infant-sibling engagement by analyzing the promptness, appropriateness, and contingency of infant-directed responses. We investigated older siblings' caregiving behaviors as a function of child age and parental caregiving behavior. Twelve-month-old infants were recruited because caregiver responsiveness during this time is important for linguistic and cognitive development (Tamis-LeMonda & Bornstein, 2002). Secondly, locomoting infants create more opportunities for social interactions.

The purpose of this research was to study the siblings of infants and assess the developmental trajectory of responsive caregiving behaviors in 3- to 10-year-old children. The current research, with its focus on the development of caregiving, represents a new initiative in the study of the intergenerational transmission of parenting behaviors. By determining the age at which children begin to display responsive caregiving behaviors and how their interactions with infants come to resemble those of their parents, we can better understand how to recognize and promote the transmission of positive parenting behaviors.

Method

Participants

Twenty-two infants participated in this study. Three infants had 2 or more older siblings who also participated, which resulted in a final sample of 26 infant-sibling-caregiver triads. The triads consisted of 12-month-old infants (M = 12.5 months, SD = 1.21), their 3- to 10-year-old siblings (M = 5 years, SD = 1.96 years, Table 1), and their primary caregivers (M = 35.8 years, SD = 4.86; age range 24-44 years; all primary caregivers were female). 72.7% of the caregivers were white, 4.5% were black, and 22.7% were either multi-racial or of other ethnicities. All of the caregivers were living with a spouse or partner. All of the mothers except one were married. The average age of the spouse/partner was 37.5 years (age range 29-44 years, SD = 4.61).

Participants were recruited through a letter given to caregivers at the time of the infant's birth. Caregivers interested in participating in studies on infant learning and development were added to a database. These caregivers were sent a second letter when their infants were near 12 months of age, followed by a telephone call to schedule an appointment. The infant age group was held constant because we wanted older siblings to have similar amounts of experience with the infants (i.e., approximately 12 months of experience both interacting with the infant and observing the caregiver interact with the infant). Additionally, we chose this age group because older infants are able to locomote independently, which affords them the opportunity to both initiate interactions and respond to others' behaviors.

Due to experimenter error, the interaction data of one caregiver was omitted from this study. Two infant-sibling-caregiver triads were also omitted; one due to experimenter error and one because the children were step-siblings and did not live in the same household, nor did they see each other often enough to provide the older child with an opportunity to observe the mother interacting with the infant. All infants received a t-shirt, sippy cup, or bib in appreciation for their participation; older siblings received a t-shirt, toy, or stickers.

Table 1

Older Sibling Age and Gender and Infant Gender

Older Sibling Age	Older Sibling Gender	Infant Gender
2;10	Female	Female
3;1	Male	Female
3;1	Male	Female
3;5	Male	Female
3;5	Male	Male
3;7	Male	Male
3;9	Female	Female
3;9	Male	Male
3;11	Female	Female
4;2	Female	Female
4;2	Female	Female
4;5	Male	Female
4;5	Female	Male
4;6	Male	Female
4;7	Male	Female
4;10	Female	Female
5;0	Female	Male
5;1	Male	Female
5;2	Female	Female
5;10	Female	Male
6;2	Male	Female
6;6	Male	Female
7;3	Female	Female
8;10	Female	Female
9;8	Male	Female
10;3	Female	Female
Average = 5;1	**13 males, 13 females**	**6 males, 20 females**

Materials and Apparatus

The study was conducted in a large playroom. Various colorful and engaging toys (e.g., stacking cups, balls, cloth blocks; Figure 1) were placed on the floor of the playroom. The center of the room was completely free of obstacles (e.g., tables, chairs), which gave the participants freedom to move around the room as they chose. Infant-caregiver and infant-sibling interactions were recorded using a Canon FS200 video camera. The videos were later digitized, saved onto a Mac computer, and coded using EventCoder software (Goldstein & Brodsky, 2006).

Figure 1. Examples of toys provided during play sessions.

Primary caregivers completed a family demographic survey that contained questions about the parents, the sibling, the infant, and the number of people in the household. The demographic survey included an assessment of socio-economic status based on occupation, information about the number of children in the household, and marital status. The parent portions of the survey included questions about the amount of time per week the parent spent with the infant and hours of employment per week. The sibling portion of the survey assessed the amount of time per week the sibling spent with the infant, the number of hours per week the sibling spent at home, in daycare, or in school, and the gender of the sibling. The infant portion of the survey included the number of hours per week the infant spent at home, in daycare or with a babysitter, and the infant's gender.

Procedure

Participants' interactions were recorded during two 20-minute unstructured play sessions. In one session, the caregiver and the infant were provided with toys and asked to play as they normally would at home. To prevent on-the-spot learning, the sibling was not present and instead played with a research assistant in another room. Thus, the sibling was unable to observe the infant-caregiver interaction. In the other session, the sibling and the infant played together while the caregiver sat in a chair in the corner of the room and completed the family demographic survey. First, the caregiver was instructed to encourage the older sibling to play with the infant. Then, she was asked to remain as quiet as possible and not to interrupt the children while they played unless she felt it was necessary for her to intervene (e.g., the infant cried and the older sibling was unable to console him/her). The order of the sessions was counterbalanced.

Coding

The 20-minute play sessions were coded for infant behaviors and the corresponding behaviors of caregivers and older siblings. Caregiver and sibling responsiveness were coded using a system derived from the coding schemes of Gros-Louis et al. (2006), Bornstein et al. (1992), and Vollmer (2007). Infant, caregiver, and sibling behaviors were classified into the following mutually exclusive categories: object-related non-vocal, object-related vocal, dyadic non-vocal, dyadic vocal, distress vocalizations (e.g., crying; for infants only), and other verbal and vocal behaviors (Table 2). These measures were chosen because they have proven to be reliable measures of responsiveness in previous studies (e.g., Bornstein et al., 1992; Vollmer, 2007).

Table 2

Descriptions of the Seven Mutually-Exclusive Categories Used to Classify Infant, Caregiver, and Sibling Behaviors

Category	Behavior	Description
1	Object-related non-vocal	Non-verbal behaviors that involve an object (e.g., manipulating, showing, pointing at, looking at, or getting a toy)
2	Object-related vocal	a. Infant: Any category 1 behavior paired with a vocalization that refers to the object (e.g., infant makes an object-directed vocalization while looking at a ball) b. Caregiver/Sibling: Any category 1 behavior paired with a vocalization that refers to the object; must be attempting to reorganize the infant's attention towards the object (e.g., infant makes an object-related vocalization while looking at a ball; caregiver says, "Look at the ball!")
3	Dyadic non-vocal	Face-to-face interaction that involves eye contact and/or physical contact (e.g., touching)
4	Dyadic vocal	Any category 3 behavior paired with a non-cry vocalization (e.g., babbling, cooing, talking)
5	Distress vocalization (coded only for infants)	Crying or extreme fussing
6	Other vocal	Any vocalization that does not fit within the above vocal categories (i.e., object-related vocal, dyadic vocal, distress vocalization)
7	Other object-related non-vocal (coded only for caregivers and siblings)	Any object-related non-vocal behavior that does not involve interaction with the infant (e.g. manipulating an object other than the one the infant is focused on).

Caregiver and sibling behaviors were only credited as responsive if they 1) occurred immediately after the infant's behavior and 2) occurred within 5 seconds of the infant's preceding behavior (Bornstein et al., 1992). If the infant preformed multiple consecutive behaviors before the sibling or caregiver responded, the sibling or caregiver was only credited with responding to the last behavior. For example, if the infant emitted three vocalizations in a row and the caregiver only responded to the third vocalization, the caregiver would be considered 33% responsive. If, on the other hand, the caregiver responded after every infant vocalization, the caregiver would be considered 100% responsive. Sibling and caregiver responses did not have to match the infant behavior. As long as their response met the two previously mentioned criteria, they could respond with any of the behaviors and be credited as responsive. Given that other vocal and other object-related non-vocal behaviors did not involve interaction with the infant and were not based on the infant's actions, they were not credited as responsive behaviors.

Results

Level of Responsiveness

Sibling and caregiver level of responsiveness to each infant behavior was also analyzed. Level of responsiveness was calculated as the number of times a sibling or caregiver responded to a behavior divided by the number of times the infant performed the behavior; thus, level of responsiveness was calculated as a proportion (e.g., 40 caregiver responses/100 infant objected-related vocalizations = .40 level of responsiveness to infant object-related vocalizations). Overall level of responsiveness was calculated by dividing the sum of all sibling or caregiver responses by the sum of all infant behaviors.

Analyses of Covariance (ANCOVAs) were used to control for participants being in the same family; the effect of sibling age on level of responsiveness for each infant behavior was analyzed. The independent variable, age, included nine levels, older sibling ages 3, 4, 5, 6, 7, 8, 9, and 10 years and mother. The dependent variables were the level of responsiveness to each infant behavior (i.e., infant object-related non-vocal responsiveness; infant object-related vocal responsiveness; infant dyadic non-vocal responsiveness; infant dyadic vocal responsiveness; overall responsiveness). Preliminary analyses evaluating the homogeneity assumption of regression for each ANCOVA indicated there was not an interaction between age and family (the covariate); thus, the assumption was supported for level of responsiveness for all infant behaviors (Table 3). The ANCOVAs were significant and there was a significant effect of age after controlling for the effect of being in the same family (Table 4). Level of responsiveness varied as a function of age and there was a strong relationship between the two variables, as indicated by partial η^2 values for age ranging from .33 to .86. The effect of family as a covariate was not significantly related to level of responsiveness for any of the ANCOVAs (Table 4).

Follow-up tests were conducted to evaluate pairwise differences among the adjusted means for age. Bonferonni pairwise comparisons indicated that 3-, 4-, 5-, and 6-year-olds did not differ significantly in their responses to any of the infant behaviors ($p > .05$; Figure 2, Figure 3, Figure 4, Figure 5, and Figure 6). Thus, in subsequent ANCOVAs, the data for children in these age groups was collapsed to create an age group called 3-6 years.

Table 3

ANCOVA Homogeneity Assumption of Regression for Age by Family Interaction: P-values

Responsiveness to Infant Behavior	*p*
Infant Object-Related Non-Vocal Responsiveness ANCOVA	.807
Infant Object-Related Vocal Responsiveness ANCOVA	.630
Infant Dyadic Non-Vocal Responsiveness ANCOVA	.255
Infant Dyadic Vocal Responsiveness ANCOVA	.597
Overall Responsiveness ANCOVA	.602

Table 4

Analyses of Covariance for Level of Responsiveness to Infant Behaviors by Age

	Source	df	F	*p*
Infant Object-Related Non-Vocal Responsiveness	Family	1	1.86	.181
	Age**	8	28.50	.000
	Error	37		
	Total	46		
Infant Object-Related Vocal Responsiveness	Family	1	0.01	.930
	Age**	8	14.52	.000
	Error	37		
	Total	46		
Infant Dyadic Non-Vocal Responsiveness	Family	1	0.04	.848
	Age*	8	2.24	.046
	Error	37		
	Total	46		
Infant Dyadic Vocal Responsiveness	Family	1	1.60	.214
	Age**	8	4.57	.001
	Error	37		
	Total	46		
Overall Responsiveness	Family	1	3.16	.084
	Age**	8	26.55	.000
	Error	37		
	Total	46		

**$p < .001$
*$p < .05$

In the United States, average spacing between children is 2-3 years (e.g., Wineberg & McCarthy, 1989) and average number of children per family is 1 (U.S. Census Bureau, 2010; Cancian & Reed, 2009). As a result, few of the caregivers had both a 12-month-old infant and a child older than 5 years. Because the number of siblings older than 5 years was low, and the level of overall responsiveness for these siblings was similar (Figure 2, Figure 3, Figure 4, Figure 5, and Figure 6), older siblings who were 7, 8, 9, and 10 years of age were combined into an older age group called 7-10 years. Additional ANCOVAs were conducted using the combined age groups. Sample sizes for the combined age groups were: 3-6 years n = 21, 7-10 years n = 4, and mothers n = 22.

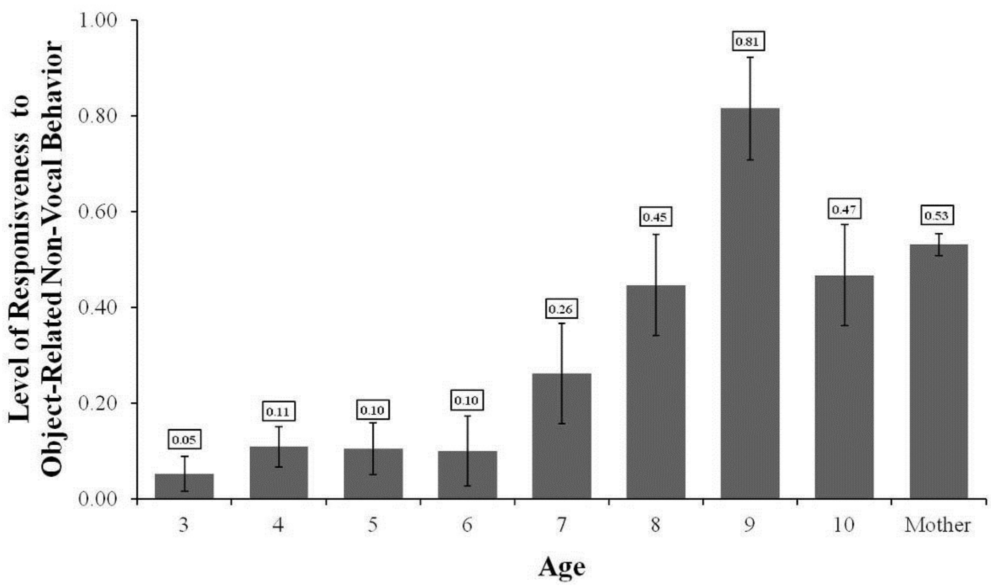

Figure 2. Older sibling and caregiver level of responsiveness to infant object-related non-vocal behavior. Level of responsiveness for children aged 3, 4, 5, and 6 years was not significantly different. Estimated marginal means and standard errors were obtained using ANCOVA. Standard errors are represented in the figure by the error bars attached to each column.

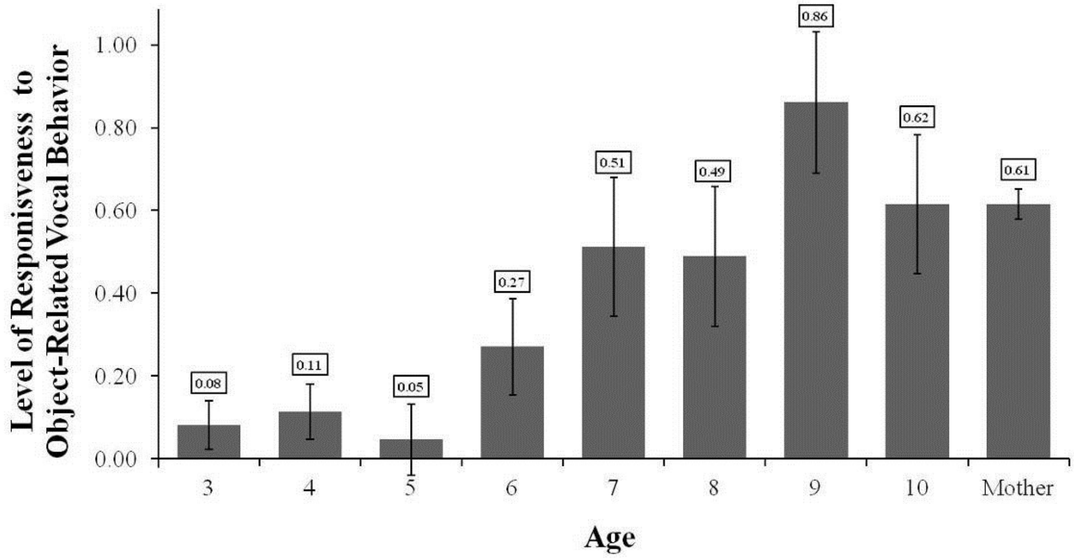

Figure 3. Older sibling and caregiver level of responsiveness to infant object-related vocal behavior. Level of responsiveness for children aged 3, 4, 5, 6, 7, 8, and 10 years was not significantly different. Estimated marginal means and standard errors were obtained using ANCOVA. Standard errors are represented in the figure by the error bars attached to each column.

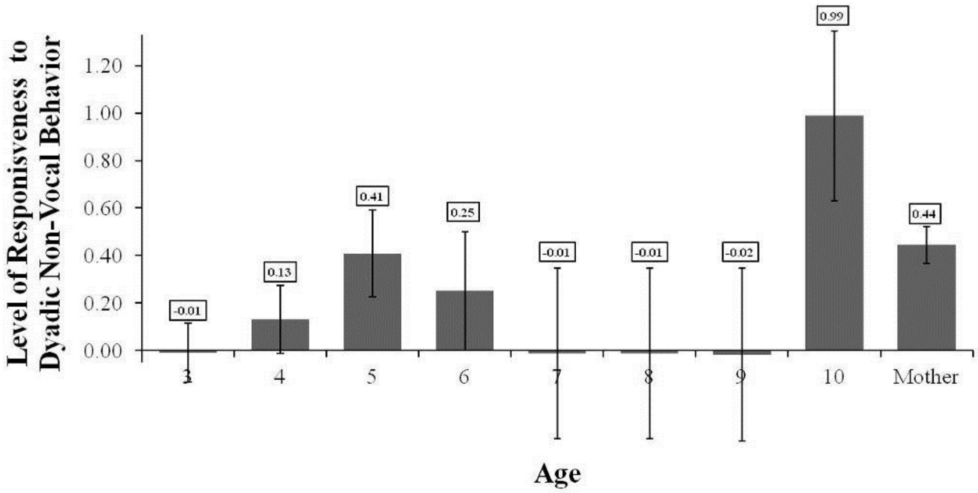

Figure 4. Older sibling and caregiver level of responsiveness to infant dyadic non-vocal behavior. Level of responsiveness was not significantly different for any of the age groups. Estimated marginal means and standard errors were obtained using ANCOVA. Standard errors are represented in the figure by the error bars attached to each column.

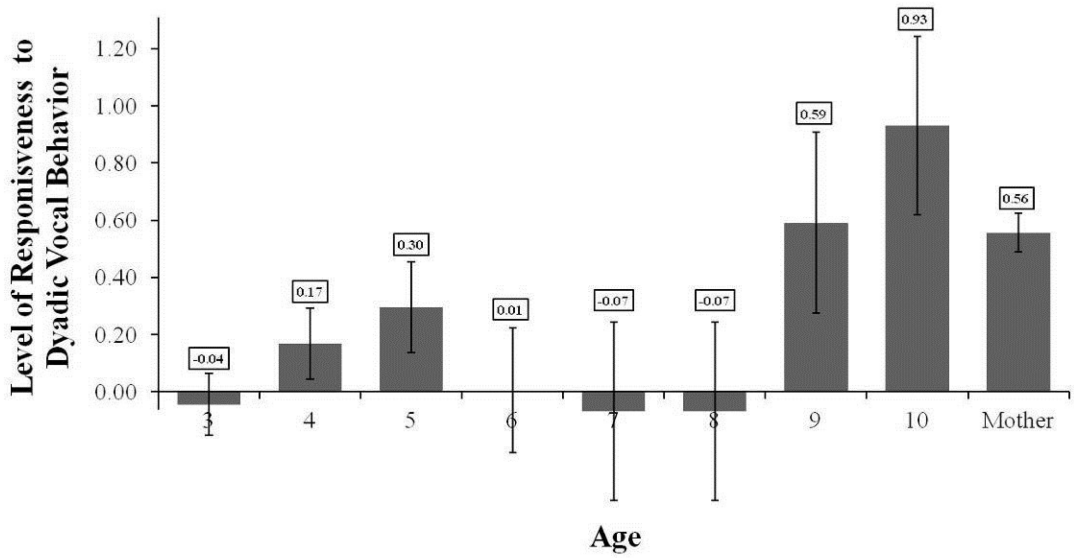

Figure 5. Older sibling and caregiver level of responsiveness to infant dyadic vocal behavior. Three-year-old level of responsiveness was significantly different from mother level of responsiveness; there were no other significant differences. Estimated marginal means and standard errors were obtained using ANCOVA. Standard errors are represented in the figure by the error bars attached to each column.

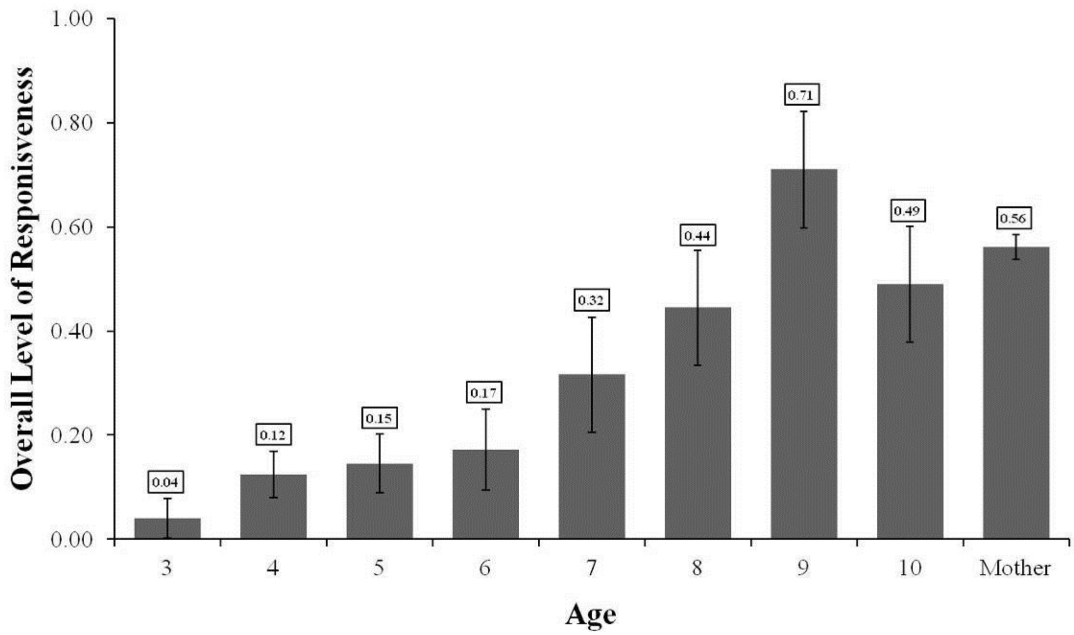

Figure 6. Older sibling and caregiver overall level of responsiveness to infant behavior. Level of responsiveness for children aged 3, 4, 5, and 6 years was not significantly different. Estimated marginal means and standard errors were obtained using ANCOVA. Standard errors are represented in the figure by the error bars attached to each column.

In analyses with combined age groups, controlling for participants being in the same family, there was a significant effect of age with partial η^2 values ranging from .15 to .81 (Table 5). The effect of family as a covariate was not significantly related to level of responsiveness for any of the ANCOVAs (Table 5). Planned Bonferonni pairwise comparisons revealed that there were significant differences in sibling and caregiver level of responsiveness to all infant behaviors. There were also significant differences in levels of responsiveness between the 3-6 and 7-10 age groups. The pattern for different levels of responsiveness in the two age groups was suggested by the small sample size for siblings aged 7 to 10 years. Overall, siblings in the 7-10 age group were more similar to each other, and more responsive, than siblings in the 3-6 age group.

Mothers' level of responsiveness to all infant behaviors was significantly different from children in the 3-6 years age group. When compared to 3- to 6-year-olds, mothers were more responsive to infant object-related non-vocal, object-related vocal, dyadic non-vocal, and dyadic vocal behaviors (all $p < .05$). In terms of overall responsiveness level, mothers responded to 56% of infant behaviors while 3- to 6-year-olds responded to 10% of infant behaviors ($p = .000$; Table 6, Figure 7, Figure 8, Figure 9).

In contrast, mothers' level of responsiveness to infant behaviors was not significantly different from siblings in the 7-10 years age group. Mothers and siblings aged 7 to 10 years had the same level of responsiveness to infant object-related non-vocal, object-related vocal, dyadic non-vocal, and dyadic vocal behaviors (all $p = 1$). For overall responsiveness, mothers responded to 56% of infant behaviors and 7- to

10-year-olds responded to 50% of infant behaviors (p = 1; Table 6, Figure 7, Figure 8, Figure 9). The results indicate that by the time older siblings are 7 to 10 years old, their level of responsiveness to infant behaviors is similar to their mothers' level of responsiveness. As previously mentioned, this pattern is based on a small sample size and emerged as a result of the similarities between the levels of responsiveness displayed by the four siblings in the 7-10 age group.

Table 5

Analysis of Covariance for Level of Responsiveness to Infant Behaviors by Combined Age Groups

		df	F	p	η^2	Power
Infant Object-Related Non-Vocal Response	Family	1	1.13	.294	0.03	0.18
	Age**	2	85.39	.000	0.80	1.00
	Error	43				
	Total	46				
Infant Object-Related Vocal Response	Family	1	0.00	.967	0.00	0.05
	Age**	2	55.29	.000	0.72	1.00
	Error	43				
	Total	46				
Infant Dyadic Non-Vocal Response	Family	1	0.27	.606	0.01	0.08
	Age*	2	3.87	.028	0.15	0.67
	Error	43				
	Total	46				
Infant Dyadic Vocal Response	Family	1	0.31	.579	0.01	0.08
	Age**	2	11.25	.000	0.34	0.99
	Error	43				
	Total	46				
Overall Responsiveness	Family	1	1.46	.233	0.03	0.22
	Age**	2	90.66	.000	0.81	1.00
	Error	43				
	Total	46				

**$p < .001$
*$p < .05$

Table 6

Bonferroni Pairwise Comparisons of Level of Responsiveness for Combined Age Groups

	Age Group	Mean	Comparison p-values: 3-6 Years	7-10 Years	Mother
Infant Object-Related Non-Vocal Response	3-6 Years	0.08	-	.000**	.000**
	7-10 Years	0.50	.000**	-	1
	Mother	0.53	.000**	1	-
Infant Object-Related Vocal Response	3-6 Years	0.10	-	.000**	.000**
	7-10 Years	0.62	.000**	-	1
	Mother	0.61	.000**	1	-
Infant Dyadic Non-Vocal Response	3-6 Years	0.13	-	1	.024*
	7-10 Years	0.28	1	-	1
	Mother	0.44	.024*	1	-
Infant Dyadic Vocal Response	3-6 Years	0.08	-	.325	.000**
	7-10 Years	0.39	.325	-	1
	Mother	0.55	.000**	1	-
Overall Responsiveness	3-6 Years	0.10	-	.000**	.000**
	7-10 Years	0.50	.000**	-	1
	Mother	0.56	.000**	1	-

**$p < .001$
*$p < .05$

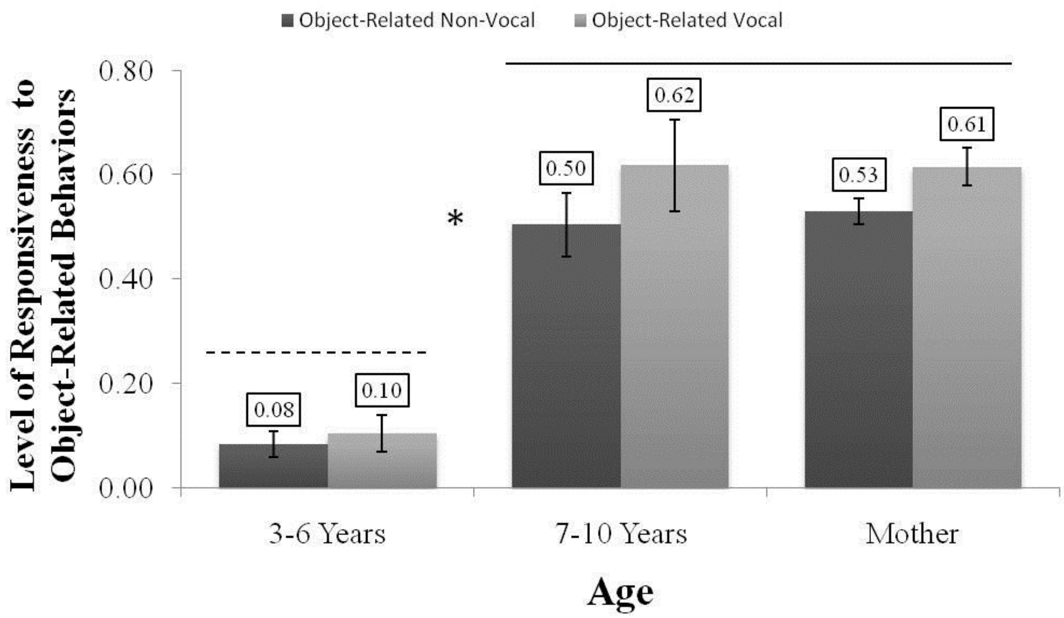

Figure 7. Level of responsiveness to infant object-related behaviors by combined age group. Mothers and older siblings in the 7-10 years age group did not differ significantly in level of responsiveness to object-related behaviors. Mothers and 7- to 10-year-olds differed significantly from 3- to 6-year-olds. Significant differences are denoted by an asterisk (*).

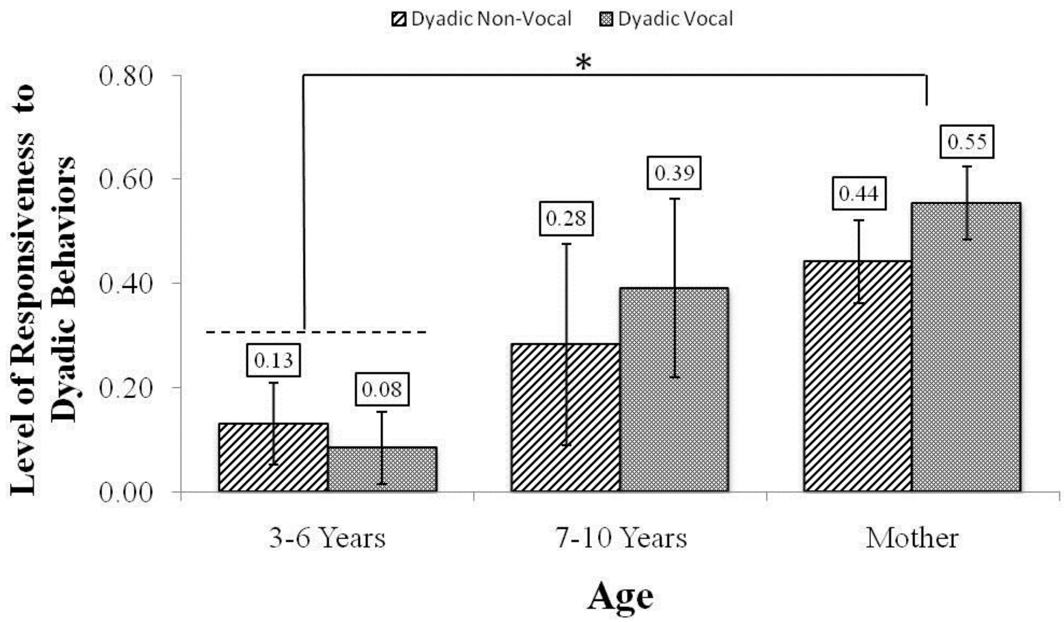

Figure 8. Level of responsiveness to infant dyadic behaviors by combined age group. Older siblings in the 7-10 years age group did not differ significantly from 3- to 6-year-olds in level of responsiveness to infant dyadic behaviors. 7- to 10-year-olds also did not differ significantly from mothers. Mothers had a higher responsiveness level than 3- to 6-year-olds and differed significantly from the 3-6 years age group. Significant differences are denoted by an asterisk (*).

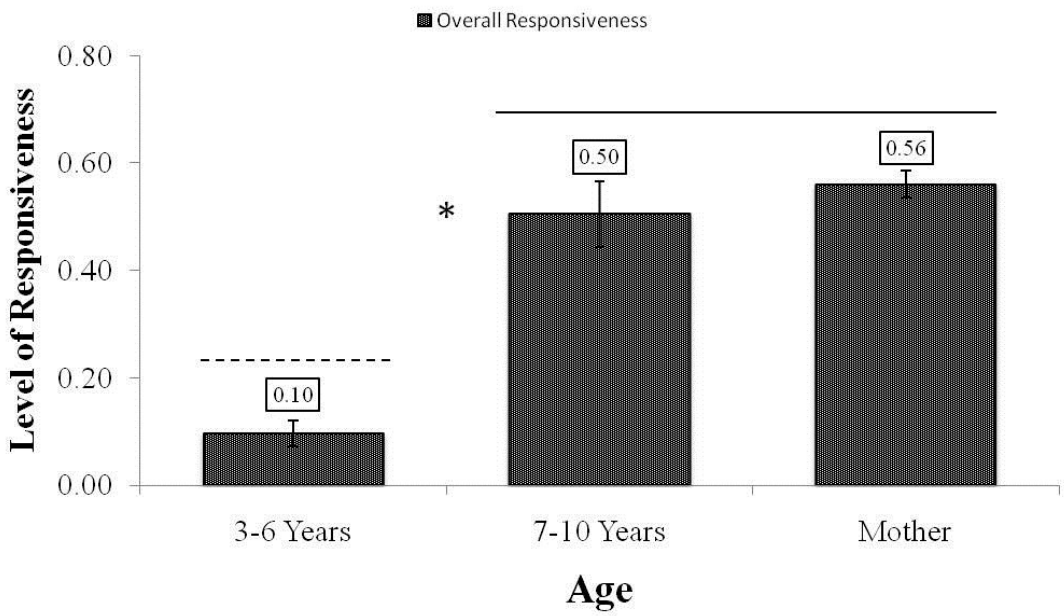

Figure 9. Overall level of responsiveness to infant behaviors by combined age group. Mothers and older siblings in the 7-10 years age group did not differ significantly in overall level of responsiveness. Mothers and 7- to 10-year-olds differed significantly from 3- to 6-year-olds. Significant differences are denoted by an asterisk (*).

Comparisons of the two sibling age groups revealed that the 7-10 years age group differed from the 3-6 years age group in their level of responsiveness to infant object-related behaviors (object non-vocal and object-related vocal behaviors, $p < .0001$; Table 6, Figure 7) and overall responsiveness ($p < .0001$; Figure 9). Level of responsiveness was not different for dyadic behaviors (dyadic non-vocal and dyadic vocal, $p > .05$; Table 6, Figure 8). Age differences in level of responsiveness to object-related and dyadic behaviors indicate that older siblings may respond selectively to certain behaviors. In particular, siblings in the 7-10 years age group were more likely to respond to object-related behaviors than dyadic behaviors, indicating that although 7- to 10-year-old siblings' level of responsiveness was similar to their mothers', siblings in this age group did not respond exactly like their mothers. Instead, their responses to dyadic behaviors were very similar to their mothers and very similar to 3- to 6-year-olds without perfectly matching either. They appeared to be in a middle, or transition, stage from very young sibling to maternal level of response (Figure 8).

It is important to note that pattern of responsiveness for 7- to 10-year-old siblings cannot be contributed to one child in the 7-10 age group. For example, although the 9-year-old exhibited high levels of object-related responsiveness and the 10-year-old exhibited high levels of dyadic responsiveness (see Figures 2, 3, 4, and 5), excluding the data for either one or both of these participants did not significantly affect the results of the group comparisons. When one participant was excluded, siblings in the older age group were not significantly different from mothers in their levels of responsiveness to object-related non-vocal behaviors, object-related vocal behaviors, dyadic non-vocal behaviors, dyadic behaviors, or overall level of responsiveness (all $p > .05$). When both participants were excluded from the analyses, only dyadic vocal behaviors differed significantly ($p = .018$). This difference can be attributed to the fact that infants did not emit any dyadic behaviors during play sessions with their 7- and 8-year-old siblings. Thus, although 7 and 8 year olds responded to the infants' behaviors, they were never given the opportunity to respond to infant dyadic behaviors because there were none.

Additionally, an independent-samples t-test was conducted to compare the level of responsiveness of male and female older siblings. Males ($M = .05$, $SD = .06$) and females ($M = .11$, $SD = .06$) in the 3-6 years age group differed in their level of responsiveness to infant object-related non-vocal behavior, $t(20) = 2.54$, $p = .02$, but not to any other behavior ($p > .05$). Males and females in the 7-10 years age group did not differ in their level of responsiveness to any of the infant behaviors ($p > .05$). However, given that gender role expectations and gender intensification increase during early adolescence (see e.g., Galambos, Almeida, & Petersen, 1990; Crouter, Manke, & McHale, 1995), a larger sample size may yield different results.

Additional Influences on Level of Responsiveness

Pearson product-moment correlation coefficients were computed to assess the relationship between siblings' overall responsiveness and other caregiver or sibling factors. For the following analyses, the original age data was used (i.e., the data for older siblings was not combined into age groups). Primary caregiver work status (i.e., inside or outside the home, $r = .42$, $n = 26$, $p = .03$), hours per week that older siblings spent at school ($r = .64$, $n = 26$, $p < .001$), number of times per week that the older sibling "read" books (i.e., reading was loosely defined as the older sibling using a book to tell the infant a story by either looking at the pictures or reading the words) to the infant (r = .54, n = 26, p = .005), and hours per week that the older sibling was required to babysit the infant (r = .891, n = 26, p < .01) were significantly positively correlated with overall responsiveness. Total hours per week that the older sibling spent with the infant (r = -.194, n = 26, p = .34) was not significantly correlated with overall responsiveness. Given the strong correlations between level of responsiveness and the abovementioned factors, multiple regressions were conducted to assess which factors were the best predictors of level of responsiveness to each infant behavior (i.e., levels of responsiveness to infant object-related and dyadic behaviors were included as dependent outcomes). A backward stepwise regression was conducted in which all variables were included in the initial model and then each non-significant variable was removed until the best, and final, model emerged.

The best predictors of level of responsiveness were sibling age and hours per week that the older sibling was required to babysit the infant. Although siblings in the 7-10 age group (M = 6.5 hours per week, SD = 3) were required to babysit more than siblings in the 3-6 age group (M = .13 hours per week, SD = .28), there were five younger siblings (ages 3 [n = 1], 4 [n = 1], 5 [n = 2], and 6 [n = 1]; M = .55 hours per week, SD = .33) who had regular babysitting responsibilities. Results of the object-related non-vocal regression indicated that hours spent babysitting explained 86% of the variance ($F(1, 24) = 150.55$, p < .001; Table 7). Hours per week spent babysitting and hours per week that the older sibling spent with the infant ($R^2 = .76$, $F(2, 23) = 39.67$, p < .001; Table 8) were the best predictors of responsiveness to object-related vocal behavior. Responsiveness to dyadic non-vocal behavior was best predicted by age and hours spent babysitting ($R^2 = .34$, $F(2, 23) = 7.31$, $p = .003$; Table 9) while responsiveness to dyadic vocal behavior was best predicted by age alone ($R^2 = .36$, $F(1, 24) = 14.95$, $p = .001$; Table 10). Siblings' overall level of responsiveness was best predicted by age and hours spent babysitting ($F(2, 23) = 61.48$, $p < .001$; Table 11); these two predictors explained 83% of the variance in overall level of responsiveness. Thus, in addition to age, the amount of time that siblings were required to take on the responsibilities of a caregiver resulted in increased levels of responsiveness to infant behavior.

Table 7

Linear Regression for Object-Related Non-Vocal Response

Variable	B	Std. Error	Beta	*p*
Constant	0.072	0.016		.000
Hours/Week Older Sibling Required to Babysit Infant	0.069	0.006	0.929**	.000
Adjusted R^2	0.86			

**$p < .001$
*$p < .05$

Table 8

Linear Regression for Object-Related Vocal Response

Variable	B	Std. Error	Beta	*p*
Constant	0.203	0.055		.000
Hours/Week Older Sibling Required to Babysit Infant	0.071	0.009	0.818**	.000
Hours/Week Older Sibling Spends with Infant	-0.001	0.0004	-0.211*	.046
Adjusted R^2	0.76			

**p < .001
*p < .05

Table 9

Linear Regression for Dyadic Non-Vocal Response

Variable	B	Std. Error	Beta	*p*
Constant	-0.527	0.185		.009
Age	0.170	0.044	1.065*	.001
Hours/Week Older Sibling Required to Babysit Infant	-0.100	0.0338	-0.827*	.007
Adjusted R^2	0.34			

**p < .001
*p < .05

Table 10

Linear Regression for Dyadic Vocal Response

Variable	B	Std. Error	Beta	*p*
Constant	-0.263	0.111		.026
Age	0.085	0.0220	0.619*	.001
Adjusted R^2	0.36			

**p < .001
*p < .05

Table 11

Linear Regression for Overall Responsiveness

Variable	B	Std. Error	Beta	*p*
Constant	-0.053	0.056		.351
Age	0.036	0.013	0.377*	.014
Hours/Week Older Sibling Required to Babysit Infant	0.042	0.0102	0.585**	.000
Adjusted R^2	0.83			

**p < .001
*p < .05

Sequential Data Analysis

To assess social learning of caregiving behavior, older siblings' responsiveness behaviors were compared to their caregivers using sequential data analysis (see e.g., Bobbitt, Gourevitch, Miller, & Jensen, 1969; Fisher & Sanderson, 1996; Hofmann, Puzicha, & Jordan, 1999; Jeong, 2005; Kogan & Wimberger, 1966; Lii, 1981; Olson, Herbsleb, & Rueter, 1994; Pan, 2010; Sawin, Langlois, & Leitner, 1977; Sigel & Parke, 1987). Sequential analyses were used to identify recurring behavioral patterns.

For example, after an infant emitted a dyadic vocalization, with which behavior (e.g., dyadic non-vocalization, dyadic vocalization) were caregivers most likely to respond? Was the probability of responding with one type of behavior greater than the probability of responding with another type of behavior? Were older siblings' responsive behavioral patterns the same as their caregivers' patterns? Sequential analyses allowed us to examine these questions and determine which behavioral sequences occurred at rates that were significantly greater than chance. For the following analyses, a behavioral sequence consisted of two behaviors – an initial behavior and the behavior immediately following it (i.e., lag 1 analysis).

Lag 1 sequential analyses were conducted using repeating consecutive behaviors and non-repeating consecutive behaviors (Bakeman & Quera, 1995). For repeating consecutive analyses, we examined all behaviors, both responsive and non-responsive, which provided a more general measure of how the infant and caregiver/sibling interacted during the 20-minute play session. In these analyses, we were also interested in how infants responded to caregiver/sibling-initiated behaviors. Hence, the analysis was bi-directional and the first behavior in a behavioral sequence could be either an infant-initiated or a caregiver/sibling-initiated behavior.

For non-repeating consecutive analyses, however, the sequence criteria was very similar to the previously stated criteria for responsiveness in that we specifically examined the caregiver and sibling responses that occurred immediately after the infant's behavior (i.e., we analyzed the pattern of responsiveness to infant-initiated behaviors). Thus, for non-repeating analyses, a sequence consisted of the infant's initiating behavior followed by the caregiver or sibling's responsive behavior.

For a repeating consecutive behavior analysis, a behavioral sequence of infant dyadic vocal (idv), infant dyadic vocal (idv), sibling dyadic vocal (sdv), infant object-related non-vocal (ion) (see Table 12 for other behavior category abbreviations) would result in an idv to idv frequency of 1 (Table 13) and a transitional probability of .50 (Table 14). In a non-repeating consecutive behavior analysis, consecutive repeating behaviors are not analyzed. Thus, a behavioral sequence of idv, idv, sdv, ion would be collapsed into an idv, sdv, ion sequence, resulting in an idv to idv frequency (Table 15) of 0 and a transitional probability of 0 (Table 16). Sequential data analysis comparisons were performed using O'Connor's (1999) SEQGROUPS SPSS syntax program.

Table 12

Behavior Category Abbreviations

ion	Infant Object-Related Non-Vocal
iov	Infant Object-Related Vocal
idn	Infant Dyadic Non-Vocal
idv	Infant Dyadic Vocal
icry	Infant Cry
iot	Infant Other Vocal
son	Sibling Object-Related Non-Vocal
sov	Sibling Object-Related Vocal
sdn	Sibling Dyadic Non-Vocal
sdv	Sibling Dyadic Vocal
sot	Sibling Other Vocal
soo	Sibling Other Non-Vocal
mon	Mother Object-Related Non-Vocal
mov	Mother Object-Related Vocal
mdn	Mother Dyadic Non-Vocal
mdv	Mother Dyadic Vocal
mot	Mother Other Vocal
moo	Mother Other Non-Vocal

Table 13

Example of Frequency Matrix of Repeating Consecutive Behaviors

	Infant dyadic-vocal	Sibling dyadic-vocal	Infant object-related non-vocal
Infant dyadic-vocal	1	1	0
Sibling dyadic-vocal	0	0	1
Infant object-related non-vocal	0	0	0

Table 14

Example of Transitional Probability Matrix of Repeating Consecutive Behaviors

	Infant dyadic-vocal	Sibling dyadic-vocal	Infant object-related non-vocal
Infant dyadic-vocal	.50	.50	0
Sibling dyadic-vocal	0	0	1
Infant object-related non-vocal	0	0	0

Table 15

Example of Frequency Matrix of Non-Repeating Consecutive Behaviors

	Infant dyadic-vocal	Sibling dyadic-vocal	Infant object-related non-vocal
Infant dyadic-vocal	0	1	0
Sibling dyadic-vocal	0	0	1
Infant object-related non-vocal	0	0	0

Table 16

Example of Transitional Probability Matrix of Non-Repeating Consecutive Behaviors

	Infant dyadic-vocal	Sibling dyadic-vocal	Infant object-related non-vocal
Infant dyadic-vocal	0	1	0
Sibling dyadic-vocal	0	0	1
Infant object-related non-vocal	0	0	0

Sibling and Primary Caregiver Sequential Data Comparisons

Repeating consecutive behaviors allowed us to more closely examine the frequency and transitional probability from infant behavior to sibling or caregiver behavior. Thus we could compare the individual response patterns of older siblings to those of their caregivers. The repeating analysis also provided a bi-directional measure of how participants were responding to each other during the play sessions. It allowed us to exam which behaviors siblings and caregivers were most likely to respond to as well as which sibling and caregiver behaviors infants were likely to respond to. In particular, we looked at behavioral patterns and examined whether certain behaviors were more likely to follow others.

Individual sequential analyses were performed for every triad. For each triad, sibling-caregiver comparisons based on likelihood ratio chi-square tests revealed that there were significant differences in the behavioral patterns of infant-sibling interactions compared to infant-caregiver interactions (Likelihood Ratio Chi-Square ranged from $\chi^2 = 204.57$ to $\chi^2 = 1262.41$, $df = 132$, $p < .001$); only two siblings displayed the same interaction patterns as their caregivers, a 3-year-old ($\chi^2 = 94.09$, $p > .05$) and a 9-year-old ($\chi^2 = 96.13$, $p > .05$). To compare the transitional probabilities of initial behaviors and following behaviors in infant-sibling and infant-caregiver interactions, the data for all sibling interactions was combined and compared to the combined data for all caregiver interactions.

The behaviors most likely to follow infant object-related behaviors, infant cries, and other infant vocal behaviors differed most for the two types of interactions. During infant-sibling interactions, infant objected-related non-vocal and infant object-related vocal behaviors were most often not responded to and siblings engaged in other vocal and non-vocal behaviors (i.e., soo and sot) that were not related to the object the infant was focused on (Table 17 and Table 18). Similarly, siblings were not likely to respond when infants cried or when infants engaged in non-dyadic vocal behaviors. Siblings, however, did respond to infant dyadic behaviors. Approximately 50% of infant dyadic vocal behaviors were followed by sibling dyadic vocal behaviors.

Caregivers were most likely to respond to infant behaviors with dyadic vocalizations (Table 19 and Table 20). With the exception of infant objected related non-vocal behaviors, which were most likely followed by infant object related non-vocal behaviors, caregivers tended to provide vocal responses to infant behaviors. Even when infants were crying, caregivers responded with either other vocal behaviors or dyadic vocal behaviors.

Infants were more likely to respond to both sibling and caregiver behaviors with infant object related non-vocal behaviors. It is important to note that siblings and caregivers were inclined to repeat their previous behaviors, which resulted in larger transitional probabilities from sibling-to-sibling and caregiver-to-caregiver behaviors than from sibling/caregiver behaviors to infant behaviors. For example, the transitional probability that an infant would respond to a sibling/caregiver behavior with an iov, idn, or idv was less than .1 for both infant-sibling and infant-caregiver interactions. However, the probability that a sibling/caregiver would respond to her own behavior ranged from .25 to .45.

Table 17

Repeating Analysis Frequencies: Infant-Sibling Interaction

	ion	iov	idn	idv	icry	iot	son	sov	sdn	sdv	sot	soo	Total
ion	654	112	2	3	8	54	85	87	17	170	693	739	2624
iov	74	181	0	0	4	6	40	53	2	108	210	117	795
idn	0	1	1	1	0	1	0	0	4	5	3	1	17
idv	5	2	1	33	1	1	10	4	6	82	19	1	165
icry	17	4	0	0	88	3	4	1	11	12	46	63	249
iot	41	3	0	2	21	174	13	4	14	47	178	162	659
son	110	46	1	11	5	16	168	57	2	20	52	25	513
sov	103	43	2	2	0	6	53	223	2	26	29	23	512
sdn	18	5	6	9	11	18	3	2	42	26	21	7	168
sdv	154	83	1	94	11	41	38	28	37	353	55	86	981
sot	701	193	2	10	41	180	50	28	22	55	1300	934	3516
soo	747	121	1	1	58	158	49	25	9	76	915	1496	3656
Total	2624	794	17	166	248	658	513	512	168	980	3521	3654	13855

Table 18

*Repeating Analysis Transitional Probabilities: Infant-Sibling Interaction**

	ion	iov	idn	idv	icry	iot	son	sov	sdn	sdv	sot	soo
ion	0.249	0.043	0.001	0.001	0.003	0.021	0.032	0.033	0.007	0.065	0.264	**0.282**
iov	0.093	0.228	0.000	0.000	0.005	0.008	0.050	0.067	0.003	0.136	**0.264**	0.147
idn	0.000	0.059	0.059	0.059	0.000	0.059	0.000	0.000	0.235	**0.294**	0.177	0.059
idv	0.030	0.012	0.006	0.200	0.006	0.006	0.061	0.024	0.036	**0.497**	0.115	0.006
icry	0.068	0.016	0.000	0.000	**0.353**	0.012	0.016	0.004	0.044	0.048	0.185	0.253
iot	0.062	0.005	0.000	0.003	0.032	0.264	0.020	0.006	0.021	0.071	**0.270**	0.246
son	0.214	0.090	0.002	0.021	0.010	0.031	**0.328**	0.111	0.004	0.039	0.101	0.049
sov	0.201	0.084	0.004	0.004	0.000	0.012	0.104	**0.436**	0.004	0.051	0.057	0.045
sdn	0.107	0.030	0.036	0.054	0.066	0.107	0.018	0.012	**0.250**	0.155	0.125	0.042
sdv	0.157	0.085	0.001	0.096	0.011	0.042	0.039	0.029	0.038	**0.360**	0.056	0.088
sot	0.199	0.055	0.001	0.003	0.012	0.051	0.014	0.008	0.006	0.016	**0.370**	0.266
soo	0.204	0.033	0.000	0.000	0.016	0.043	0.013	0.007	0.003	0.021	0.250	**0.409**

**behavior with the largest transitional probability denoted in bold*

Table 19

Repeating Analysis Frequencies: Infant-Caregiver Interaction

	ion	iov	idn	idv	icry	iot	mon	mov	mdn	mdv	mot	moo	Total
ion	1260	334	14	20	0	17	404	880	67	525	73	182	3776
iov	167	247	3	7	0	8	82	294	4	297	46	33	1188
idn	5	0	13	9	0	3	11	2	31	36	0	1	111
idv	6	21	3	39	0	8	9	12	30	220	7	1	356
icry	0	0	0	0	7	0	0	2	1	6	8	0	24
iot	18	7	4	5	3	72	10	19	12	89	49	30	318
mon	447	80	5	8	0	13	322	306	17	69	26	15	1308
mov	1005	236	6	16	3	30	305	1148	13	101	58	56	2977
mdn	64	10	13	22	1	14	22	11	50	101	5	1	314
mdv	562	190	46	217	5	78	97	164	78	795	31	61	2324
mot	64	42	3	10	2	51	25	62	8	39	220	89	615
moo	176	23	1	2	3	25	21	79	2	47	93	183	655
Total	3774	1190	111	355	24	319	1308	2979	313	2325	616	652	13966

Table 20

*Repeating Analysis Transitional Probabilities: Infant-Caregiver Interaction**

	ion	iov	idn	idv	icry	iot	mon	mov	mdn	mdv	mot	moo
ion	**0.334**	0.089	0.004	0.005	0.000	0.005	0.107	0.233	0.018	0.139	0.019	0.048
iov	0.141	0.208	0.003	0.006	0.000	0.007	0.069	0.248	0.003	**0.250**	0.039	0.028
idn	0.045	0.000	0.117	0.081	0.000	0.027	0.099	0.018	0.279	**0.324**	0.000	0.009
idv	0.017	0.059	0.008	0.110	0.000	0.023	0.025	0.034	0.084	**0.618**	0.020	0.003
icry	0.000	0.000	0.000	0.000	0.292	0.000	0.000	0.083	0.042	0.250	**0.333**	0.000
iot	0.057	0.022	0.013	0.016	0.009	0.226	0.031	0.060	0.038	**0.280**	0.154	0.094
mon	**0.342**	0.061	0.004	0.006	0.000	0.010	0.246	0.234	0.013	0.053	0.020	0.012
mov	0.338	0.079	0.002	0.005	0.001	0.010	0.103	**0.386**	0.004	0.034	0.020	0.019
mdn	0.204	0.032	0.041	0.070	0.003	0.045	0.070	0.035	0.159	**0.322**	0.016	0.003
mdv	0.242	0.082	0.020	0.093	0.002	0.034	0.042	0.071	0.034	**0.342**	0.013	0.026
mot	0.104	0.068	0.005	0.016	0.003	0.083	0.041	0.101	0.013	0.063	**0.358**	0.145
moo	0.269	0.035	0.002	0.003	0.005	0.038	0.032	0.121	0.003	0.072	0.142	**0.279**

**behavior with the largest transitional probability denoted in bold*

Second, we analyzed the frequency with which siblings and caregivers responded to each infant behavior. In this analysis, consecutive behaviors could not repeat. Non-repeating consecutive behaviors allowed us to more closely examine the frequency and transitional probability from infant behavior to sibling or caregiver behavior. Using this analysis method, the immediate response time of siblings, caregivers, and infants was also taken into account; and the frequency of responsive behaviors (as opposed to the frequency of all behaviors) was measured. Thus, the non-repeating consecutive behavioral sequential analysis was a time-based analysis of level of responsiveness to infant behaviors.

When non-responsive behaviors were excluded from the sequential analysis, sibling-caregiver comparisons based on likelihood ratio chi-square tests revealed that there were not significant differences in the pattern of responsiveness for infant-sibling interactions compared to infant-caregiver interactions; siblings and caregivers responded similarly to infant behaviors (Likelihood Ratio Chi-Square ranged from $\chi^2 = 3.59$ to $\chi^2 = 46.62$, $df = 56$, $p > .05$). Only one sibling, a 5-year-old, displayed a responsiveness pattern that differed from the caregiver ($\chi^2 = 75.81$, $p = .04$). A comparison of the combined responsiveness pattern data indicated that siblings mostly responded to infant behaviors with sdvs (Table 21and Table 22). Caregivers were more likely to respond to infant object-related behaviors with movs and infant dyadic behaviors with mdvs (Table 23 and Table 24). Infants most often responded to both sibling and caregiver behaviors with ions (transitional probability ranged from .48 to .76).

Additional repeating and non-repeating analyses were conducted by dividing caregivers into groups of low responders and high responders using a median split of overall level of responsiveness (*Mdn* = .55, *M* = .56. *SD* = .13, Range .29-.80; 11 Low Responders, 10 High Responders). Sibling-caregiver comparisons of sequential behaviors of high and low responders were not significant ($p > .05$).

Table 21

Non-Repeating Analysis Frequencies: Infant-Sibling Interaction

	ion	iov	idn	idv	son	sov	sdn	sdv	Total
ion	0	0	0	0	83	86	20	172	363
iov	0	0	0	0	35	53	1	112	201
idn	0	0	0	0	0	0	4	5	9
idv	0	0	0	0	9	4	5	80	98
son	79	32	2	8	0	0	0	0	121
sov	75	53	1	8	0	0	0	0	137
sdn	20	3	1	4	0	0	0	0	28
sdv	172	106	4	77	0	0	0	0	359
Total	346	194	8	97	127	143	30	369	1316

Table 22

Non-Repeating Analysis Transitional Probabilities: Infant-Sibling Interaction

	ion	iov	idn	idv	son	sov	sdn	sdv
ion	0.003	0.003	0.000	0.000	0.229	0.237	0.055	**0.474**
iov	0.000	0.000	0.000	0.000	0.174	0.264	0.005	**0.557**
idn	0.000	0.000	0.000	0.000	0.000	0.000	0.444	**0.556**
idv	0.000	0.000	0.000	0.000	0.092	0.041	0.051	**0.816**
son	**0.653**	0.265	0.017	0.066	0.000	0.000	0.000	0.000
sov	**0.547**	0.387	0.007	0.058	0.000	0.000	0.000	0.000
sdn	**0.714**	0.107	0.036	0.143	0.000	0.000	0.000	0.000
sdv	**0.479**	0.295	0.011	0.215	0.000	0.000	0.000	0.000

Table 23

Non-Repeating Analysis Frequencies: Infant-Caregiver Interaction

	ion	iov	idn	idv	mon	mov	mdn	mdv	Total
ion	0	0	0	0	319	905	31	444	1703
iov	0	0	0	0	69	274	2	226	572
idn	0	0	0	0	3	5	20	38	66
idv	0	0	0	1	9	9	9	187	215
mon	298	86	5	6	0	0	0	0	395
mov	901	253	14	19	0	0	0	0	1187
mdn	34	10	8	9	0	0	0	0	61
mdv	454	216	38	179	0	0	0	0	887
Total	1687	565	65	214	400	1193	62	895	5086

Table 24

Non-Repeating Analysis Transitional Probabilities: Infant-Caregiver Interaction

	ion	iov	idn	idv	mon	mov	mdn	mdv
ion	0.001	0.002	0.000	0.000	0.187	**0.531**	0.018	0.261
iov	0.002	0.000	0.000	0.000	0.121	**0.479**	0.004	0.395
idn	0.000	0.000	0.000	0.000	0.046	0.076	0.303	**0.576**
idv	0.000	0.000	0.000	0.005	0.042	0.042	0.042	**0.870**
mon	**0.754**	0.218	0.013	0.015	0.000	0.000	0.000	0.000
mov	**0.759**	0.213	0.012	0.016	0.000	0.000	0.000	0.000
mdn	**0.557**	0.164	0.131	0.148	0.000	0.000	0.000	0.000
mdv	**0.512**	0.244	0.043	0.202	0.000	0.000	0.000	0.000

Discussion

As predicted, the development of caregiving behaviors was age related and there was a gradual onset of these behaviors. An analysis of level of responsiveness to infant behaviors revealed that the way older siblings interact with their infant siblings comes to resemble the interactive style of their parents after age 6. Due to the gradual development of social interaction and communication skills, the caregiving behaviors of 3- to 6-year-olds were similar to each other. More specifically, siblings in the younger age group had difficulty attuning to the infant and did not provide a significant amount of responsive feedback. Although siblings, in general, tended to respond to infant behaviors with non-responsive other behaviors, 3- to 6-year-old siblings displayed non-responsive behaviors more often. Older siblings, aged 7 to 10 years old, were more responsive to infant behaviors and they exhibited levels of responsiveness similar to those of their caregivers.

Given that 7 to 10 year olds differed from 3 to 6 year olds in responsiveness to objected-related behaviors but not dyadic behaviors, type of responsive caregiving behavior may also develop with age. Younger siblings responded to infant dyadic behaviors (i.e., behaviors directed at them), but not to infant behaviors directed at objects. Thus, younger siblings were more adept at engaging in dyadic interactions than they were at participating in object-related joint attention activities. Although they responded to face-to-face interactions, younger siblings were more inclined to play with one object while infants played with another object; they showed a preference for playing with their own toys. Occasionally, sibling object-related responsiveness occurred because the sibling wanted an object that the infant was playing with, which required the sibling to focus on the same object as the infant. Caregivers responded to both object related and dyadic infant behaviors.

A sequential analysis of only responsive behaviors indicated that siblings were not significantly different from their caregivers in terms of pattern of responsiveness. Although level of responsiveness differed for siblings and caregivers, when siblings responded to infant behaviors, they were likely to respond as their caregiver would - with vocal responsive behaviors. In contrast, when infant behavior was taken into account and the entire bi-directional interaction was analyzed, the behavior patterns of siblings differed significantly from the behavior patterns of caregivers. For example, the frequency of infant dyadic behaviors was much lower during infant-sibling interactions as compared to infant-caregiver interactions. Overall, siblings and caregivers differed in their level of responsiveness and behavioral patterns, but not their pattern of responsiveness.

In particular, siblings engaged in more other behaviors and provided infants with an interaction environment that was substantially different from the environment provided by caregivers. Infants were less vocal during interactions with siblings as compared to primary caregivers. As a result, infants emitted more responsive behaviors during infant-caregiver interactions. Caregiver responsiveness encouraged infants to respond in kind. In contrast, siblings' lack of responsiveness limited the amount of interaction between siblings and infants; siblings did not respond to infant behaviors, thus infants were less likely to exhibit behaviors that would encourage a sibling response.

An analysis of family demographics indicated that siblings who read to infants, attended school, were required to babysit, or had primary caregivers who worked inside the home were more responsive to infant behaviors. Although having a primary caregiver who spent a majority of her time at home caring for the family may have provided more opportunities for older siblings to engage in observational learning of caregiving behaviors, the influence of other types of interactions show that siblings learn interaction behaviors from multiple sources. Reading aloud, participating in school activities, and babysitting all require siblings to engage in social behaviors which may, in turn, foster their ability to interact responsively with infants. Skills that are enhanced include turn-taking, prosocial responsiveness, joint attention, and monitoring the body language, facial expressions, and mood of one's interaction partner.

The results suggest that children learn a majority of their caregiving behaviors via observational learning and supplement their social skills from interactions with their infant siblings. Yet it can also be argued that older siblings do not learn caregiving behaviors through the observation of infant-caregiver interactions. Instead, older siblings may learn through their own experiences with their caregivers (i.e., they learn to interact with their children in a manner which is similar to the way their parents interacted with them). If this is the case, then personal experience should be added as an additional source of caregiving behavior. To test this source, we would need to conduct a longitudinal study with children who have siblings and children who do not to see which family model resulted in the greatest intergenerational transmission of caregiving behaviors.

Limitations and Future Directions

While the present study has a number of strengths in that it has provided insight into when and how siblings model the behaviors of their primary caregivers, it also has some limitations. For example, an assessment of gender revealed that the responsiveness behavior of male and female siblings was not significantly different. It is possible that the siblings in this study were too young to allow for an accurate assessment of gender differences. These differences may become more apparent during adolescence when children are developing their identities, exploring their gender status, participating in gender-typical school and home activities, and displaying more gender-typed behaviors. An assessment of caregiver responsiveness for siblings older than 10 years of age would help clarify the age at which gender differences emerge during infant-sibling interactions.

A longitudinal, in-home study that follows multiple families would be beneficial in that it would provide a continuous record of caregiving behaviors. Furthermore, a longitudinal study would provide additional insight into the effects that differences in sibling age, household size, birth order, and sibling spacing have on the trajectory of caregiving behaviors. A longitudinal study can also be used to evaluate the types of caregiving behaviors that are inherited from one generation to the next. Do other mutually exclusive behaviors emerge with increases in family size or access to family members from multiple generations? What other familial situations provide older siblings with opportunities to learn caregiving behaviors? Are ethnicity and socio-economic status influential factors in the intergenerational transmission of caregiving behaviors?

The majority of the participants in this study were white and from middle to upper-middle class families. Different behavioral and responsiveness patterns may emerge if this study were conducted with families of different socio-economic and cultural backgrounds (see e.g., Kärtner, Keller, & Yovsi, 2010; Rabain-Jamin, 2001). Additionally, in cultures (e.g., the Wolof of Senegal; Rabain-Jamin, 2001) where older siblings are expected to do a majority of the caregiving, even younger siblings may be more responsive to infant behaviors. If that is the case, we would expect to see fewer differences between age groups and an earlier emergence of caregiver-like responsiveness levels in cultures where sibling childrearing is common.

The mutually exclusive categories of caregiving behaviors employed herein provide a useful way to assess the behaviors of families from a myriad of cultures and backgrounds. The technique offers an easy way to explore infant-sibling and infant-caregiver interactions without needing to make the assumption that only primary caregivers provide caregiving behaviors. The categories are also beneficial to the study of the intergenerational transmission of caregiving behaviors in that the behaviors analyzed are not culture specific. Thus, they provide a measure of flexibility that other caregiving categories may not offer.

Chapter 3: Study 2

Facilitation of Spatial Vocabulary via Infant-Directed Speech: A Longitudinal Study

From previous research, we know that infant vocabulary develops with age (Nelson, 1973) and that differences in the quantity of parental linguistic input results in differential levels of infant learning (Hart & Risley, 1995; Hoff, 2003). However, aside from internal biological factors (e.g., brain development, neuronal connectivity), which result in increased cognitive capacity, and the total number of utterances spoken by parents, what other factors facilitate language development? More specifically, what features of infant-directed speech are the best predictors of infant spatial vocabulary (e.g., prepositions such as in and on)? Spatial vocabulary is important because it allows infants to learn about the relationships among objects. Knowing how objects are spatially related provides a basis for comparison and makes it easier to locate objects in space (e.g., the box is under the table; the ball is on the table).

At any given time, children's vocabulary comprehension (i.e., what infants understand) is greater than their level of production (i.e., what infants say; e.g., Tsao, Liu, & Kuhl, 2004; Nelson, 1973). Yet is the developmental trajectory of comprehension and production vocabulary correlated with maternal acoustic input? Using a longitudinal study, we attempted to identify the characteristics of infant-directed-speech that, combined, are the strongest predictors of infant comprehension (i.e., understanding) and production (i.e., saying) of spatial vocabulary.

General Language Development and Milestones

Infants' language abilities increase dramatically during the first two years of life (e.g., Nelson, 1973; Benedict, 1977; Goldfiled & Reznick, 1990). The progression from emitting prelinguistic vocalizations (e.g., crying, cooing) to understanding and producing speech is viewed as a developmental milestone that caregivers anticipate and encourage. For newborns, crying is an effective mode of verbal expression and communication. By 2 months, cooing becomes a way to express happiness and excitement. From 6 to 12 months, infants become proficient in babbling; they are able to combine consonant and vowel sounds as well as use rising and falling patterns of intonation (e.g., Stoel-Gammon, 2002; Nelson, 1973). By 8 months, they are beginning to understand language and their receptive vocabulary consists of approximately 20 words (Fenson et al., 1994). Although they are not yet producing linguistic vocalizations, infants are beginning to understand language and can respond to simple commands and questions.

Finally, around 11 to 13 months, infants speak their first word (e.g., mama, dada; e.g., Fenson et al., 1994). Initially, language production is slow and it takes 3 to 4 months to acquire a productive vocabulary of 10-30 words (e.g., Fenson et al., 1994; Nelson, 1973). However, by 18 months, infants are producing approximately 50 words (Nelson, 1973; Goldfiled & Reznick, 1990). At 24 months, the typically developing infant can produce between 200 and 500 words (Fenson et al., 1994).

The developmental picture painted above provides a general overview of language development and, on the surface, appears complete. However, an important aspect of language development is missing – that of word category or class (e.g., noun, spatial location). Approximately 65% of the words acquired during the first two years of life are nouns, while 2% of the words refer to space and location (Nelson, 1973).

Nouns are generally tangible objects (e.g., ball) that infants can see and touch, and noun acquisition requires infants to focus on one object at time. In contrast, the acquisition of word categories (e.g., spatial categories) that require infants to evaluate the relationships among objects (e.g., ball *on* the table), and thus focus on more than one object, is not so easily outlined. Nor does the developmental trajectory increase as rapidly as that of nouns.

Spatial Vocabulary Development

Unlike nouns, comprehension and production of spatial vocabulary occurs slowly. Although habituation studies indicate that infants as young as 3 months old can visually discriminate between different spatial relationships (e.g., above vs. below, in vs. on; e.g., Quinn, 1994; Quinn et al., 1996; Casasola & Cohen, 2002), it is not until 15 months of age that infants actually understand spatial vocabulary and can reliability look at a particular relationship when asked to do so (e.g., hearing the word *on* and looking at the ball *on* the table, as opposed to looking at the ball *under* the table; Meints, Plunkett, & Harris, 2002). In addition, 50% of infants do not produce their first spatial word until they are around 17 months old (Fenson et al., 1994; Tomasello, 1987; for evidence of earlier spatial word production, occurring between 14 and 16 months, see e.g., Choi & Bowerman, 1991). In, on, and under are among the first spatial words understood and produced (Meints, Plunkett, & Harris, 2002).

Infant-Directed Speech

Prosody (i.e., acoustic variations in pitch, intonation, stress patterns, and rate of speech) is a salient communicative feature (e.g., Frick, 1985; Fernald, 1989; Fernald et al., 1989) that aids in language acquisition (e.g., Fisher & Tokura, 1996; Thiessen, Hill, & Saffran, 2005; Morgan, Meier, & Newport, 1987). When communicating with infants, adults do not rely solely on language. Instead, they can effectively use the acoustic properties of infant-directed speech (IDS) to help convey meaning (Fernald, 1989; Katz, Cohn, & Moore, 1996) and regulate infant behavior (Friend, 2001). The use of IDS also serves to boost infants' comprehension (Fernald, 1989) and segmentation of language (Thiessen, Hill, & Saffran, 2005; Segal, Nir-Sagiv, Kishon-Rabin, & Ravid, 2009). Whether a mother is soothing her infant or trying to get his attention, the acoustic properties of her speech are much more exaggerated than those she would use when speaking to an adult.

It has long been shown that adults modify their speech patterns when talking to infants (Ferguson, 1964; Jacobson, Boersma, Fields, & Olson, 1983; Papousek, Papousek, & Bornstein, 1985). Speech directed toward infants and very young children is often referred to as infant-directed speech. Compared to adult-directed speech (ADS), infant-directed speech (IDS) is characterized by exaggerated modulation of fundamental frequency, a slower rate of speech, and simpler speech. Not only do these prosodic characteristics of infant-directed speech serve to organize infants' attention and facilitate associative learning (Kaplan et al., 1996), they are important for communicating emotional messages (Fernald, 1989; Fernald, 1992).

Cooper and Aslin (1990) showed that infants as young as one month old prefer IDS to ADS (also see Fernald, 1985). Furthermore, the prosodic information of IDS, without linguistic content, is more informative than non-linguistic ADS; even adult listeners are better able to judge a speaker's intent when the information is presented in IDS (Fernald, 1989). Evidence that non-linguistic information influences infant behavior also exists. For example, the visual behavior of four-month-old infants, who are not expected to process linguistic information, is influenced by the presentation of approving vs. disapproving contours. Infants looked longer at a face while listening to approving speech, while disapproving speech inhibited infant looking (Papoušek et al., 1990). IDS provides cues that draw infant attention to specific information that the speaker is trying to convey. These results suggest that prosodic cues serve to focus infant attention and promote learning. As a result, IDS during infant-caregiver interactions should be a strong motivator of infant language development.

The Current Study

Given that tone, intonation, and affect can be powerful tools for communicating with both preverbal and verbal infants (Papousek, Papousek, & Haekel, 1987), the facilitative effects of IDS should also promote spatial vocabulary development. While previous studies have focused on IDS and spatial vocabulary development in isolation, the current study is an analysis of how maternal prosodic speech characteristics (i.e., fundamental frequency, utterance duration, and amount of linguistic input) contribute to the development of spatial vocabulary. The goal was to determine whether IDS can be used to create a regression model that predicts spatial vocabulary development. Specifically, what characteristics of IDS are the strongest predictors of the comprehension (i.e., understanding) and production (i.e., saying) of spatial words? Given that age and the increases in cognitive development that accompany biological maturation contribute significantly to infants' ability to acquire language, age was also included in the analyses.

Method

Participants

Four children (2 males, 2 females) from monolingual, English-speaking homes and their mothers were visited at home every six weeks for a total of twelve visits (i.e., each family was followed for approximately 1.5 years). Surveys of infants' spatial vocabulary development and mothers' vocal interactions began when the infants were 10 months old (M = 10, SD = .24) and ended when the infants were 27 months old (M =25.6, SD = .33). Due to scheduling conflicts, both acoustic and vocabulary data for Visit 6 was missing for one dyad. Visit 6 vocabulary data for a second infant was also missing; Visit 6 acoustic data for that infant was available.

Infants were recruited through a letter given to caregivers at the time of the infant's birth. Caregivers interested in participating in studies on infant learning and development were added to a database. These parents were sent a second letter when their infants were approximately 9.5 months old, followed by a telephone call to schedule an appointment. Caregivers were informed that they would be participating in a longitudinal study and that researchers would be visiting their homes to videotape them and their infants. At the end of each visit, infants received a book in appreciation for their participation.

Procedure

During each visit, mothers played with their infants for 20 minutes using toys provided by the researcher. The toys (e.g., blocks, nesting cups, stacking rings; Figure 10) were specifically chosen such that they elicited the use of spatial prepositions, particularly *in* and *on*. The toys were organized into bags with each bag containing three different toys (e.g., nesting cups, Lego blocks, and a magnet board with magnets). Every 5 minutes, participants were given a new bag of toys to play with, which resulted in the dyads playing with four different bags of toys over the course of 20 minutes. After the researcher took the toys out of the bag and placed them on the floor in front of the mother and infant, she explained that the mother should play as she normally would at home. Mothers were also asked to play with each type of toy at least once during the 5 minutes. The presentation order of the bags was counterbalanced across participants and visits.

Figure 10. Examples of toys provided during play sessions.

Apparatus

Each session was videotaped so that mother's speech could be subsequently analyzed using Raven Pro Sound Analysis Software 1.4 (Cornell Lab of Ornithology Bioacoustics Research Program, www.birds.cornell.edu/raven, 2010; Charif, Waack, & Strickman, 2010). The visits were filmed in a comfortable, quiet, well-lit room in the participants' house, which helped ensure the capture of good audio and video recordings. Additionally, to limit additional sounds that would interfere with the audio recordings, each mother was informed that only she, her infant, and the researcher should be in the room during the visits. To assess changes in infant vocabulary, mothers completed the MacArthur-Bates Communicative Development Inventory

(CDI; Fenson et al., 1993) at the beginning of every visit. This study specifically focused on spatial vocabulary (i.e., prepositions and place words; e.g., in, outside, under, bottom, side). Infants' comprehension and production of 37 spatial words (Table 25) was recorded.

Table 25

Spatial Vocabulary List

Above	Next to
Apart	Off
Around	On
Away	(On the) edge
Back	Out
Behind	Outside
Below	Over
Beside	Side
Between	Through
Bottom	To
Down	Together
Fit	Top (on top of)
Front	Under
Here	Underneath
In	Underside
In back of	Up
In front of	Upside down
In the middle of	Where
Inside	

Coding

Raven Pro Sound Analysis Software 1.4 (Cornell Lab of Ornithology Bioacoustics Research Program, 2010) was used to transcribe and analyze the acoustics of maternal speech. Using Raven, coders listened to the video recordings, viewed spectrograms of the speech, and segmented, transcribed, and analyzed maternal utterances. An utterance was defined as a word or sequence of words preceded and followed by a pause or a change in speaker. Coders used both auditory and visual information (i.e., spectrograms) to determine pauses and utterance boundaries.

The following prosodic and descriptive measurements were taken: maximum fundamental frequency (Hz), median fundamental frequency (Hz), first quartile fundamental frequency (Hz) (Q1 frequency; a measure of the lowest 25% of energy in the utterance), third quartile fundamental frequency (Hz) (Q3 frequency; a measure of the highest 75% of energy in the utterance), interquartile fundamental frequency range (Hz) (fundamental frequency range; interquartile fundamental frequency range is a measure of the range of the middle 50% of the data and as a result it is not affected by outliers and extreme frequency values; it is the difference between Q3 and Q1; see e.g., Sprinthall, 2011; Charif, Waack, & Strickman, 2010 for a detailed explanation of quartiles and interquartile range), utterance duration (s), mean length of utterance (MLU; i.e., a measure of speech complexity that is calculated by counting the number of morphemes in an utterance), total number of utterances, and percentage of visit time spent talking. Percentage of time spent talking was calculated by summing the duration of all of the maternal utterances during a visit, dividing the sum by the length of the visit, and multiplying by 100 (e.g., 5 total minutes of talking/20 minute visit*100 = 25%). Only maternal speech directed at the infant was coded. Maternal utterances directed at the researcher, laughs, unintelligible utterances, and infant babbling were excluded from the analyses. In total, 17,625 maternal utterances were analyzed (i.e., data for all infants, and all visits, was combined into one data set).

Results

The development of spatial vocabulary was analyzed using one-way analyses of variance (ANOVAs). To investigate spatial vocabulary development over the course of the 12 visits, the affect of visit number (i.e., age) on comprehension and production was analyzed. An examination of the development of child spatial vocabulary revealed that both comprehension, $F(11, 34) = 4.16$, $p = .001$) and production, $F(11, 36) = 4.16$, $p = .001$) significantly increased from 10 months to 27 months (Figure 11). One-way between subjects ANOVAs comparing differences in vocabulary development between the four infant participants indicated that there were between group differences (i.e., individual differences) in both comprehension, $F(3, 42) = 6.03$, $p = .002$ and production, $F(3, 44) = 4.07$, $p = .012$ (Figure 12, Figure 13, Figure 14, and Figure 15). In the subsequent analyses, the male infants are referred to as Infant 1 and Infant 3 and the female infants are referred to as Infant 2 and Infant 4.

Post-hoc Tukey HSD tests showed comprehension for Infant 2 (female) was significantly different from all of the other infants ($p < 0.05$; Figure 12 and Figure 13). From Visit 2 to Visit 11, Infant 2 had a higher vocabulary than the other infants. The lowest vocabulary difference occurred at Visit 2 with a 13.5% difference between Infant 2 and Infant 4 (female). By Visit 12, Infant 2 and Infant 1 (male) both had spatial comprehension vocabularies of 100% on the CDI.

For production of spatial vocabulary, there was a significant difference between Infant 2 and Infant 4 ($p = .007$; Figure 14 and Figure 15). At Visit 5, Infant 2 began producing more words than Infant 4, a trend that continued for the remainder of the study. At Visit 12, Infant 2 had a production vocabulary of 100% and Infant 4 had a production vocabulary of 29.7%.

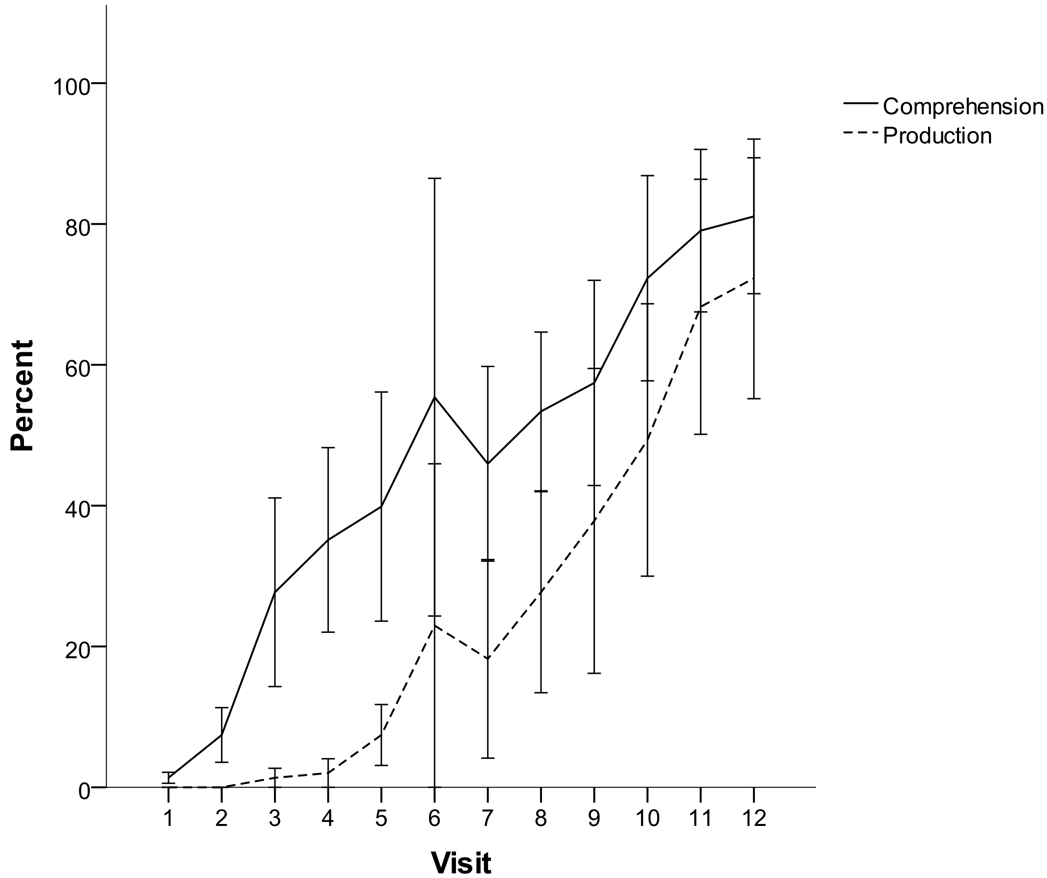

Figure 11. Comprehension and production of spatial vocabulary from Visit 1 (10 months) to Visit 12 (27 months). The spikes (i.e., sudden increases) at Visit 6 are due to missing data for two infants.

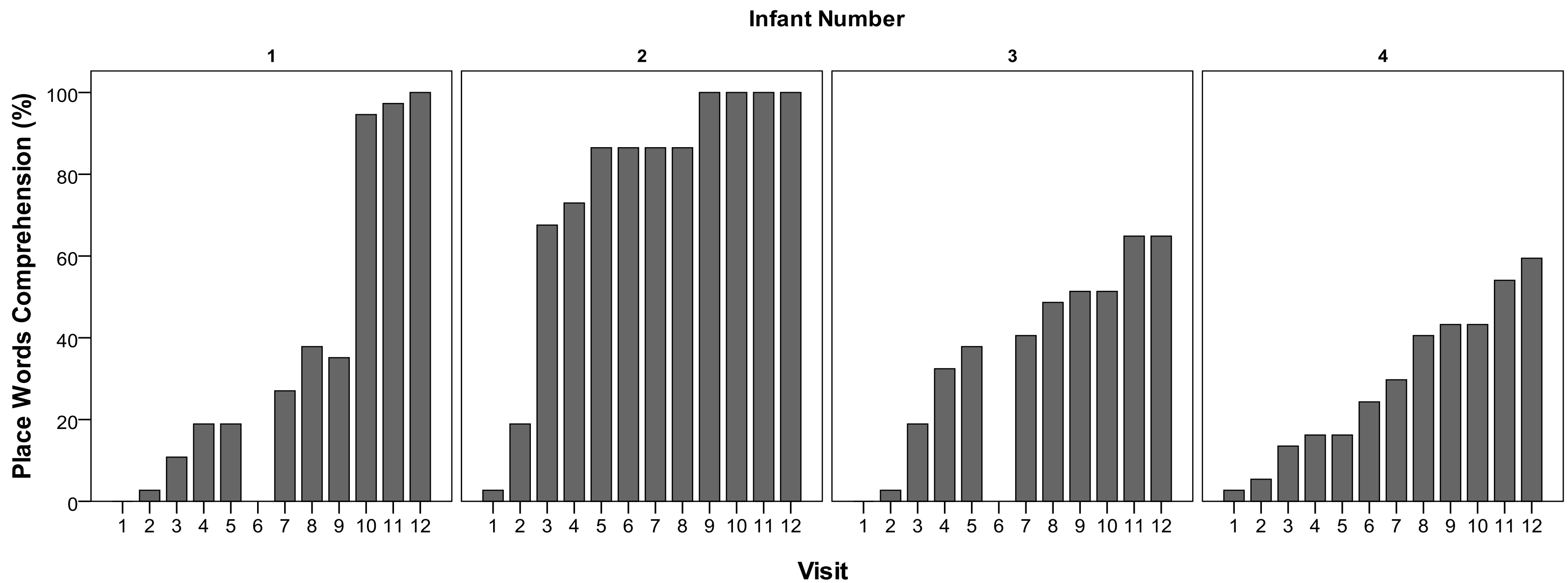

Figure 12. Percentage of place words comprehended by infants 1, 2, 3, and 4 from Visit 1 to Visit 12. From Visit 2 to Visit 11, Infant 2 comprehended significantly more spatial words than the other infants ($p < 0.05$).

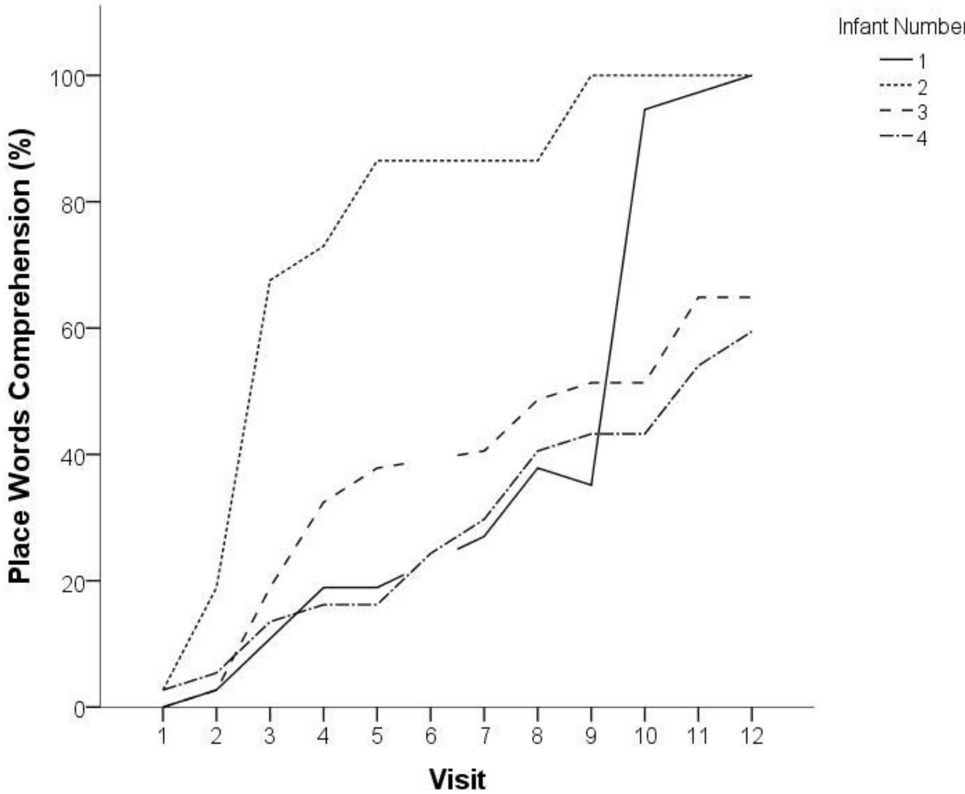

Figure 13. Percentage of place words comprehended by infants 1, 2, 3, and 4 from Visit 1 to Visit 12. From Visit 2 to Visit 11, Infant 2 comprehended more spatial words than the other infants ($p < 0.05$).

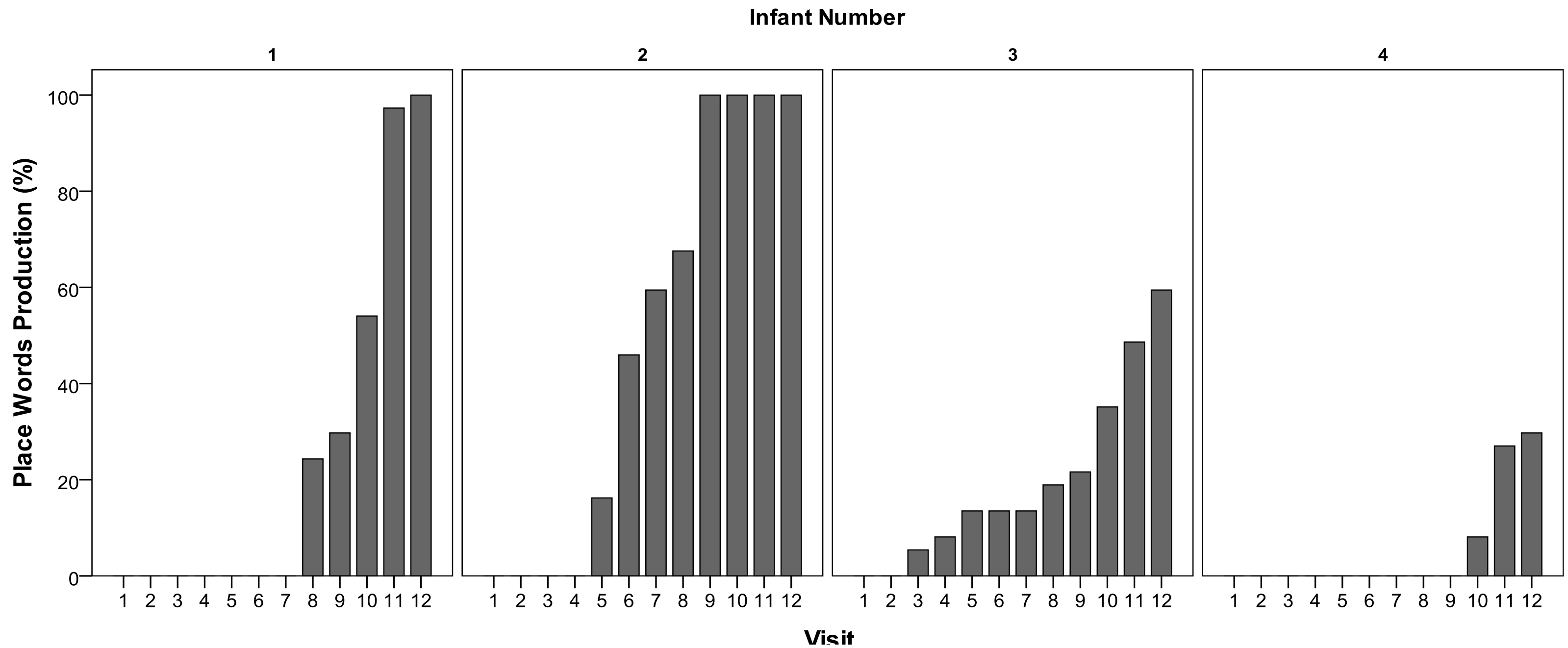

Figure 14. Percentage of place words produced by infants 1, 2, 3, and 4 from Visit 1 to Visit 12. There was a significant difference between Infant 2 and Infant 4 (both female, p = .007).

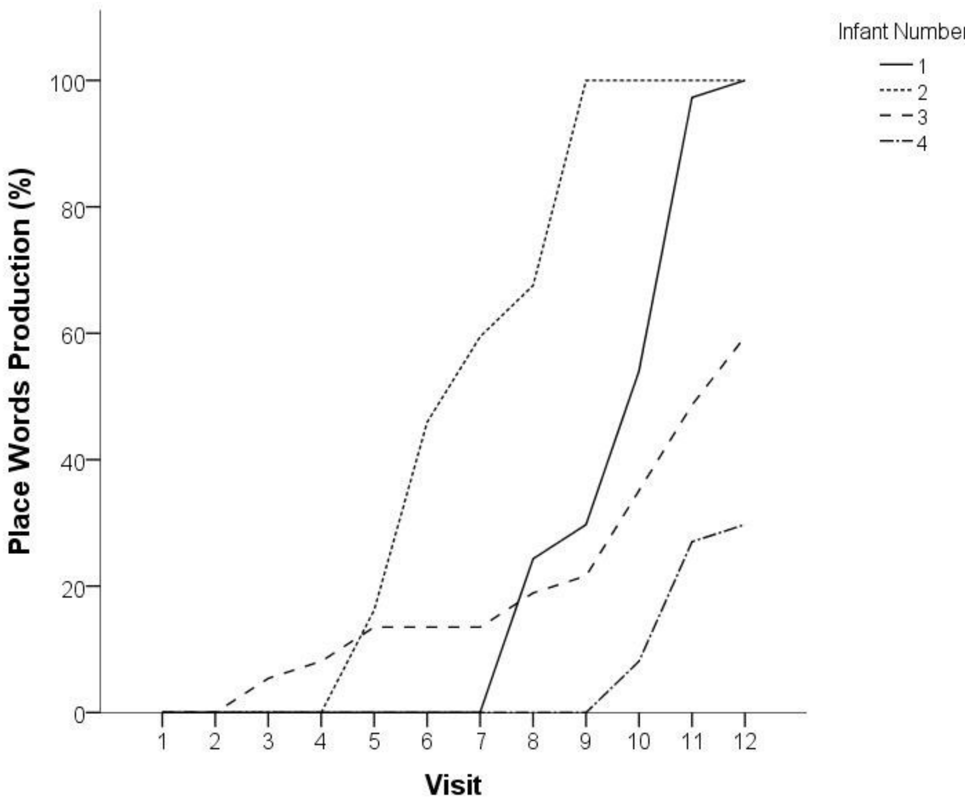

Figure 15. Percentage of place words produced by infants 1, 2, 3, and 4 from Visit 1 to Visit 12. There was a significant difference between Infant 2 and Infant 4 (p = .007).

Acoustic and Speech Analysis

All of the acoustic properties of maternal speech varied significantly from Visit 1 to Visit 12. Maximum fundamental frequency (Hz), median fundamental frequency (Hz), first quartile fundamental frequency (Hz), third quartile fundamental frequency (Hz), and fundamental frequency range (Hz) significantly increased from Visit 1 to Visit 12 (all $p < .0001$; Table 26; Figure 16, Figure 17, and Figure 18). Given that all measures of fundamental frequency were highly correlated (Pearson correlation coefficient ranged from $r(47) = .39$ to $r(47) = .98$, all $p < .01$), only fundamental frequency range was used in subsequent analyses. Additionally, fundamental frequency range was selected because the modulation of fundamental frequency is the key element that attracts and maintains infant attention (Fernald, 1985). It is the difference between the highest and the lowest frequency that is most salient to infants. Thus, frequency range is the measure that most exemplifies the fundamental frequency of IDS and it is the measure that was used to create regression models of spatial comprehension and production.

An ANOVA revealed that utterance duration ($F(11, 17613) = 26.67$, $p < .0001$), MLU ($F(11, 17613) = 16.54$, $p < .0001$), and total number of utterances ($F(11, 17613) = 395.54$, $p < .0001$) differed significantly from Visit 1 to Visit 12 (Table 26, Figure 19, Figure 20, and Figure 21). Percentage of visit time spent talking was not significantly different across visits ($F(11, 35) = .91$, $p = .54$; Figure 22). However, percentage of visit time spent talking was significantly different across infants, $F(3,43) = 13.63$, $p < .0001$; the mother of Infant 1 spoke less than the mothers of Infants 2, 3, and 4 (Tukey HSD all $p < .01$; Figure 23). Because total number of utterances was highly correlated with percentage of time spent talking (Pearson correlation coefficient $r(47) = .49$, $p = .001$), it was excluded from further analyses. Furthermore, number of utterances is a broad measure of input, but by virtue of it being a count variable, it does not include information that would indicate the length of time spent talking. A mother who produces more utterances may not spend more time talking to her infant. For example, "Ball!" and "Look at the ball!" both count as one utterance. Yet it takes longer to say the second utterance. For the purpose of creating a model, percentage of time talking and mean length of utterance are more accurate measures of maternal linguistic input.

Table 26

Analysis of Variance for Acoustic and Speech Properties of Maternal Speech for Visit1 to Visit 12

		df	F
Maximum Frequency (Hz)**	Between Groups	11	57.11
	Within Groups	17613	
	Total	17624	
Median Frequency (Hz)**	Between Groups	11	124.61
	Within Groups	17613	
	Total	17624	
Q1 Frequency (Hz)**	Between Groups	11	109.06
	Within Groups	17613	
	Total	17624	
Q3 Frequency (Hz)**	Between Groups	11	110.03
	Within Groups	17613	
	Total	17624	
Frequency Range (Hz)**	Between Groups	11	18.57
	Within Groups	17613	
	Total	17624	
Utterance Duration (s)**	Between Groups	11	26.67
	Within Groups	17613	
	Total	17624	
Mean Length of Utterance**	Between Groups	11	16.54
	Within Groups	17613	
	Total	17624	
Total Utterances**	Between Groups	11	395.54
	Within Groups	17613	
	Total	17624	

**$p < .0001$

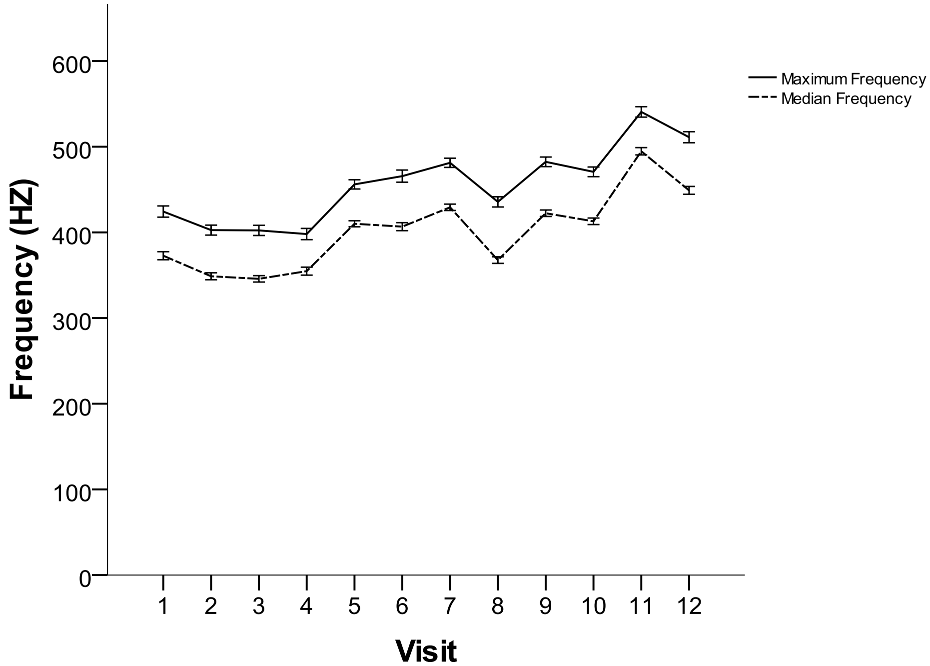

Figure 16. Maximum and median frequency of maternal utterances from Visit 1 to Visit 12.

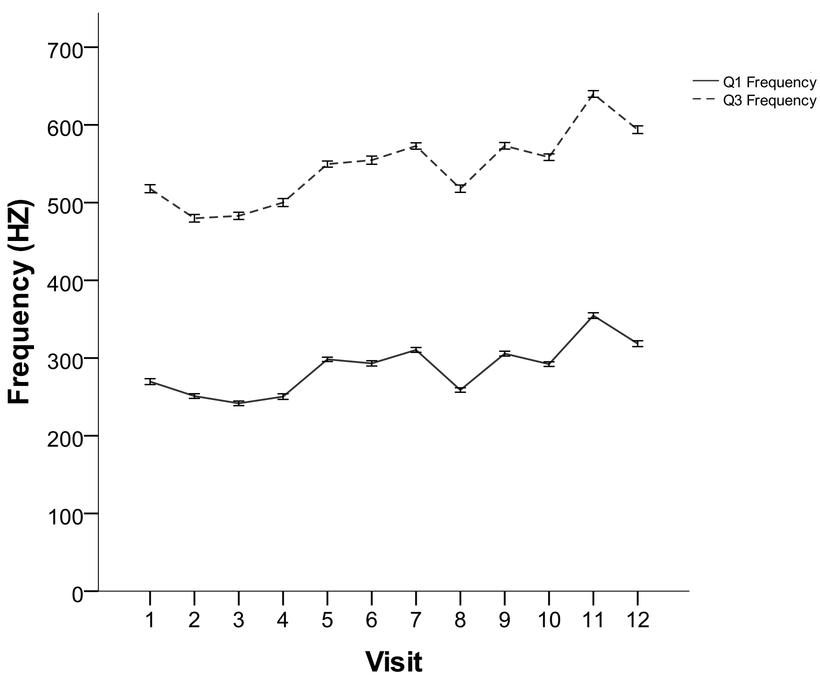

Figure 17. First quartile (Q1) and third quartile (Q3) frequency of maternal utterances from Visit 1 to Visit 12.

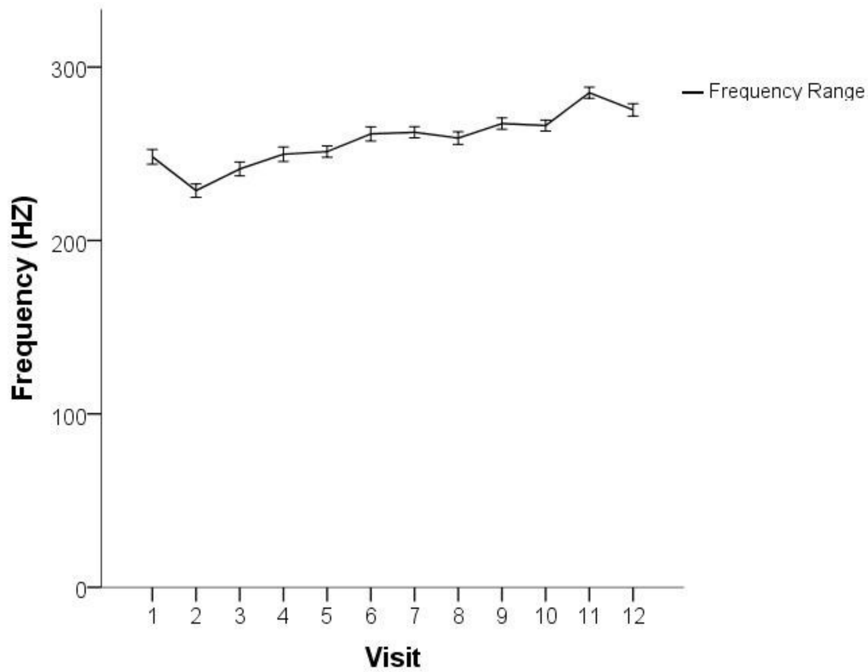

Figure 18. Frequency range of maternal utterances from Visit 1 to Visit 12.

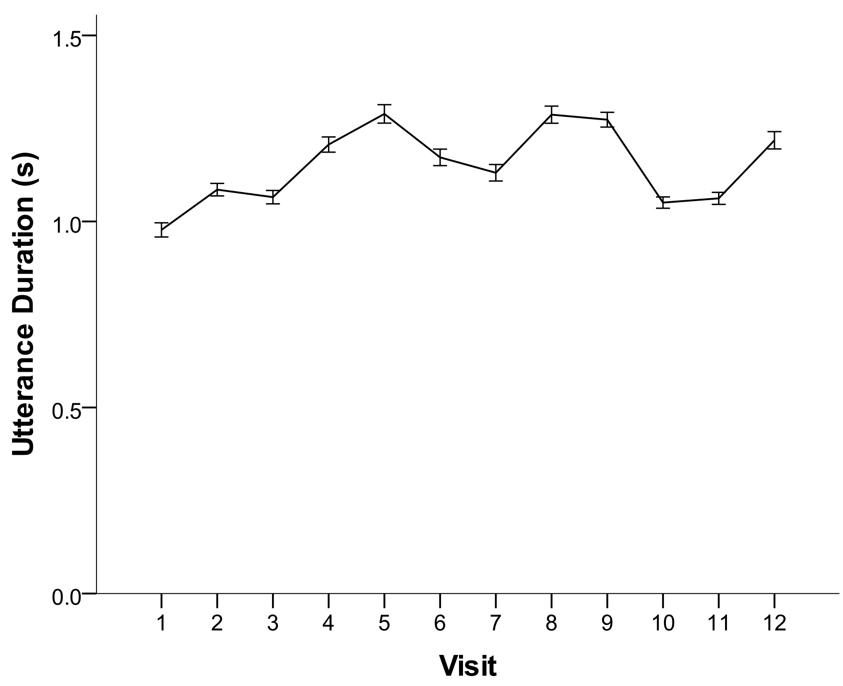

Figure 19. Utterance duration of maternal utterances for Visit 1 to Visit 12.

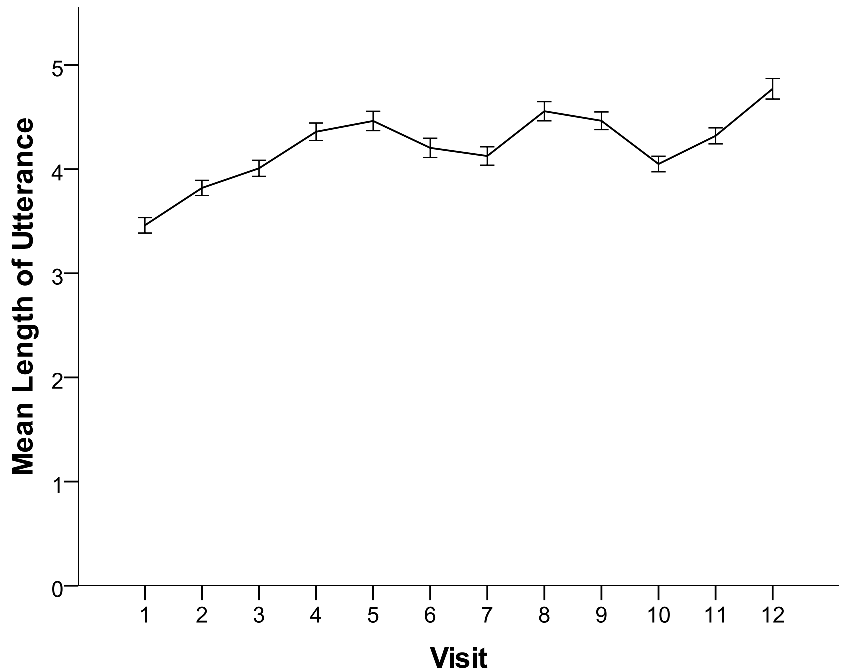

Figure 20. Mean length of utterance (MLU) of maternal utterances for Visit 1 to Visit 12.

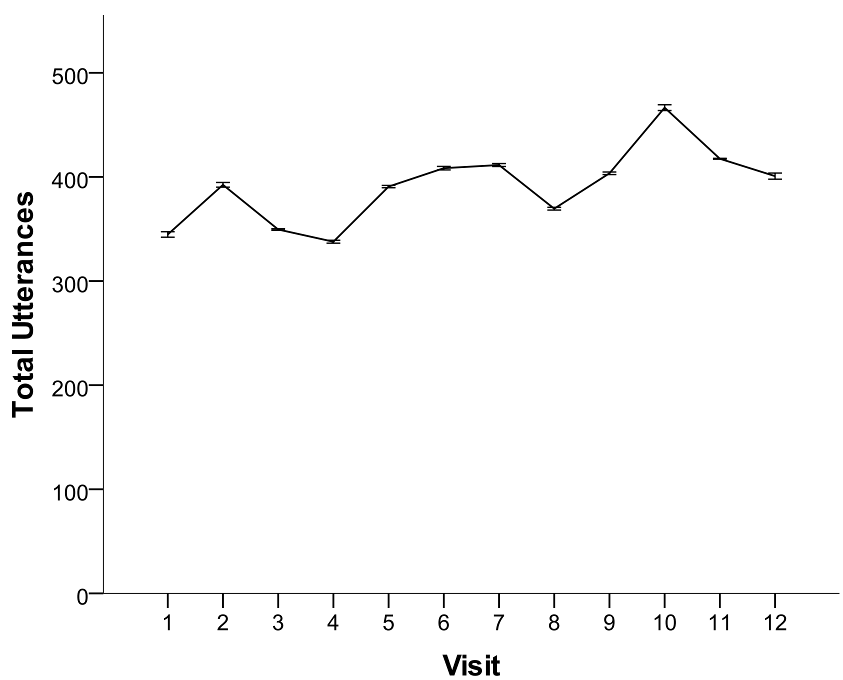

Figure 21. Total number of maternal utterances for Visit 1 to Visit 12.

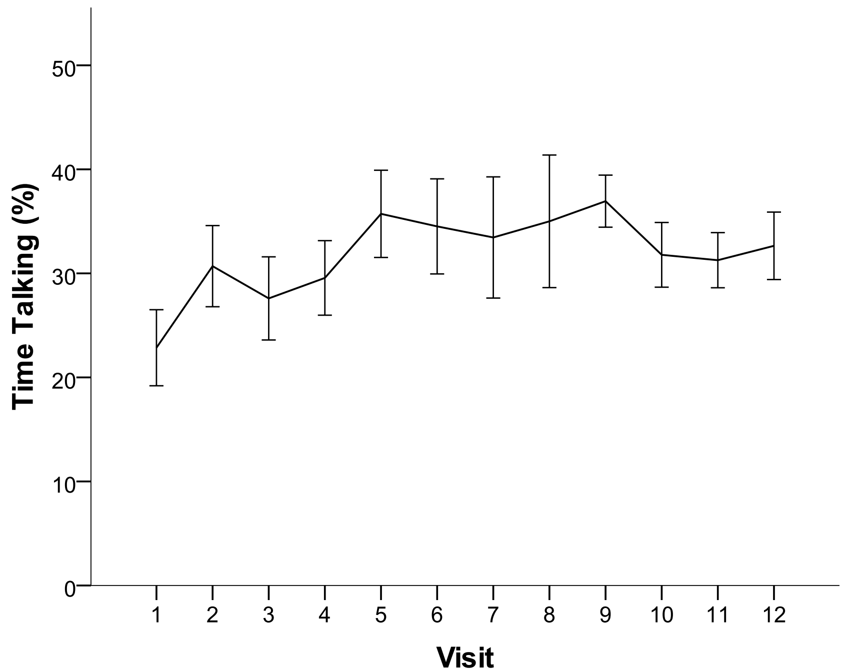

Figure 22. Percentage of time mothers spent talking for Visit 1 to Visit 12.

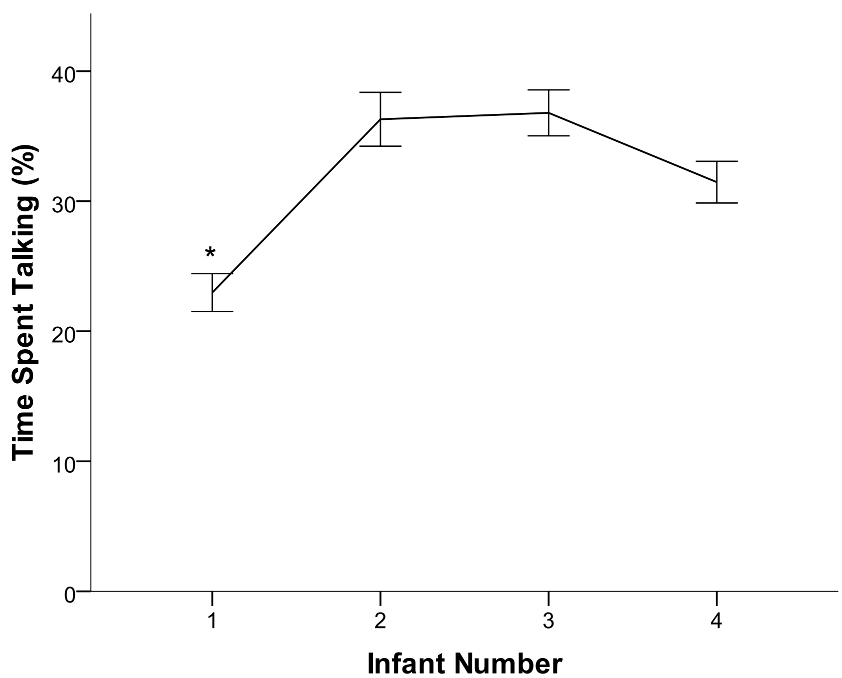

Figure 23. Percentage of visit time spent mothers spent talking. The mother of Infant 1 spoke significantly less than the mothers of Infants 2, 3, and 4 ($p < .01$).

Regression Models of Spatial Comprehension and Production

After accounting for correlation and variable appropriateness, infant age (in months), MLU, frequency range, utterance duration, and percentage of time talking remained as the variables of interest to include in the regression models. To account for individual differences and repeated measurements taken at each visit, and correct for standard error, repeated measures generalized linear mixed model (GLMM; SPSS Inc., 2005, 2010) regression analyses were conducted. The participant identification variable, infant number, was accounted for in the model as a random effect (i.e., individual, infant specific differences). All other variables were analyzed as fixed effects.

From these analyses, two linear regression models emerged: one for spatial comprehension and one for spatial production (Table 27 and Table 28). Of all the variables analyzed, infant age, MLU, and frequency range were the best predictors of spatial vocabulary comprehension; utterance duration and percentage of time spent talking were not good predictors of comprehension ($p > .05$). Infant age, MLU, frequency range, and utterance duration were the best predictors of spatial production; time talking was not a good predictor of production ($p > .05$).

The results indicate that increases in age, more complex speech (i.e., MLU), and greater frequency range result in greater comprehension. The significance of MLU, and the non-significance of time talking, indicates that when time talking is compared to speech complexity, complexity is a better predictor variable. For example, when MLU was removed from the model, time talking became a significant predictor ($p < .05$) of comprehension, which would be expected considering that children with more verbal parents have higher vocabularies (e.g., Hart & Risley, 1995). However, its significance was greatly reduced (p = .36) when MLU was included in the model.

Table 27

Linear Regression Analysis for Spatial Comprehension with 95% Confidence Intervals

Variable	B	Std. Error	Beta	*t*	*p*	95% CI for B
Constant**	-111.17	11.95		-9.30	.000	-135.32, -87.01
Age (Months)**	3.65	0.39	0.54	9.43	.000	2.87, 4.44
MLU**	20.64	5.68	0.55	3.64	.001	9.17, 32.12
Frequency Range**	0.11	0.02	0.12	4.87	.000	0.07, 0.16
Utterance Duration	-29.10	16.96	-0.24	-1.72	.094	-63.38, 5.19
Time Talking	0.17	0.18	0.04	0.93	.357	-0.20, 0.53

**$p \leq .001$

Table 28

Linear Regression Analysis for Spatial Production with 95% Confidence Intervals

Variable	B	Std. Error	Beta	*t*	*p*	95% CI for B
Constant*	-69.71	29.05		-2.40	.021	-128.37, -11.05
Age (Months)**	5.10	0.60	0.73	8.49	.000	3.89, 6.32
MLU**	41.67	6.96	1.08	5.99	.000	27.62, 55.72
Frequency Range*	-0.25	0.08	-0.25	-3.17	.003	-0.41, -0.09
Utterance Duration**	-94.06	21.47	-0.75	-4.38	.000	-137.43, -50.70
Time Talking	-0.19	0.38	-0.04	-0.50	.622	-.95, 0.57

**$p < .001$
*$p < .05$

Additionally, it is important to note that although utterance duration was not a significant predictor of comprehension, the negative coefficient for utterance duration suggests that longer maternal utterances would result in a decrease in vocabulary comprehension. The model fits what is currently known about infant-directed speech and infant language comprehension in that short utterances with varying frequency attract infant attention and aid in language processing. The information added by the model is that adding grammatical complexity to these short, melodic sentences as the infant ages is beneficial for learning spatial vocabulary.

Similarly, in the vocabulary production regression model, MLU was a significant factor and utterance duration was both negative and significant. The significance of utterance duration is a clear indicator that short, complex utterances also support the production of spatial vocabulary. The models differed, however, in their interpretation of frequency range. For vocabulary production, the frequency range coefficient was negative, which means less variation in pitch aids vocabulary production. The difference in the function of frequency range for comprehension and production can probably be attributed to the trade-off that occurs between rate of speech and frequency range. For example, speaking very quickly usually results in a reduction in frequency range (see e.g., Fougeron & Jun, 1998). Thus, a larger frequency range would lead to slower speech.

As mentioned previously, slower speech is good for comprehension. Yet for production, infant attention to external maternal prosodic cues is not compulsory. Instead, production is dependent upon the infant’s ability to say the word. As a result, the trend is reversed and the negative value of the coefficient may simply be an indicator that, although frequency range is beneficial for vocabulary development in general, it is not the most important factor for spatial vocabulary production. Overall, an increase in age, more complex speech, less variation in frequency, and shorter utterances result in greater production. Essentially, caregivers should decrease their attention getting behaviors and allow their infants time to talk.

Discussion

Although previous research indicates that the exaggerated characteristics of maternal IDS, particularly fundamental frequency, decline as infant age increases (e.g., Amano, Nakatani, & Kondo, 2006; Stern, Spieker, Barnett, & MacKain,1983), the results of this study show that this is not necessarily the case. For all of the fundamental frequency measures, there was an increasing trend in fundamental frequency over the course of a year and a half. The consistent and significant increase in frequency is surprising. However, this developmental trajectory of maternal speech may have a facilitative effect that is linked to children's vocabulary development.

One way to explain this phenomenon is to focus on the situation in which spatial vocabulary learning occurred. For example, the study was specifically designed so that we could monitor spatial interactions – all of the toys promoted spatial play. Also, by encouraging mothers to interact with their infants, in addition to requiring them to complete a vocabulary checklist at each visit, we may have created a situation in which mothers were using visits as a time to teach their infants about spatial relationships. As a result, as infants learned new words and underwent the vocabulary spurt that occurs in the first two years of life, mothers increased their fundamental frequency in an attempt to focus infant attention and facilitate language learning. Spatial words are difficult for infants to learn, and mothers may have been using increased fundamental frequency to reinforce concepts that infants do not readily grasp. It is possible that when infant language learning is at its peak, fundamental frequency is also at its peak because mothers are using the exaggerated properties of IDS at a time when infants are most likely to benefit in terms of spatial vocabulary development.

A second explanation regarding the increasing fundamental frequency trend centers around the infant. Research by Cooper and Aslin (1994) suggests that infants' preference for the exaggerated acoustic properties of IDS is developmental and dependent on interactive experiences with caregivers. Is it possible that when infants are learning spatial vocabulary, they show an increased preference for IDS? In this case, the infants' preference for IDS creates a bi-directional effect in which mothers reinforce the preference by increasing the fundamental frequency of their speech. Infants' increasing preference for IDS while learning spatial vocabulary results in mothers modulating their speech to facilitate learning. Of particular interest is whether this trend continues beyond 27 months. Further investigation of the IDS preferences of older infants during spatial vocabulary learning tasks is needed before we can thoroughly explore these hypotheses.

Two Models of Spatial Vocabulary Development

The models of spatial vocabulary development indicate that different factors of IDS account for comprehension and production. As expected, infant age and fundamental frequency range were both important variables for modeling spatial vocabulary development. However, proportion of time that mothers spent talking was only a good predictor of spatial word comprehension when MLU was not included in the model. The importance of MLU can be explained in two ways. First, because MLU is a count of the number of morphemes in an utterance, it can be used as an approximate calculation of amount of time spent talking (i.e., more morphemes generally correspond to longer utterances). Second, more advanced infant-directed and child-directed maternal speech has been shown to enhance children's vocabulary (see e.g., Rowe, 2007; Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991). Combined, these two explanations provide evidence that MLU is a more multifarious measure of maternal speech input. MLU is two-dimensional; while time spent talking is a rich, but less advanced, measure of speech input. Whenever possible, both MLU and time spent talking should be included as important factors in studies regarding infant-caregiver interactions and infant vocabulary development.

Additionally, while the duration of maternal utterances was a good predictor of spatial word production, it was not the best predictor of comprehension. Given that comprehension precedes production, it makes sense that the models would not be identical. Identical models would imply that comprehension and production have similar developmental trajectories. If that were the case, there would not be a delay between when infants understand a word and when they are able to say that word.

Comprehension is a measure of infants' receptive vocabulary. And in order for infants to understand language, they must first have some experience with that language. When mothers talk to their infants, they are providing the input that infants need to learn language; in this case, spatial language. Thus, more linguistic input during a spatially geared interaction results in better spatial comprehension.

Production on the other hand requires that infants have time to respond to their mothers and practice their vocalizations. Utterances with the longest durations tended to be more representative of conversations. For example, they consisted of questions (e.g., Can you push the pink block through?) and suggestions (e.g., Here, let's try putting the bear at the bottom.), which imply that the mother wanted her infant to respond in some way. Because mothers are waiting for a response, this conversational aspect of the interaction may give infants time to practice speaking. Similarly, longer maternal utterances would necessitate longer pauses (i.e., the mother needs time to catch her breath before producing the next utterance). If this is the case, then it is actually the pauses between utterances that drive the production of spatial vocabulary, and utterance duration is instead a proxy for pause duration. We did not measure pause duration between utterances, yet given that infants need opportunities to demonstrate their ability to produce spatial vocabulary, it is likely that pauses are an important aspect of vocabulary production.

Overall, the models show that fundamental frequency range and age are not the only variables that drive spatial vocabulary development. Comprehension and production are not simply by-products of biological maturation, nor are they solely influenced by fundamental frequency. Instead, there are other factors of maternal linguistic input that facilitate vocabulary development and increase infants' cognitive abilities.

Comparison to General Vocabulary Development

In terms of language development in general, the results for language comprehension mirror what has been found in previous studies. Comprehension increases with age and there is evidence that infants comprehend their first words between 8 and 10 months (see e.g., Fenson et al., 1994). The results of the current study are similar in that all four infants comprehended at least one spatial word by

Visit 2. More specifically, by Visit 1, Infant 2 (9.93 months) and Infant 4 (10.23 months) comprehended their first spatial words. By Visit 2, Infant 1 (11.9 months) and Infant 3 (11.54 months) comprehended their first spatial words. The mean age for comprehension of the first spatial word was 10.9 months, similar to the age of onset for language comprehension.

For production, however, although the number of words produced increased with age, the onset of spatial production occurred later than general vocabulary production. Research by Fenson et al. (1994, 2000) and Bates et al. (1994) regarding infant vocabulary growth and the study of the developmental composition of early vocabulary revealed that there is a significant positive correlation between age and production. Most children produce very few words between 8 and 11 months of age and, after 12 months, there is a rapid increase in production. In contrast, infants in the current study produced their first spatial words at Visit 3 (Infant 3, 13.28 months), Visit 5 (Infant 2, 15.81 months), Visit 8 (Infant 1, 20.71 months), and Visit 10 (Infant 4, 22.45 months). The mean age for production of the first spatial word was 18.08 months, approximately 6 months later than when 50% of children produce their first words (Fenson et al., 1994).

Although, the delay in spatial word production seems large, it is not unusual and has been documented in previous studies (see e.g., Tomasello, 1987). The results indicate that even when mothers are aware of the purpose of a spatially focused study and infants have some knowledge of spatial words, spatial word production remains difficult. Detailed analyses of both infant and caregiver vocalizations, pause length during conversations, and infant-caregiver turn-taking as they relate to spatial vocabulary development during a spatial learning task would enhance our knowledge of the mechanisms that influence spatial vocabulary comprehension and production. Moreover, we can use our knowledge of maternal input and infant-caregiver interactions to develop intervention programs for infants who are at-risk for vocabulary development delays.

Chapter 4: Study 3

Parent Education Program and Early Childhood Intervention

Studies with at-risk families have consistently shown that parental responsiveness affects children's development. In terms of familial interactions and communicative behaviors, researchers have consistently shown that, compared to children who are raised in families with higher socio-economic statuses, children in low-income households have fewer words spoken directly to them in their first year of life (Hart & Risley, 1995; Hoff, 2003). For example, in an observational, longitudinal study of parent-child verbal interactions, Hart and Risley (1995) showed that children in professional families heard an average of 2,153 words per hour, children in working class families heard an average of 1,251 words per hour, and children in welfare families heard an average of 616 words per hour. In a year, it is estimated that children in professional, working class, and welfare families heard, on average, 11 million, 6 million, and 3 million words, respectively. By age three, the observed cumulative vocabulary for children in professional families was about 1,100 words, 750 words for children from working families, and 500 words for children in welfare families.

By the time less advantaged children reach first grade, it is already apparent that they are behind their more privileged counterparts in terms of academic achievement (see e.g., Walker, Greenwood, Hart, & Carta, 1994; Bradley & Caldwell, 1984; Bradley, Caldwell, & Rock, 1988). Furthermore, having a low vocabulary often leads to low performance in school, low test scores, and high dropout rates. These results provide clear evidence that the way parents communicate with their children affects subsequent development. Why, then, are parents not providing their infants with the caregiver-infant interactions that are so important for infant development?

Studies that explore the relation between self-efficacy (i.e., a person's judgment of their own capabilities and their ability to deal with a specific challenge (Bandura, 1982)) and how mothers perceive their infants suggests that, compared to middle-class mothers, working-class mothers less frequently believe that their infants are capable of communicating with other people and therefore feel it is futile to attempt to interact with them verbally (Tulkan & Kagan, 1972). Furthermore, mothers who perceive themselves as has having lower self-efficacy may feel shut out of the child-caregiver interaction when their children do not respond as they expect (Raver & Leadbeater, 1999).

Maternal self-efficacy, however, is associated with multiple risk factors (e.g. amount of social support, stressful life events, child's temperament) (Raver & Leadbeater, 1999) and should not be considered the sole factor affecting child-caregiver relationships and communicative interaction. Moreover, the harmful physical, socioemotional, and cognitive affects that poverty has on children and their families are multi-causal; exposure to pollution, violence, and instability greatly impacts children's well-being (Evans, 2004). So what can parents who may not have the time, energy, or resources to constantly interact with their pre-verbal infants do to positively influence the development of their young children? How can we increase their parental responsiveness levels?

One solution is to create a parent training class that is simple, easy to teach, inexpensive, and effective for the parents of at-risk children. Parent education programs that have proven to be effective: 1) have program goals that are explicitly stated as measurable outcomes, 2) the length and intensity of the program is relative to the severity of the risk factor, 3) the program is family-focused, 4) are designed around important developmental milestones and transitions, 5) have a strength based (asset) model, 5) are designed to respect parental authority and appreciate individual differences, and 6) incorporate an ecological approach which acknowledges the influence of neighborhoods, schools, and employment (Colosi & Dunifon, 2003).

To show that enhanced stimulation by the primary caregiver affects infant habituation and enhanced responsiveness affects infant self-efficacy (i.e., exploratory behavior and ability to analyze contingencies), Riksen-Walraven (1978) designed a three-month, at-home intervention program. Caregivers and their 9-month-old infants were randomly assigned to the Control group or one of three intervention groups (Stimulation, Responsive, or Stimulation-Responsive); intervention groups received workbooks and the experimenter demonstrated some of the games in the book. The Stimulation book emphasized the importance of providing infants with perceptual experiences (e.g., visual, tactual-kinesthetic); caregivers were encouraged to speak to their infants, point to, and name objects. The Responsiveness book stressed that infants learn from the effects of their own behavior; caregivers were advised to praise their infants' efforts and allow them to find out things for themselves. The Stimulation-Responsiveness book was a combination of both books.

Pre/post program comparisons revealed that the Stimulation group habituated fastest to a presentation of colored slides. Responsive group infants: 1) exhibited more exploratory behaviors while playing with a novel cup, 2) in a pairs test, explored novel objects more than familiar ones, and 3) in an operant conditioning contingency test (i.e. infants pressed a button to make colored slides appear), significantly more infants learned to make three slides appear successively with less than ten seconds between the disappearance of one slide and the presentation of the next. The Stimulation-Responsive group displayed a combination of Stimulation and Responsive behaviors. The Control group was stable over time. The results imply that habituation and self-efficacy are functions of different kinds of infant experiences and develop fairly independently of each other (Riksen-Walraven, 1978). Yet, what are the long-term effects of increasing parental responsiveness and can these results be achieved with shorter parent intervention programs?

Lim et al. (2005) conducted a parent training study to examine the effect that a two-hour parenting program had on motivating parents to change their behavior. Participants were placed in one of two groups: the control group or the videotape modeling and group discussion (VMG) group; the control group did not participate in an intervention project. The VMG group watched a 30-minute video *(Parenting in the Teenage Years*; Dishion, Kavanagh, and Christianson, 1995), which models counterproductive and constructive parental reactions to adolescent behaviors. Afterwards, with the aid of a trained therapist, they discussed the video and exchanged parenting techniques. Post observational data of parent-adolescent interactions were used to measure positive family interactions and negative family interactions before and after the intervention. The results show that, at posttest, parental involvement of the two groups was marginally significantly different; the VGM group reported greater involvement. The VMG group also engaged in significantly more positive family interactions. These findings imply that a brief intervention has some affect on parental behavior.

The results also imply that relatively short interventions can be effective; however, such brief, highly interactive interventions are not common in infant-focused parenting programs. Although the aforementioned information provides great insight into how parents can influence the behavior and learning of their young children, the question of how to effectively create an education program that causes minimal stress for parents still remains. Therefore, the proposed research seeks to develop an infant-caregiver centered program that: 1) focuses on infants, not adolescents, 2) focuses on prevention and early intervention instead of finding an intervention after a problem has been identified, and 3) is short as well as effective.

Central Research Question and Its Importance

What kind of parent education class will best help parents foster the language development of their infants?

The above research question is important because research on designing an effective parent-infant program for at-risk families, as well as investigating the way caregiver responsiveness impacts the language and cognitive development of infants, will provide insight into how parents can positively influence the development of their young children without adding additional stress to their lives. Not only will this research enhance the development of infants who are at risk for deprivation of communication and/or social interactions, it will also provide parents with information about simple and nearly effortless behaviors that will benefit their infants. Showing parents that their interaction with their infants today has a long-term positive effect on their infants' futures may prove to be a strong motivator that encourages parents to change their behaviors toward infants. Furthermore, by increasing awareness about the importance of caregiver responsiveness, parents and educators will realize that the vocal limitations of infants does not mean that they have a reduced understanding of the world around them or that they are not learning.

In addition to improving infant-caregiver relationships, this research will also expand knowledge in the fields of parent education and developmental psychology. Specifically, data from the proposed research could be used to design constructive child development interventions and preventive programs for at-risk families, as opposed to waiting for a problem to occur before intervention is sought. Not only could very early childhood intervention for at-risk families prove to be both valuable and useful, it is possible that changing parental responsiveness during a child's infancy may alleviate future educational and behavioral problems. The results of this investigation can be used to help the directors of parenting education programs design better, more effective, curricula as well as raise awareness about the importance of early childhood intervention and the long-term positive effects that it can have on children. This research can also be used to help psychologists identify the key parental behavioral responses that impact language and cognitive development.

Method

Participants

Twenty-three infants between the ages of 8 and 24 months (*M* = 13.7 months, *SD* = 3.73; 11 females, 12 males) and their primary caregivers (*M* = 34.6 years, *SD* = 5.77, age range 26-42 years; only one primary caregiver was male) participated in this study. Although the intervention was designed for low-income families, approximately

83% of the participants were from middle- to upper-middle class families. All caregivers had at least a high school diploma. 43.5% had bachelor's degrees and 39% had master's degrees or higher. 78.3% of the participants where white, 4.3% black, 4.3% Hispanic, and 13% were either multi-racial or of other ethnicities.

Four additional participants were omitted from the study because of equipment failure (1), experimenter error (1), fussiness (1), and failure to return for a second session (1). Approximately 61% of families participated in all three sessions (n = 14). As in the previous two studies, infants were recruited through a letter given to parents at the time of the infant's birth. All infants received a t-shirt, sippy cup, or bib in appreciation for their participation.

Stimuli

Caregiving behavior information was presented in the form of a 10-minute video, which highlighted the importance of talking to infants. Main topics of discussion included how caregivers can help their infants learn about the world around them, what infants learn before and after birth, how caregivers can help their infants continue learning, and tips for talking to infants. "Improving Your Baby's Language Skills" by talking to your baby was the overall theme of the video. In the video, caregivers were given four tips for talking to their infants: 1) Be Positive and Patient, 2) Act Naturally, 3) Name Objects for Your Baby, and 4) Practice.

After the introduction of each tip, caregivers were given strategies for how to interact with their infants. Tips one and three were also modeled by a mother and her 18-month-old son. After watching the video, caregivers discussed the video with a trained researcher. At the end of the information session, caregivers received magnets and reminder cards outlining the four "Tips for Talking to Your Baby" (see Figure 24 for pictures of information magnet and card). Caregivers were encouraged to display the magnets on their refrigerators and post the cards throughout their houses as well as carry them in their wallets. They were also instructed to talk to their infants and practice the caregiving behaviors that were demonstrated in the video.

Figure 24. Tip magnet (top) and reminder card (bottom)

Coding

As in Study 1, the play sessions were coded for infant behaviors and the corresponding behaviors of their caregivers. Caregiver responsiveness was coded using a system based on Gros-Louis et al. (2006), Bornstein et al. (1992), and Vollmer (2007). For specific descriptions of each behavior, see Table 2.

Procedure

Over the course of a month, each dyad was observed and video-taped in three 20-minute interactive play sessions which occurred approximately 2.5 weeks apart. At the first session, each caregiver was asked to complete a demographic survey. The family demographic survey was similar to the survey used in Study1. The survey contained questions about the caregiver, the infant, and the number of people in the household. The demographic survey included an assessment of socio-economic status based on occupation, information about the number of children in the household, and marital status. The caregiver portions of the survey included questions about the amount of time per week the caregiver spent with the infant and hours of employment per week. The infant portion of the survey included the number of hours per week the infant spent at home, in daycare or with a babysitter, and the infant's gender. For examples of survey questions, see Appendix.

To assess changes in infant vocabulary, caregivers completed Level I of the MacArthur-Bates Communicative Development Inventory (CDI; Fenson et al., 1993) at all three sessions. At each session, the dyads were given a set of toys to play with and asked to play as they would at home. At the end of session 1, caregivers received information about caregiving behavior in the form of a 10-minute video, which highlighted the importance of talking to infants. After watching the video, caregivers discussed the video with a trained researcher. During the discussion, the researcher answered caregivers' questions about the tips presented in the video, reiterated the importance of practicing positive caregiving behaviors, and, if requested, provided additional examples of how caregivers could interact with their infants given the family's demographic characteristics (e.g., number of other children in the household). Caregivers did not receive additional caregiving information at sessions 2 or 3 (Figure 25).

Results

Similar to the data analysis of Study 1, the frequency of each infant behavior and caregiver level of responsiveness to each behavior was analyzed. Level of responsiveness to infant behavior was calculated as a proportion and changes in caregivers' level of responsiveness before and after the intervention were examined. Repeated-measures ANOVAs indicated that caregiver responsiveness to infant object-related non-vocal, object-related vocal, dyadic non-vocal, and dyadic vocal behaviors did not significantly differ from session 2 to session 3, nor was there a difference in overall responsiveness between these two sessions (all $p > .05$). Therefore, the data for these two sessions was combined into a category that is referred to as session 2/3.

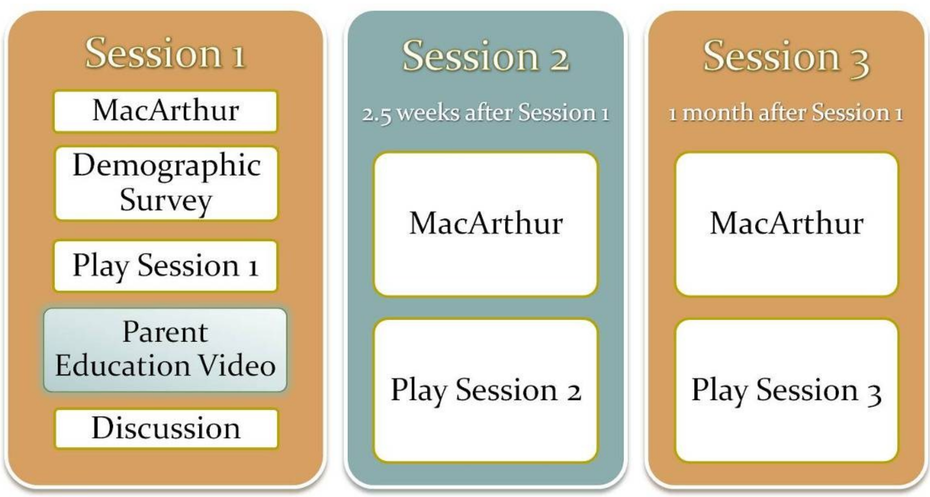

Figure 25. Surveys, events, and activities for interactive Sessions 1, 2, and 3.

Repeated measures ANOVAs determined that caregiver responsiveness to object-related non-vocal ($F(1, 22) = 8.3$, $p = .009$) and dyadic vocal ($F(1, 22) = 5.1$, $p = .034$) behaviors significantly increased from session 1 to session 2/3. Overall responsiveness ($F(1, 22) = 8.34$, $p = .009$) also increased significantly. However, responsiveness to object-related vocal ($F(1, 22) = .029$, $p > .05$) and dyadic non-vocal ($F(1, 22) = 2.39$, $p > .05$) behaviors was not significantly different, although there was a decreasing trend for dyadic non-vocal behaviors (Figure 26). There were no significant differences between the number of words infants comprehended ($F(2,56) = 1.5, p > .05$) or produced ($F(2,56) = 1.07, p > .05$) in sessions 1, 2, or 3.

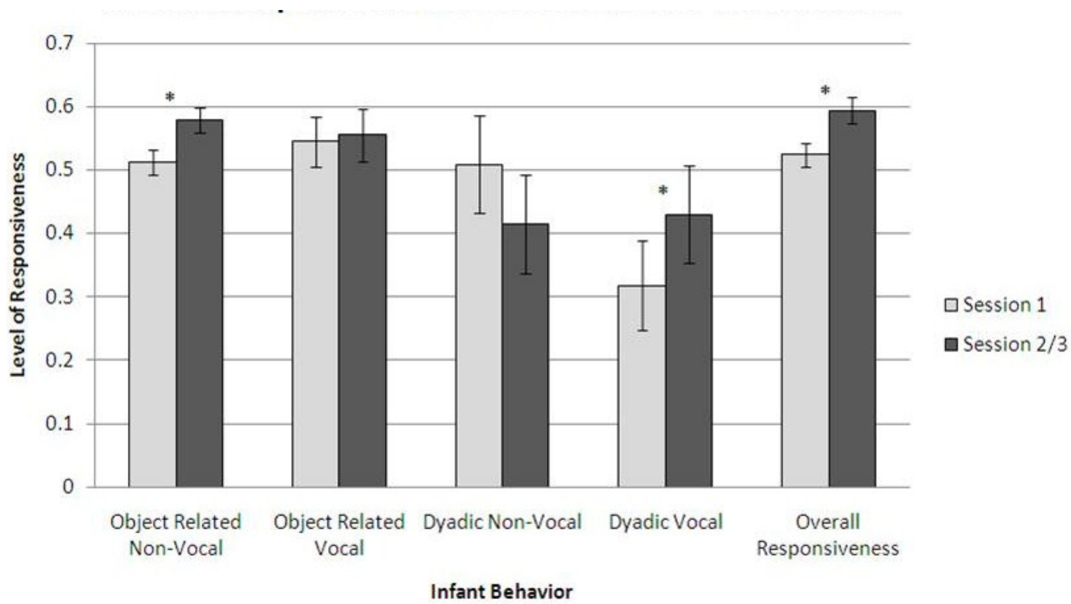

Figure 26. Level of responsiveness before and after intervention.

Pre- and Post-Intervention Comparison: Sequential Data Analysis

Lag 1 sequential data analyses of repeating and non-repeating consecutive behaviors were conducted to assess changes in caregiver responsiveness before and after the intervention. As in study 1, sequential data analysis comparisons were performed using O'Connor's (1999) SEQGROUPS SPSS syntax program. Pre- and post-intervention comparisons based on likelihood ratio chi-square tests revealed that there were significant differences in the behavioral patterns of caregivers from session 1 to session 2/3 (Likelihood Ratio Chi-Square $\chi^2 = 866.72$, $df = 156$, $p < .001$). Most notably, caregivers' dyadic vocal responsiveness to all infant behaviors increased (Table 29, Table 30, Table 31, and Table 32). A comparison of transitional probabilities show that dyadic vocal responsiveness to infant object-related non-vocal behaviors increased by 5.5% (adjusted residual $z = 18.02$, $p < .001$), object-related vocal by 5% ($z = -6.167$, $p < .001$), dyadic non-vocal by 8.4% ($z = 9.967$, $p < .001$), dyadic vocal by 4.7% ($z = 9.114$, $p < .001$), infant cries by 12.7% ($z = 5.236$, $p < .001$), and other infant vocal behaviors by 5.3% ($z = 10.651$, $p < .001$). In both session 1 and session 2/3, infants tended caregivers' behaviors with object-related non-vocalizations.

Caregiver and infant behavior responsiveness patterns were examined using a non-repeating consecutive behavior analysis. With the exception of caregivers' increased use of dyadic vocal behavior (Likelihood Ratio Chi-Square $\chi^2 = 843.14$, $df = 156$, $p < .001$), caregiver and infant responsiveness patterns remained fairly stable from session 1 to session 2/3 (Table 33, Table 34, Table 35, and Table 36). Infant objected-related non-vocal responses to other caregiver vocal behaviors increased by 4.2% ($z = -6.82$, $p < .001$) and caregiver dyadic vocal responses to infant dyadic non-vocal behavior increased by 9.5% ($z = 13.45$, $p < .001$).

Table 29

Repeating Analysis Frequencies: Session 1

	ion	iov	idn	idv	icry	iot	mon	mov	mdn	mdv	mot	moo	Total
ion	3875	759	38	65	7	77	1785	1447	354	2042	79	348	10876
iov	519	219	13	3	1	3	203	360	26	204	30	77	1658
idn	41	7	67	21	41	4	48	10	149	130	0	1	519
idv	54	4	24	37	0	0	30	8	30	77	0	2	266
icry	8	0	29	0	57	0	9	3	33	57	3	8	207
iot	68	2	10	1	0	155	43	14	42	147	6	40	528
mon	1831	164	52	24	6	37	765	358	33	404	3	13	3690
mov	1626	265	13	10	6	19	316	1525	15	103	20	86	4004
mdn	353	18	129	30	31	37	36	8	337	410	1	5	1395
mdv	2093	134	144	74	50	154	426	134	374	1058	10	79	4730
mot	78	21	0	0	3	5	6	36	2	18	74	108	351
moo	327	66	1	1	5	37	23	101	1	81	125	211	979
Total	10873	1659	520	266	207	528	3690	4004	1396	4731	351	978	29203

Table 30

*Repeating Analysis Transitional Probabilities: Session 1**

	ion	iov	idn	idv	Icry	iot	mon	mov	mdn	mdv	mot	moo
ion	**0.356**	0.070	0.003	0.006	0.001	0.007	0.164	0.133	0.033	0.188	0.007	0.032
iov	**0.313**	0.132	0.008	0.002	0.001	0.002	0.122	0.217	0.016	0.123	0.018	0.046
idn	0.079	0.013	0.129	0.040	0.079	0.008	0.092	0.019	**0.287**	0.250	0.000	0.002
idv	0.203	0.015	0.090	0.139	0.000	0.000	0.113	0.030	0.113	**0.289**	0.000	0.008
icry	0.039	0.000	0.140	0.000	0.275	0.000	0.043	0.014	0.159	**0.275**	0.014	0.039
iot	0.129	0.004	0.019	0.002	0.000	**0.294**	0.081	0.027	0.080	0.278	0.011	0.076
mon	**0.496**	0.044	0.014	0.007	0.002	0.010	0.207	0.097	0.009	0.109	0.001	0.004
mov	**0.406**	0.066	0.003	0.002	0.001	0.005	0.079	0.381	0.004	0.026	0.005	0.021
mdn	0.253	0.013	0.092	0.022	0.022	0.027	0.026	0.006	0.242	**0.294**	0.001	0.004
mdv	**0.442**	0.028	0.030	0.016	0.011	0.033	0.090	0.028	0.079	0.224	0.002	0.017
mot	0.222	0.060	0.000	0.000	0.009	0.014	0.017	0.103	0.006	0.051	0.211	**0.308**
moo	**0.334**	0.067	0.001	0.001	0.005	0.038	0.023	0.103	0.001	0.083	0.128	0.216

**behavior with the largest transitional probability denoted in bold*

Table 31

Repeating Analysis Frequencies: Session 2/3

	ion	iov	idn	idv	icry	iot	mon	mov	mdn	mdv	mot	moo	Total
ion	6517	1173	41	80	0	61	2896	2256	491	4416	55	215	18201
iov	829	253	8	6	2	8	262	552	48	428	21	58	2475
idn	31	4	93	54	4	17	56	29	198	244	0	0	730
idv	62	1	35	40	0	3	48	21	109	162	0	1	482
icry	0	0	3	0	15	1	2	1	26	33	0	1	82
iot	51	5	16	4	1	193	92	16	52	228	1	30	689
mon	2851	235	61	39	1	93	1220	677	45	1005	4	15	6246
mov	2503	428	35	18	0	22	612	2447	24	247	24	78	6438
mdn	479	41	176	86	21	55	36	27	491	748	0	4	2164
mdv	4606	269	264	156	40	210	1005	308	678	2348	9	65	9958
mot	61	17	0	0	0	1	2	36	0	13	51	58	239
moo	204	52	0	0	0	26	17	63	1	87	75	143	668
Total	18194	2478	732	483	84	690	6248	6433	2163	9959	240	668	48372

Table 32

*Repeating Analysis Transitional Probabilities: Session 2/3**

	ion	iov	idn	idv	icry	iot	mon	mov	mdn	mdv	mot	moo
ion	**0.358**	0.064	0.002	0.004	0.000	0.003	0.159	0.124	0.027	0.243	0.003	0.012
iov	**0.335**	0.102	0.003	0.002	0.001	0.003	0.106	0.223	0.019	0.173	0.008	0.023
idn	0.042	0.005	0.127	0.074	0.005	0.023	0.077	0.040	0.271	**0.334**	0.000	0.000
idv	0.129	0.002	0.073	0.083	0.000	0.006	0.100	0.044	0.226	**0.336**	0.000	0.002
icry	0.000	0.000	0.037	0.000	0.183	0.012	0.024	0.012	0.317	**0.402**	0.000	0.012
iot	0.074	0.007	0.023	0.006	0.001	0.280	0.134	0.023	0.075	**0.331**	0.001	0.044
mon	**0.456**	0.038	0.010	0.006	0.000	0.015	0.195	0.108	0.007	0.161	0.001	0.002
mov	**0.389**	0.066	0.005	0.003	0.000	0.003	0.095	0.380	0.004	0.038	0.004	0.012
mdn	0.221	0.019	0.081	0.040	0.010	0.025	0.017	0.012	0.227	**0.346**	0.000	0.002
mdv	**0.463**	0.027	0.027	0.016	0.004	0.021	0.101	0.031	0.068	0.236	0.001	0.007
mot	**0.255**	0.071	0.000	0.000	0.000	0.004	0.008	0.151	0.000	0.054	0.213	0.243
moo	**0.305**	0.078	0.000	0.000	0.000	0.039	0.025	0.094	0.001	0.130	0.112	0.214

**behavior with the largest transitional probability denoted in bold*

Table 33

Non-Repeating Analysis Frequencies: Session 1

	ion	iov	idn	idv	Icry	iot	mon	mov	mdn	mdv	mot	moo	Total
ion	-	759	38	65	7	77	1785	1447	354	2042	79	348	7001
iov	519	-	13	3	1	3	203	360	26	204	30	77	1439
idn	41	7	-	21	41	4	48	10	149	130	0	1	452
idv	54	4	24	-	0	0	30	8	30	77	0	2	229
icry	8	0	29	0	-	0	9	3	33	57	3	8	150
iot	68	2	10	1	0	-	43	14	42	147	6	40	373
mon	1831	164	52	24	6	37	-	358	33	404	3	13	2925
mov	1626	265	13	10	6	19	316	-	15	103	20	86	2479
mdn	353	18	129	30	31	37	36	8	-	410	1	5	1058
mdv	2093	134	144	74	50	154	426	134	374	-	10	79	3672
mot	78	21	0	0	3	5	6	36	2	18	-	108	277
moo	327	66	1	1	5	37	23	101	1	81	125	-	768
Total	6998	1440	453	229	150	373	2925	2479	1059	3673	277	767	20823

Table 34

*Non-Repeating Analysis Transitional Probabilities: Session 1**

	ion	iov	idn	idv	icry	iot	mon	mov	mdn	mdv	mot	moo
ion	-	0.108	0.005	0.009	0.001	0.011	0.255	0.207	0.051	**0.292**	0.011	0.050
iov	**0.361**	-	0.009	0.002	0.001	0.002	0.141	0.250	0.018	0.142	0.021	0.054
idn	0.091	0.015	-	0.046	0.091	0.009	0.106	0.022	**0.330**	0.288	0.000	0.002
idv	0.236	0.017	0.105	-	0.000	0.000	0.131	0.035	0.131	**0.336**	0.000	0.009
icry	0.053	0.000	0.193	0.000	-	0.000	0.060	0.020	0.220	**0.380**	0.020	0.053
iot	0.182	0.005	0.027	0.003	0.000	-	0.115	0.038	0.113	**0.394**	0.016	0.107
mon	**0.626**	0.056	0.018	0.008	0.002	0.013	-	0.122	0.011	0.138	0.001	0.004
mov	**0.656**	0.107	0.005	0.004	0.002	0.008	0.127	-	0.006	0.042	0.008	0.035
mdn	0.334	0.017	0.122	0.028	0.029	0.035	0.034	0.008	-	**0.388**	0.001	0.005
mdv	**0.570**	0.036	0.039	0.020	0.014	0.042	0.116	0.036	0.102	-	0.003	0.022
mot	0.282	0.076	0.000	0.000	0.011	0.018	0.022	0.130	0.007	0.065	-	**0.390**
moo	**0.426**	0.086	0.001	0.001	0.007	0.048	0.030	0.132	0.001	0.105	0.163	-

**behavior with the largest transitional probability denoted in bold*

Table 35

Non-Repeating Analysis Frequencies: Session 2/3

	Ion	iov	idn	idv	icry	iot	mon	mov	mdn	mdv	mot	moo	Total
ion	-	1173	41	80	0	61	2896	2256	491	4416	55	215	11684
iov	829	-	8	6	2	8	262	552	48	428	21	58	2222
idn	31	4	-	54	4	17	56	29	198	244	0	0	637
idv	62	1	35	-	0	3	48	21	109	162	0	1	442
icry	0	0	3	0	-	1	2	1	26	33	0	1	67
iot	51	5	16	4	1	-	92	16	52	228	1	30	496
mon	2851	235	61	39	1	93	-	677	45	1005	4	15	5026
mov	2503	428	35	18	0	22	612	-	24	247	24	78	3991
mdn	479	41	176	86	21	55	36	27	-	748	0	4	1673
mdv	4606	269	264	156	40	210	1005	308	678	-	9	65	7610
mot	61	17	0	0	0	1	2	36	0	13	-	58	188
moo	204	52	0	0	0	26	17	63	1	87	75	-	525
Total	11677	2225	639	443	69	497	5028	3986	1672	7611	189	525	34561

Table 36

*Non-Repeating Analysis Transitional Probabilities: Session 2/3**

	ion	iov	idn	idv	icry	iot	mon	mov	mdn	mdv	mot	moo
ion	-	0.100	0.004	0.007	0.000	0.005	0.248	0.193	0.042	**0.378**	0.005	0.018
iov	**0.373**	-	0.004	0.003	0.001	0.004	0.118	0.248	0.022	0.193	0.009	0.026
idn	0.049	0.006	-	0.085	0.006	0.027	0.088	0.046	0.311	**0.383**	0.000	0.000
idv	0.140	0.002	0.079	-	0.000	0.007	0.109	0.048	0.247	**0.367**	0.000	0.002
icry	0.000	0.000	0.045	0.000	-	0.015	0.030	0.015	0.388	**0.493**	0.000	0.015
iot	0.103	0.010	0.032	0.008	0.002	-	0.185	0.032	0.105	**0.460**	0.002	0.060
mon	**0.567**	0.047	0.012	0.008	0.000	0.019	-	0.135	0.009	0.200	0.001	0.003
mov	**0.627**	0.107	0.009	0.005	0.000	0.006	0.153	-	0.006	0.062	0.006	0.020
mdn	0.286	0.025	0.105	0.051	0.013	0.033	0.022	0.016	-	**0.447**	0.000	0.002
mdv	**0.605**	0.035	0.035	0.020	0.005	0.028	0.132	0.040	0.089	-	0.001	0.009
mot	**0.324**	0.090	0.000	0.000	0.000	0.005	0.011	0.191	0.000	0.069	-	0.309
moo	**0.389**	0.099	0.000	0.000	0.000	0.050	0.032	0.120	0.002	0.166	0.143	-

**behavior with the largest transitional probability denoted in bold*

Demographic Survey Analysis

Pearson product-moment correlation coefficients were computed to assess the relationship between family demographic characteristics and influences on responsiveness level before and after the intervention. At session 1, hours per week that caregivers spent with their infants was positively correlated with dyadic non-vocal behavior ($r = .46$, $n = 23$, $p < .05$). At session 2/3, hours per week spent with infant was negatively correlated with object related vocal behavior ($r = -.36$, $n = 37$, $p < .05$) but remained positively correlated with dyadic non-vocal behavior ($r = .44$, $n = 37$, $p < .05$). At session 1, caregiver education, hours per week that the caregiver worked, and number of adults in the household was not correlated with any of the responsive behaviors (all $p < .05$). At session 2/3, caregiver education ($r = -.4$, $n = 37$, $p < .05$) and hours working per week ($r = -.37$, $n = 37$, $p < .05$) were negatively correlated with dyadic non-vocal behavior and number of adults in the house was positively correlated with object related vocal behavior ($r = .33$, $n = 37$, $p < .05$). Object related non-vocal behaviors, dyadic vocal behaviors, and overall responsiveness were not significantly correlated with any of the four measures (Table 37).

Discussion

The present study was aimed at designing an effective parent education program that can be used to increase caregiver responsiveness to infant behavior which will, in turn, enhance infant language development. As predicted, the results of the pre- and post-intervention verify that a brief, 10-minute intervention can effectively increase caregiver responsiveness. Even without additional education sessions, caregivers maintained an increased level of responsiveness to infants'

Table 37

Pearson Product-Moment Correlation Coefficients: Sessions 1 and 2/3

Session	Behavior	Caregiver Education	Hours/Week Caregiver Spends with Infant	Hours/Week Caregiver Works	Number of Adults in Household
1[a]	Object Related Non-Vocal	-0.07	0.03	-0.08	-0.18
	Object Related Vocal	0.10	-0.13	0.10	-0.35
	Dyadic Non-Vocal	-0.33	0.46*	-0.27	0.17
	Dyadic Vocal	-0.04	0.23	-0.09	-0.28
	Overall Responsiveness	-0.04	0.00	-0.06	-0.21
2/3[b]	Object Related Non-Vocal	0.07	-0.25	0.11	0.22
	Object Related Vocal	-0.02	-0.36*	0.24	0.33*
	Dyadic Non-Vocal	-0.40*	0.44*	-0.37*	0.05
	Dyadic Vocal	-0.18	0.32	-0.21	0.07
	Overall Responsiveness	0.05	-0.27	0.11	0.28

[a]$n = 23$
[b]$n = 37$
*$p < .05$

behaviors.

Given that the majority of families were from middle- to upper income families, these results are particularly impressive. Previous research on socioeconomic status (SES) and infant-caregiver interactions indicate that higher income parents are already very responsive to their infants. Yet from this study we now know that high SES parents are not at the highest level of responsiveness and that their responsive caregiving behaviors further improve after a brief intervention. Thus, the intervention program may prove beneficial to infants and families from all socioeconomic strata, not just families who are at risk.

Behavioral Changes

Increases in caregiver dyadic vocalizations and level of responsiveness to object-related non-vocal behaviors indicate that caregivers were labeling objects more often (as suggested in Tip #3) and engaging their infants in more object-related play. In order for labeling to be effective, both the infant and the caregiver must be engaged in a moment of shared attention. However, this moment of shared attention results in a triadic infant-object-caregiver interaction where the infant and the caregiver, by necessity, are more focused on the object than they are on each other. Thus, the slight, but non-significant, decrease in caregiver responsiveness to infant dyadic non-vocal behaviors may signify that there is a trade-off between dyadic and object related behaviors. To increase infant vocabulary, caregivers have to selectively attune to infant behaviors that have the potential to provide the infant with knowledge of objects in the environment. And although hugging, smiling, and other such dyadic non-vocal behaviors may be beneficial for helping infants develop social and emotional competency, they may not be the best tools for developing academic competency.

Responsiveness to dyadic vocal behaviors, on the other hand, has the potential to provide infants with both social and academic knowledge. Depending on the sequence of events during the interaction, infants can use dyadic vocal behaviors to either interact socially or academically. For example, infants can use vocal turn-taking as a mechanism to engage their caregivers in a conversation in which sounds, tones, and words convey may emotion, but do not serve as an opportunity for caregivers to teach vocabulary. Additionally, infants may vocalize to get their caregiver's attention, then redirect the caregiver's attention to an object and thereby establish a teaching moment. The duality of dyadic vocal behaviors may explain why there does not seem to be a trade-off between object-related vocal and dyadic vocal behaviors. By default, object related vocal behaviors already provide teaching opportunities, and we would not expect to see much change in caregiver responsiveness to these behaviors post-intervention.

An analysis of family demographics indicated that before the intervention, caregiver education level and number of hours per week that the caregiver worked did not influence level of responsiveness to infant behaviors. Post-intervention analyses revealed that responsiveness to infant dyadic non-vocal behavior decreases as caregivers obtain more education and work longer hours. At first glance, it appears that these two factors may negatively impact infant-caregiver interactions. Yet if we take into account the trade-off between object-related non-vocal and dyadic non-vocal behaviors, we may conclude that more educated caregivers are already engaging their infants in more object-related teaching behaviors, which results in decreased responsiveness to dyadic non-vocal behaviors. Before we can state that this is indeed the case, a larger sample of participants is needed.

Limitations and Future Directions

The results of this study are very promising in that they provide evidence that a brief intervention can result in significantly positive changes in caregiving behaviors. Nevertheless, more research must be conducted before we can accurately assess the cognitive benefits that this intervention program provides to infants. For example, pre- and post-intervention comparisons of infant vocabulary were not significant. Two limitations to vocabulary assessment were the ages of the infants and the length of the study. Because participating infants were as young as 8 months old, many of them understood and produced very few words at session 1. Furthermore, for infants so young, the one-month interval between the first and last session of the study may not provide sufficient time for infants to benefit from the intervention. Instead, a longitudinal study that lasts at least six months would afford a more accurate account of the relationship between vocabulary development and the intervention-aided increase in caregiver responsiveness.

Currently, the intervention program is designed for caregivers with infants of any age. However, future directions include the development of specific, age-related programs that are based on developmental milestones (e.g., talking and independent locomotion). For example, is it better for caregivers to participate in the intervention program right after their babies are born, or should the infant reach a specific milestone before caregivers are encouraged to participate? Age-specific programs would provide an opportunity to assess at which age the intervention is most effective.

In addition to examining infant cognitive and vocabulary development, it is important to assess long-term changes in caregiving behaviors and analyze the sustainability and effectiveness of the intervention. The results provide evidence that the intervention is effective for at least one month. A long-term study would assess how long the effects last and establish whether one training session is sufficient to sustain caregivers' behavioral changes. The impact of the intervention on both the infant and the caregiver must be taken into consideration.

Finally, factors that explain changes in level of responsiveness must be explored in more detail. For example, increases in infant age, demand characteristics (i.e., an unconscious change in participants' behaviors as a result of their interpretation of the experiment's purpose), and voluntary, conscious changes in behavior may have affected caregiver responsiveness. To determine whether caregivers become more responsive as their infants age, caregivers would participate in a longitudinal play session study. The caregivers would not receive any information about caregiving behaviors and their level of responsiveness would be analyzed once a month for approximately six months.

In contrast to the straightforward method for assessing the impact of infant age, assessing the effects of conscious and unconscious changes in behavior is a more difficult problem and requires multiple approaches. The difficulty arises because, at the beginning of the study, caregivers are told that the purpose of the study is to improve caregiving behaviors. Furthermore, the 10-minute video, tip magnet, and reminder card outline in detail the types of behaviors that caregivers are expected to display while interacting with their infants. As a result, it is likely that caregivers know exactly which behaviors they are displaying pre- and post-intervention. Subjective and objective analyses of caregivers' behaviors are necessary to determine which behaviors are conscious and unconscious.

To determine conscious behaviors, caregivers would participate in a detailed debriefing and question and answer session at the end of the study. Caregivers would be asked to explain the purpose of the study, state whether they consciously changed their behaviors during the play sessions, and discuss how often they practiced the caregiving techniques at home. Asking caregivers about their behaviors will provide insight into the participants' conscious actions as well as help determine the extent to which demand characteristics affect subsequent caregiving behaviors. However, interviews and personal reflections of behaviors are subjective.

An objective assessment of post-intervention caregiving behaviors would require recording infant-caregiver interactions before, during, and after the study. Thus, we would be able to analyze how caregivers behave when they believe they are participating in the study to how they behave when they think the cameras are off. This approach requires constant video recording and elements of deception. However, it will provide further evidence that the intervention program is the most significant factor affecting changes in caregiving behaviors.

Chapter 5: General Discussion

The three studies strongly supported the fact that caregivers' behaviors greatly influence both the behavior and cognitive development of their children. In particular, what children learn from infant-caregiver observations and interactions with their primary caregivers helps determine how older siblings interact with their younger siblings. According to the intergenerational transmission model, older siblings will continue to display the learned behaviors during adulthood and, eventually, use their childhood experiences as a framework for interacting with their own children. The relationship between siblings and their caregivers provide insight into how children learn patterns of behavior from their parents. It is also a great conduit for studying sibling interactions and analyzing the development of sibling relationships during childhood.

Gibbs, Teti, and Bond's (1987) research on child spacing (i.e., the time intervals separating the births of siblings) showed that interactions between widely-spaced siblings closely resembled parent-child interactions (e.g., involved greater responsiveness; siblings used more vocal, verbal, and gestural behaviors, and provided more attention-getting utterances). Although infant-sibling social interactions remained stable across time, unlike infant-caregiver interactions, sibling social interactions were not predictive of linguistic development. Thus, there was no evidence that highly communicative firstborns promoted (or hindered) the infant sibling's linguistic or intellectual development. Thus, although older siblings learn caregiving behaviors from their parents, the extent to which these interactions impact infant siblings' cognitive and linguistic development is still unclear. An assessment of older infant-sibling dyads is needed to uncover the long-term effects, if any, that sibling social interactions have on later cognitive and linguistic development.

In contrast, caregiver linguistic and behavioral input consistently predict infant cognitive development (e.g., Riksen-Walraven, 1978; Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991; Hart & Risley, 1995; Tamis-LeMonda & Bornstein, 2002; Hoff, 2003). One remaining question of interest is whether there is an optimal level of responsiveness for infant learning. Although previous research studies show that level of parental responsiveness has a direct impact on cognitive and language development, they do not quantify what constitutes too much or too little responsiveness. Given that some caregivers are high responders (i.e., they frequently respond to their children's bids for attention) and others are low responders (i.e., they rarely respond to bids for attention), level of responsiveness is a central component for generating an in depth model of infant learning. For example, children whose parents are less responsive do learn words. Yet is it better to have caregivers who are too responsive (e.g., respond 100% of the time) or parents who are not responsive at all? Moreover, what are the benefits of having responsive caregivers as opposed to intrusive caregivers who, on the surface, appear to be very interactive and involved in their children's activities?

Caregivers who are constantly talking to, touching, and providing directions for their infants may appear responsive. However, a key distinction between intrusiveness and responsiveness is that negative intrusive caregivers interrupt the infant's activities and try to control the infant's behaviors by imposing their own agenda onto the child. Intrusive caregivers are inconsiderate of the child's wishes, fail to recognize the child's efforts to gain autonomy, and can be verbally controlling (e.g., providing repeated and unnecessary direction) as well as physically controlling (e.g., repositioning the child, taking over tasks that the child can master by herself; see e.g., Egeland, Pianta, & O'Brien, 1993; Pungello, Iruka, Dotterer, Mills-Koonce, & Reznick, 2009; Ispa et al., 2004). The children of intrusive mothers have a slower rate of language growth (Pungello, Iruka, Dotterer, Mills-Koonce, & Reznick, 2009) and perform poorly academically, socially, emotionally, and behaviorally in the first and second grades (see e.g., Egeland, Pianta, & O'Brien, 1993).

In contrast, responsive caregivers are aware of their infants' behaviors, yet they do not try to impose their own agendas or control all of the child's activities. Instead, responsive caregivers respond positively to their infants' behaviors and bouts for attention. They base their actions off of the infant's previous actions and allow their children space to explore and learn on their own without constant disruptive, interference. The children of responsive caregivers are also more linguistically and cognitively advanced than the children of non-responsive caregivers (see e.g., Hart & Risley, 1995; Riksen-Walraven, 1978; Tamis-LeMonda & Bornstein, 2002). Yet what factors motivate caregivers to improve their caregiving behaviors and thus enhance infant learning?

Underlying Mechanisms for Improving Caregiver Responsiveness and Infant Cognitive Development

Mechanisms that may influence and improve caregiver responsiveness include: knowledge about the impact of positive, responsive caregiving behaviors (e.g., as presented in the parent education video in Study 3); the presence of an authority figure or child development expert who is associated with an institution of higher education (e.g., researchers, research assistants); motivation and willingness to modify caregiving behaviors (e.g., with the goal of improving infant cognitive abilities); and cultural influences and societal expectations that encourage academic success in young children. In the current studies, the presence of a child development, university-associated authority figure gave credence to the studies and encouraged caregivers to donate their time to research. However, simply participating in a study is not enough to result in a change in caregiving behaviors. Instead, it is likely that the other three factors – knowledge, motivation, and culture – combined with the advice of an expert, are the most important mechanisms for changing caregivers' behaviors.

Specifically, having information about how to become more responsive allows caregivers to assess their current behaviors and make adjustments towards becoming more like the models described to them. Motivation to become more responsive helps caregivers take the information they have learned and put it into practice. Knowledge alone will not result in the development of positive caregiving behaviors. Instead, knowledge and motivation are both necessary components for becoming a better caregiver. Moreover, culture and the current educational standards that require the production of smarter, more cognitively developed children may influence caregiver responsiveness. Increasing academic standards compel caregivers to modify their behaviors, teaching strategies, and daily activities in an effort to provide their children with academic advantages. If an expert in the field provides advice regarding ways to simultaneously improve caregiving behaviors and infant cognitive development, caregivers are more likely to pay attention to the information presented and rely on their newly acquired knowledge to motivate them to be more responsive. Caregivers' awareness of the impact that their behaviors have on infant cognitive development, increased motivation, the influence of culture, and the advice of an expert yields a change in caregiving behavior that is more beneficial to the infant.

As a result of having more responsive caregivers, infants are provided with greater opportunities to explore their environment and gain autonomy (see e.g., Riksen-Walraven, 1978). With this independence comes more opportunities to learn. Responsive caregivers will respond to their infants' bids for attention, label objects that the infants are interested in, provide positive, non-intrusive support when needed, and respond to infant-initiated behaviors. As infants learn more, they explore more. As caregivers become more aware of infant learning, they become more responsive to the infants' behaviors, which, in turn, encourages more infant learning and exploration. This bi-directional cycle demonstrates how responsiveness imparts its beneficial effects on infant learning. It also reveals that infants and caregivers greatly influence each other during interactions.

As we learn more about familial interactions and the factors that impact caregiver responsiveness and infant learning, we can build models that accurately reflect the complex environment in which an infant learns language. In-depth analyses of infant-caregiver interactions will result in measurable, quantifiable guidelines for creating early childhood interventions. Instead of suggesting that caregivers talk more, read more, and interact more with their infants, we will be able to recommend specific levels of engagement and responsiveness as well as provide detailed advice for how to enhance infants' learning experiences.

APPENDIX

Studies 1 and 3

Examples of Questions on the Demographic Survey

Questions marked with asterisks (*) only appear on the Caregiving Behaviors Survey

- Race/Ethnicity
- Highest level of education completed (for both primary caregiver and spouse/partner)
- Do you work outside the home?
  - What is your occupation?
  - How many hours per week do you spend at work?
- How many biological children do you have?
- How many step-children do you have?
- How many hours/week do you spend with your older child?*
- How many hours/week do you spend with your infant?
- How many times a week do you read books to your older child?*
- How many times a week do you read books to your infant?
- How many times a week do you tell stories to your infant?
- How many times a week do you sing songs to your infant?
- How many hours/week does your older child spend with your infant?*
- What activities do your older child and your infant do together?*
- How many hours/week do you require your older child to babysit/watch/care for your infant?*
- Do you have a spouse or romantic partner?
- How many hours/week does your spouse/partner spend with your older child?*
- How many hours/week does your spouse/partner spend with your infant?
- How many other adults (18 years of age or older), not including yourself or your spouse/partner, live in your household?

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