A Longitudinal Investigation of Infant Gesture Use and Parent Speech:
Unique and Dynamic Influences on Infant Vocabulary Acquisition

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Dissertation submitted in partial fulfillment of
the requirements for the degree of Doctor
of Philosophy in the Department of
Psychology & Neuroscience in the Graduate School
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ABSTRACT

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Abstract

How do infants learn word meanings? Research has established the impact of both parent and child behaviors on vocabulary development, however the processes and mechanisms underlying these relationships are still not fully understood. Much existing literature focuses on direct paths to word learning, demonstrating that parent speech and child gesture use are powerful predictors of later vocabulary. However, an additional body of research indicates that these relationships don’t always replicate, particularly when assessed in different populations, contexts, or developmental periods.

The current study examines the relationships between infant gesture, parent speech, and infant vocabulary over the course of the second year (10-22 months of age). Through the use of detailed coding of dyadic mother-child play interactions and a combination of quantitative and qualitative data analytic methods, the process of communicative development was explored. Findings reveal non-linear patterns of growth in both parent speech content and child gesture use. Analyses of contingency in dyadic interactions reveal that children are active contributors to communicative engagement through their use of gestures, shaping the type of input they receive from parents, which in turn influences child vocabulary acquisition. Recommendations for future studies and the use of nuanced methodologies to assess changes in the dynamic system of dyadic communication are discussed.
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There are many parallels between the development of an infant and the development of a dissertation. They both begin as a seed of an idea and flourish into a fully individuated entity. They both involve trial and error, regressions to previous states, and moments of triumphant success. And most importantly, to promote the development either while maintaining your sanity, it takes a village.

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1. Introduction

The acquisition of language is an astoundingly rapid process, in which infants transform from naïve listeners to masters of their mother tongue in a few short years. The second year, in particular, is a period of rapid vocabulary growth, unmatched by any other period in a young child’s life (Fenson, et al., 1994; Huttenlocher, et al., 1991). However, there is a great deal of variability in the onset, growth, and amount of vocabulary knowledge children possess during this period, and much speculation about the likely source (e.g., Bates, Bretherton & Snyder, 1980; Bornstein, Haynes, & Painter, 1998; Fenson, et al., 1994; Huttenlocher, et al., 1991). Both parent talk and child gesture have been implicated as major players in the process, however, the dynamic and variable nature of these relationships and the mechanisms that underlie them are not fully understood. For example, while researchers have often argued that the pathway between infant gesture and later language is mediated through parental responses, few studies have specifically tested this hypothesis (Goldin-Meadow, Goodrich, Sauer & Iverson, 2007; Masur, 1982), and no studies have examined variability in these parent-child interactions across development.

Given the extensive research conducted on children’s early gestures and their impact on language development (e.g., Bates, et al., 1977; Colonnese, Stams, Koster, & Noom, 2010; Goodwyn, Acredolo, & Brown, 2000; Iverson & Goldin-Meadow, 2005; Rowe, Ozcaliskan, & Goldin-Meadow, 2008), it is surprising how little is known about
how dyadic parent-child interactions involving early gestures contribute to the process of language acquisition. In particular, we have a very poor understanding of the developmental stability and change in parent-child communicative interactions over the course of the second year, and the impacts of this variability on children’s acquisition of verbal language. The potential cost of this lack of understanding is not a small one; vocabulary knowledge is highly predictive of later developmental capabilities and outcomes. For example, reading comprehension is predicted by children’s early vocabulary knowledge, word recognition skills and grammatical capacity (Muter, Hulme, Snowling, & Stevenson, 2004). In fact, the size of children’s vocabulary at 24 months of age predicts their language and literacy skills through 5th grade, even after controlling for factors such as gender, birth order, ethnicity, and socioeconomic status (Lee, 2010). Literacy is the foundation of academic achievement and attainment. Poor literacy skills are linked to a number of potentially harmful outcomes, including lower rates of graduation, higher likelihood of incarceration, fewer vocational prospects, and poorer overall health (Auguste, Hancock, & Laboissière, 2009). Thus, failing to invest in early vocabulary learning can result not only in individual deficits, but also in greater overall costs to society. The current study will provide a necessary addition to our understanding of the sources of variability in early vocabulary acquisition, with a particular focus on the unique and dynamic roles parents and children play, and how the impact and nature of these roles shift and develop over time.
1.1 **Parent talk**

As with all developmental processes, the acquisition of a spoken vocabulary is influenced by a number of factors. One factor that has been consistently implicated is the oral language input children receive from their parents (e.g., Bornstein, Haynes, & Painter, 1998; Goodman, Dale and Li, 2008; Hardy-Brown & Plomin, 1985; Hart & Risley, 1995; Huttenlocher, et al., 1991; Pancsofar & Vernon-Feagans, 2006). The sheer amount of linguistic information to which children are exposed has a fundamental impact on the size of their vocabularies. An oft-cited study by Hart & Risley (1995) directly linked socioeconomic discrepancies in children’s vocabularies to discrepancies in maternal oral language input. The authors observed that during the first two years, children from working-class families heard about half as many words per hour as the children in professional families. The children in families receiving welfare heard only a third as many words as those from professional families. These differences in exposure had striking associations with the language-learning outcomes of these children: by age three, the children in the working-class families produced two-thirds the number of words, and children in families receiving welfare produced half as many words, as children from professional families.

It is clear that amount of exposure to oral language plays a fundamental role in children’s vocabulary development. However, quantity alone is not sufficient to explain the relationship between parent language input and infant language learning. The
quality of parent speech, in terms of *what* they say also plays a role. Take, for example, two mothers discussing a toy with their infant. One may say, “The ball, look at the ball!” while another says, “See the ball, it is round!” While the total number of words each mother uses is identical, the second mother is providing more unique lexical items (i.e., words) to her learning infant. Lexical diversity in parent speech, or the number of different root words produced, is highly predictive of the rate at which infants acquire new words (Huttenlocher, et al., 1991; Pan, Rowe, Singer, & Snow, 2005). Furthermore, the specific types of words infants acquire can be directly linked to the types of words parents use. The majority of English-learning infants first learn names for objects (nouns), later learning verbs, adjectives, and closed-class words (e.g., that, some). Goodman, Dale and Dale (2008) observed that this pattern of acquisition mirrored the frequency with which parents used words within these categories. This finding is particularly notable given that the researchers observed an overall *negative* relationship between word frequency and children’s word comprehension. Thus, how much a parent speaks should not be the only clue in predicting child vocabulary growth; the content of their speech is also a powerful indicator.

The content of parent speech, and in particular, the sophistication of oral language input must also be matched to the developmental level of the child. While abstract language and leading questions may enhance the vocabulary of a 2-year-old, these same strategies are unlikely to be useful to a 12-month-old. Parents seem to be
aware of the need for developmentally appropriate interactions, altering their speech based on their child’s age and skill level. Murray, Johnson and Peters (1990) observed that as infants’ word comprehension abilities emerge between 6 and 9 months, mothers actually reduce the mean length of their utterances (MLU). For example, saying, “See the dog? It’s red!” rather than “Look at the big red dog!” Mothers who engaged in a greater degree of this “fine-tuning” of MLU when their infants were between 6 and 9 months had children with larger receptive vocabularies at 18 months. This indicates that for children undergoing significant transitions, an overabundance of lexical information may actually be detrimental. By limiting the amount of speech directed to young infants on the cusp of first words, parents allow them to isolate the most meaningful information. Once infants begin speaking, parents then begin to gradually increase both the amount and diversity of speech in interactions with their infants (Bornstein, Tamis-LeMonda & Haynes, 1999; Rowe, Pan & Ayoub, 2005). Thus, neither the patterns of parent speech to infants, nor the impact of parent speech on infant vocabulary are linear and uniform across development. In order to fully understand the process of vocabulary acquisition, it is necessary to consider this developmental variability.

1.2 Child gesture

Although parents play an enormous role in contributing to their children’s burgeoning vocabulary, children are not simply passive recipients of lexical information. Children’s own preverbal behaviors are often highly predictive of their later spoken
vocabularies. For example, children begin producing simple manual gestures, such as pointing, giving, showing, and requestive reaches between 7 and 15 months, with a mean age of onset around 12 months (Bates, Camaioni & Volterra, 1975; Camaioni, Perucchini, Bellagamba, & Colonnesi, 2004; Carpenter, Nagell, & Tomasello, 1998). The use of these object-oriented gestures (also referred to as deictic gestures) has been observed in nearly all cultures (see Wilkins, 2003 for exceptions), and the developmental progression across cultural groups is fairly consistent. In a series of studies, Blake (2000) and her colleagues (1997; 2003) assessed the developmental changes in the use of deictic gestures between 9 and 15 months in samples of Canadian, Canadian-Italian, French and Japanese infants. The findings revealed that, in all samples, there are marked increases in the use of pointing and object exchange (e.g., give and take) gestures between 9 and 15 months, while in contrast the use of requestive gestures (e.g., reaching) decreases during the same period (Blake, 2000; Blake, Olshansky, Vitale & Macdonald, 1997; Blake, Osborne, Cabral & Gluck, 2003). Interestingly, the amount of object exchange gestures used by infants at 15 months was positively related to the vocabulary size of the infants at the same time point, indicating that the relative increase in these gestures, as compared to other types, may uniquely influence vocabulary acquisition.

Many other researchers have documented the utility of early deictic gestures for predicting both the onset and complexity of later vocabulary skills (Bates, et al., 1977; Colonnesi, et al., 2010; Iverson & Goldin-Meadow, 2005). In fact, gestures can be used to
predict not only how much children will say, but also which words they will say first. In a longitudinal examination of ten infants between 10 and 24 months of age, Iverson & Goldin-Meadow (2005) found that the referents identified through gesture were some of the first labels to enter into their spoken vocabularies. That is, if a child frequently points to dogs prior to the acquisition of verbal language, the word “dog” is likely to be one of the first she utters. The robust relationship between children’s early use of communicative gestures and their later vocabulary holds even when rates of maternal speech and gesture use are taken into account (Rowe, Ozcaliskan, & Goldin-Meadow, 2008). Thus, infants are independently contributing to their own language acquisition through the behaviors in which they engage before they have the capacity to speak. In fact, Butterworth (2003) contends that deictic gestures, such as pointing are the “royal road to language for babies.”

While deictic gestures may be some of the first to enter a child’s gestural repertoire, as children develop, they acquire new ways to represent meaning through movement. Symbolic gestures represent objects or events, often in a pantomimic fashion, such as sniffing pinched fingers to represent a flower, or flapping arms to represent a bird. In contrast to deictic gestures (e.g., pointing, giving, showing), which precede the onset of spoken language, there is a parallel development of symbolic gestures and spoken words, with an onset around 15 months (Acredolo & Goodwyn, 1988). However, symbolic gestures still have value for predicting the continued variability in vocabulary
acquisition, and this association may be exploited to enhance a child’s language growth. Goodwyn, Acredolo and Brown (2000) conducted an experimental study assessing the utility of symbolic gestures, revealing that when parents are specifically instructed to use symbolic gestures with their infants, beginning at 11 months, children themselves use more symbolic gestures. Most strikingly, the children whose parents received gesture training scored higher on all subsequent measures of vocabulary, as compared with controls. This study provides compelling evidence in support of the capacity of gesture to shape and drive the acquisition of a spoken vocabulary. Not only does gesture use predict later language, providing children with access to these nonverbal labels can alter the course and capacity for acquisition of verbal labels.

1.3 Dyadic interactions

The acquisition of language is, at its core, a social endeavor; we learn to speak in order to communicate our thoughts and desires to other individuals. Thus, it is appropriate that the act of acquiring a spoken vocabulary is the result of social collaboration between caregiver and child. Vygotsky (1980), well known for his sociocultural perspective on human development, asserted that learning is the result of dyadic, shared experiences between caregiver and child. In fact, he proposed his own theory about the contributions of infant gesture and parent speech to vocabulary acquisition (Vygotsky, 1961). Vygotsky contended that early preverbal gestures are egocentric; a child’s reach toward a cup is driven by desire, rather than any
communicative intent. However, this initial motor act prompts a response from a parent: “You want your cup?”. Over time, the child begins to learn that these manual acts are useful for retrieving linguistic information, as well as objects of interest. As infants acquire knowledge, through the use of their own exploration and interaction with caregivers, they become more adept at forming connections between the use of communicative cues (e.g., gestures), symbols (e.g., words), and referents (e.g., objects and events).

More recent research has provided evidence in support of Vygotsky’s theories. By the end of the first year, infants become aware of their agency, and ability to influence the behavior of their parents. In an examination of 10- to 13-month-old infants, Wu and Gros-Louis (2014) found that infants observe their parents’ attentional state and recruit different strategies for communication based on this information. For example, an infant may simply point when their parent is attentive, but use a vocalization along with their gesture if a parent doesn’t immediately respond. The type of response a parent provides following their child’s preverbal engagements is essential. When a child indicates interest or attention to a particular object or event, parents have the option of commenting on the target of interest (follow-in), or attempting to shift the focus of interest by commenting on something else (redirect). Research has consistently shown that parents who follow-in have children with larger vocabularies, as compared to those who redirect, even if the content and sophistication of parent speech is the same.
(Bornstein, Tamis-LeMonda, & Haynes, 1999; Carpenter, Nagell & Tomasello, 1998; Dunham, Dunham & Curwin, 1993; Tamis-LeMonda, Bornstein, & Baumwell, 2001). In fact, one study demonstrated that maternal verbal responsivity at 13 months had a larger impact on children’s vocabulary at 20 months than did maternal vocabulary at 13 months (Bornstein, Tamis-LeMonda & Haynes, 1999), suggesting that it is not simply how much, or what parents say, but when they say it that matters.

The research on maternal responsiveness suggests that perhaps the relationships between infant gesture and their later language can be explained by the specific responses parents provide following infant gestures. However, surprisingly little research has examined these moment-to-moment interactions between infants and parents. Masur (1982) conducted a detailed examination of four infants in interactions with their mothers during the transition from gesture to speech. Masur found that when parent responses included a larger proportion of object labels, children’s reported vocabularies were far more likely to include those object names. Similarly, an observational study on ten children followed from the onset of first words (10-14 months of age) to the emergence of two-word combinations (17-23 months of age) revealed that parent responses to infants’ gesture+speech combinations were highly predictive of the onset of the two-word stage (Goldin-Meadow, et al., 2007). While these studies lend tentative support to the child gesture > parent response > child language relationship, important questions remain.
1.4 Gaps in the literature

One of the most striking gaps in our understanding of the relations between child gesture and parent speech is that we still do not have a full developmental picture of parent and child communicative behaviors, particularly during joint-play over the course of the second year. While there is piecemeal evidence from several different studies of various age groups and developmental stages, this amalgam of studies cannot reveal the process through which infants move from first gestures to first words to more complex verbal acts. This examination of developmental process is particularly desirable given the inconsistency of relationships and patterns observed in the extant research. The initial literature reviewed made this process appear straightforward and linear (e.g., more gestures = more words). However, a deeper examination reveals this is not always the case. For example, while Butterworth (2003) has claimed that pointing is the “royal road to language”, in his own research, he found no relationships between the onset of infant pointing and either expressive or receptive measures of vocabulary at 14 months (Butterworth & Morissette, 1996). In a similar finding, while Blake and colleagues found significant concurrent relationships between object exchange gestures and vocabulary at 15 months, the amount of pointing, whether at 9 or 15 months had no relation to 15 month vocabulary (Blake et al., 1997; 2003).

In a cross-cultural analysis of the relations between gesture and language, Iverson and colleagues (2008) found that, while Italian infants outpace their American
peers in the amount of gestures used, the Italian children produced fewer words at all
time points of the longitudinal study. In Italian children, there is an inverse relationship
between the number of gestures children produce and their spoken vocabularies. The
authors argue that the smaller spoken vocabularies are a result of the Italians’ use of
representational gestures – their gestures conveyed meaning that made the use of words
redundant. It appears that the culturally-specific use of gesture and the types of gestures
produced lead to different relationships to spoken children in these children (Iverson,
Capirci, Volterra & Goldin-Meadow, 2008). Thus, whether impacted by time or by
culture, the “more is more” message appears simplistic and not adequate to capture the
nuance of infant language development. By shifting our focus to developmental process,
rather than predictors and outcomes, we can develop a better understanding of how and
when children’s gestures impact their later learning.

Another gap in the current research concerns documenting what parents are
saying in response to their infants’ gestures, and how patterns of parent-child
engagement shift over time. While maternal responsiveness to infants has generally
been implicated as an influence on language development (Carpenter, Nagell &
Tomasello, 1998), the content of these interactions and the impact of specific responses
on language learning are unclear. To their credit, a few studies have made initial forays
into examining the content of parental responses to infant gestures (e.g., Goldin-
Meadow, et al., 2007; Masur, 1982); however, these samples are small (10 and 4 dyads,
respectively) and observations of parent-child communicative interactions occur at a single time point. Therefore, it is unwise to assume that the patterns that emerge at one time point will be stable across development. There is plenty of evidence showing that the engagement styles of parents and children change over the course of development (Bigelow, MacLean & Proctor, 2004; Pellegrini, Perlmutter, Galda & Brody, 1990; Tamis-LeMonda & Bornstein, 1991). Often these changes reflect a scaffolding behavior in the parent that leads to greater mastery and skill by the child (e.g., Diaz, Neal, & Vachio, 1991; Morrissey & Brown, 2009). Furthermore, it is important to understand not only how the relationships between parent and child behavior change over time, but also to understand how the factors we know to be predictive of language learning change over time.

1.5 The current study

The current study provides new evidence detailing the process of language development through an examination of the relationships between infant gesture, parent speech, and infant vocabulary over the course of the second year (10-22 months of age). Through the use of a short-term longitudinal design, it is possible to probe these relationships, both concurrently and over time, as well as determine whether patterns of relationships change over the course of development. The current study has three primary aims: (1) To describe the developmental patterns of infant gesture use and parent talk during a joint play interaction, (2) To examine the impact that
communicative behaviors during joint play have on the partner in a moment-to-moment evaluation, (3) To determine which factors are the most valuable in predicting child language development.

1.5.1 Developmental patterns

It is important to provide an accurate description of the types of communicative behaviors parents and infants engage in during joint interactions, as well as how the frequency of particular behaviors may change over time. I predict that gesture rates at the initial time point (i.e., 10 months) would be relatively low, with steady increases over the course of the study. Furthermore, since previous research suggests that the use of symbolic gesturing suppresses the frequency of deictic gestures (Vallotton, 2010), it was expected that as rates of symbolic gesture use rise, rates of deictic gesture use would decline. Developmental changes in parent speech were also assessed, both in terms of overall quantity as well as the content of utterances directed to their infants. Based on previous research, I expected that the total number of words used by parents, as well as the number of different words used would increase over the course of the study (Bornstein, Tamis-LeMonda & Haynes, 1999; Rowe, Pan & Ayoub, 2005). Changes in the content of parent speech to developing infants are less studied, however there is some evidence to suggest that parents engage in more eliciting and scaffolding talk as their infants’ vocabulary skills increase (Kalia, Johnson, & Wilbourn, under review). Thus, I
expected that the relative proportion of questions and abstract talk (i.e., extensions) would increase over time.

1.5.2 Moment-to-moment interactions

The second aim concerns assessing the impact parents and children have on the behaviors of one another during a joint-play interaction, as well as whether these interactions change over the course of the second year. In particular, the patterns of call and response, whether child- or parent-initiated were examined, both in terms of frequency of engagement and behavior type (e.g., point, label). Previous research suggests that, as early as 10 months, infants use their gestures to intentionally engage their parents (Wu & Gros-Louis, 2014). Furthermore, children’s spontaneous engagements with parents (as opposed to prompted), increase over the course of the second year (Tamis-LeMonda & Bornstein, 1991). Thus I expected that the patterns of engagement in the current study would mirror these findings, with infant-led engagements increasing in frequency over time.

Of particular interest in the current study is an exploration of the types of speech used by parents during these engagements. For example, are parents likely to use different strategies when engaging versus responding to their infants? Can infant gesture use be predicted by the engagement style of the parent? While we know that responsiveness is an important aspect of parent-child relationships (Carpenter, Nagell & Tomasello, 1998), the content of these interactions is less understood. Based on previous
findings in book-reading contexts, I anticipated that the use of questions by parents would elicit gestural responses from their children, and that the use of gestures by children would prompt a labeling response from parents (Johnson, Shroads & Wilbourn, 2015). While the literature on developmental changes in parent-child communicative interactions is scant, I expected that the patterns of engagement would change over the course of the study. In particular, I expected that parent responses to infant gestures would increase in sophistication as children developed. That is, parent responses to gesture at 10 and 14 months were expected to contain a higher proportion of unelaborated, label-based responses (e.g., “Ball!”), while responses to older children would contain a higher proportion of complex responses, such as extensions (e.g., “That ducky is like the one you played with yesterday.”)

1.5.3 Predicting vocabulary

The final aim of the current study is to expose both the unique and joint influences of infants and parents on children’s acquisition of a spoken vocabulary. First, the relations between measures of parent speech, infant gesture and infant vocabulary were examined, both concurrently and over time. Based on the existing literature, I expected that rates of child gesture would predict child vocabulary both directly and indirectly, through parent speech, and that this relationship would be relatively stable over time.
Beyond measures of frequency of behaviors, the current study seeks to determine whether certain patterns of parent-child engagement are uniquely predictive of children’s vocabulary development. Responsive, rather than redirecting, parent speech is consistently linked to enhanced vocabulary outcomes (Carpenter, Nagell & Tomasello, 1998; Dunham, Dunham, & Curwin, 1993; Tamis, LeMonda, Bornstein, & Baumwell, 2001). However, it is unclear whether the responsiveness alone is responsible for the boost in language learning, or whether particular types of responses are particularly effective. For example, a parent responding to a child’s point saying, “Yes, I see it!”, is likely less impactful than “That is a ball!” Furthermore, the effect of developmental stage on the impact of parent speech is not well understood. While use of more sophisticated input in the form of questions or extensions may be highly predictive of vocabulary for infants at 18 or 22 months, this type of input is unlikely to be impactful at 10 months. In fact, this type of sophisticated input might be a detriment to young infants, if this level of input exceeds the child’s zone of proximal development. Therefore, I predicted that maternal utterances that follow infants’ gesture will be more impactful on infants’ vocabulary than those that precede it, however the impact of particular types of parent utterances would be variable based on infant age, with increasing sophistication playing more of a role as infants develop and acquire larger vocabularies.
2. Methods

2.1 Participants

Infants (24 female, 21 male) and their mothers (N = 45 dyads) were brought into the laboratory four times over a 12-month period, with observations at 10, 14, 18, and 22 months. Participant information was collected via public birth records, and parents were contacted by telephone once their infant reached the appropriate age range for each observation. As a token of appreciation for participation, infants received a t-shirt or board book at each visit, and parents received a customized mug and a certificate detailing their child’s vocabulary growth throughout the study, as well as up to $10 in gas compensation at each visit.

At the 10-month session, mothers’ average age was 33 years (range = 19-45 years), and 58% of infants were first-born, only children. Eighty-nine percent of mothers were married, and 96% reported that they were either the primary caregiver, or shared caregiving responsibilities equally with a partner or other individual (e.g., infant’s grandmother). The sample was primarily middle class; 84% of mothers had a college or graduate degree, and 82% reported a household income of $50,000 or higher. Eighty percent of mothers reported their race as White, 16% as Black or African-American, 2% as Asian, and 2% opted not to report. Mothers also reported their infants’ race: 76% reported their infants’ race as White, 16% as Black or African-American, 2% as more than one race, 2% as other and 4% opted not to report. While all parents reported that
English was the primary language their infant was exposed to at home, 16% reported that their infant was also regularly exposed to a language other than English. Infant ages (in months) at each observation are as follows: 10 months ($M = 10.12$, $SD = .27$), 14 months ($M = 13.90$, $SD = .26$), 18 months ($M = 17.73$, $SD = .56$), 22 months ($M = 22.13$, $SD = .91$).

Fifteen additional mother-child dyads were tested at 10 months, but were not included in the final sample due to: missing 2 or more data collections ($n = 9$), missing data from the first or last data collection ($n = 2$), or reporting a primary home language other than English ($n = 4$). There were no significant differences between those included in the sample and those not included on any of the reported demographic characteristics.

### 2.2 Measures and stimuli

To assess toddlers’ oral language skills, mothers completed the short-form version of the MacArthur-Bates Communicative Development Inventory (Fenson, et al., 2000). This provided a measure of toddlers’ receptive vocabulary (e.g., the words a toddler understands) and expressive vocabulary (e.g., the words a toddler understands and says).

At each session, parents and infants were provided with a selection of 12 toddler-friendly toys. These toys were specifically selected to be balanced on a number of
attributes, including color and toy type (e.g., animal, vehicle, food). A complete list of these toys, can be seen in Appendix I.

2.3 Procedure

The sessions took place in a 3.5 m x 6.5 m room in the laboratory space. The play interactions took place on a white area rug placed in the center of the room. Two handheld cameras on tripods captured the sessions, and a separate camera feed was streamed to an adjoining room so the sessions could be monitored.

After obtaining informed consent for both mother and child, the dyads participated in both a book-reading interaction and a free play interaction. The order of interactions was counterbalanced across participants, but consistent within participants (i.e., dyads who participated in the free play interaction first at the 10-month session did so at all subsequent sessions). The current study specifically examines parent and child behaviors during the free play interaction. Free play interactions with toys have often been used to assess communicative, dyadic interactions with mothers and young children (e.g, Carpenter, Nagell & Tomasello, 1998; Choi, 2000; Pancsofar & Vernon-Feagans, 2006; Tamis-LeMonda & Bornstein, 1991). Furthermore, joint play allows for face-to-face interaction between mother and child and is culturally and developmentally universal, which makes assessment of this task preferable to assessment of the book-reading interaction for the purposes of the current study.
In the free play interaction, parents were instructed that they had ten minutes to interact freely with their infant, but were welcome to end the session or take a break (e.g., for changing or feeding) at any time if they wished. There were no restrictions or instructions provided to the parent about the nature of their interaction with the infant during the session. The research assistant then produced the toys and left to monitor the session from the adjoining room.

2.4 Coding

The videotaped play interactions were transcribed verbatim. Each transcript was also checked by an additional trained research assistant to ensure accuracy, and any remaining discrepancies or inaudible segments were checked by a third individual.

Following transcription, the transcripts were formatted and coded using the Systematic Analysis of Language Transcripts - Research Version software program (SALT; Miller & Chapman, 2004). Research assistants involved in coding were trained in SALT conventions, as well as the codes specific to the current project over the course of 3-4 weeks (approximately 8-10 hours per week). After the completion of training, coded transcripts were regularly reviewed and any issues or discrepancies are discussed and resolved during weekly meetings to ensure consistency. A secondary research assistant independently coded 10% of transcripts to ensure reliability. Reliability for all coding was assessed using Krippendorff’s alpha, which is an appropriately conservative test of reliability for nominal data across multiple coders (Hayes & Krippendorff, 2007).
2.4.1 Parent speech

Parent speech was assessed and coded at each time point. From the data available in the transcripts, calculations were performed using SALT to assess various global measures of maternal speech, including the number of words produced per minute (WPM) and the number of different root words produced (NDW).

The content of maternal speech was also coded using SALT. This coding was done at the level of the utterance, which is a unit of the speech stream that can be easily separated, whether by pauses, syntactic completeness, or logical completeness. Each utterance was classified as belonging to one of six primary categories, using coding conventions similar to those of other researchers in the field (e.g., Abraham, Craig, Vernon-Feagans, and the Family Life Project Investigators, 2013; Danis, Bernard & Leproux, 2000; Kalia, Johnson & Wilbourn, under review). These categories were: (1) Labels, which provide a name for something; (2) Questions, which are a clear request for an informative or behavioral response; (3) Extensions, which provide information beyond what is readily observable, (4) Comments, which serve as a narrative of events or behaviors; (5) Behavior Modifications, which are focused on the behavioral or attentional behaviors of the child; and (6) Other Utterances, which include non-informative content, such as onomatopoeia or imitations. In order to further describe the content and function of maternal speech, each utterance was also coded into a more specific subtype. For example, the utterance “Ball.” would be coded as a Label, as well as a Simple Noun.
Phrase. Similarly, “He’s running down the street!” would be coded as a Label and an Elaborated Verb Phrase. A full list of utterance categories and subtypes can be found in Table 1. Krippendorff’s $\alpha = .92$ for category and .87 for subtype.

### 2.4.2 Child gestures

Children’s gestural behaviors were also assessed and coded at each time point, using conventions similar to those of other researchers in the field (e.g., Blake, 2000; Capone & McGregor, 2004; Goodwyn & Acredolo, 1993; Iverson, Capirci, Longobardi & Caselli, 1999). For the purposes of the current study, I was interested in coding gestures that were either intentionally communicative (deliberately intended to signal a message to the mother) or symbolically representative (able to stand in the place of a referent label), or both.

Most of the early gestures young children produce are object-oriented. Young children frequently hold up toys to show their parents or use pointing gestures to single out objects of interest. These gestures require the presence of a referent in order to be meaningful. However, not all object-oriented acts are intentionally communicative; thus, coders were trained extensively in distinguishing which actions to code as a gesture, and which to pass by as a manual act that was not intentionally communicative.
Table 1: Classification of parent utterances.

<table>
<thead>
<tr>
<th>Parent Utterance</th>
<th>Definition</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Labels</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Simple Noun Phrase</em></td>
<td>Naming or labeling of an object</td>
<td>“This is broccoli.”</td>
</tr>
<tr>
<td><em>Elaborated Noun Phrase</em></td>
<td>Labeling an object with modification or elaboration</td>
<td>“Look at the yellow ducky!”</td>
</tr>
<tr>
<td><em>Descriptions</em></td>
<td>Adjective or modifying content</td>
<td>“That’s green.”</td>
</tr>
<tr>
<td><em>Emotions</em></td>
<td>Label for emotional states</td>
<td>“Look how happy he is!”</td>
</tr>
<tr>
<td><em>Simple Verb Phrase</em></td>
<td>Labeling of an action</td>
<td>“The frog is jumping.”</td>
</tr>
<tr>
<td><em>Elaborated Verb Phrase</em></td>
<td>Labeling an action with modification or elaboration</td>
<td>“He’s running so fast!”</td>
</tr>
<tr>
<td><strong>Questions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Simple</em></td>
<td>Questions about observable events</td>
<td>“What do you do with a spoon?”</td>
</tr>
<tr>
<td><em>Elaborative</em></td>
<td>Questions that require abstraction</td>
<td>“How did he get so dirty?”</td>
</tr>
<tr>
<td><em>Polar</em></td>
<td>Yes-No questions</td>
<td>“Can I take that apple from you?”</td>
</tr>
<tr>
<td><em>Prompting</em></td>
<td>Request for action from the child</td>
<td>“Right?”</td>
</tr>
<tr>
<td><em>Clarifications</em></td>
<td>Request for more information</td>
<td>“What did you say?”</td>
</tr>
<tr>
<td><strong>Extensions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Attribution to Stimuli</em></td>
<td>Inference made regarding the stimuli</td>
<td>“The ducky wants a hug!”</td>
</tr>
<tr>
<td><em>Attribution to Child</em></td>
<td>Inference made regarding the child</td>
<td>“You’re tired.”</td>
</tr>
<tr>
<td><em>Connection to Object</em></td>
<td>Statement linking two objects</td>
<td>“The ball is green like the frog.”</td>
</tr>
<tr>
<td><em>Connection to Event</em></td>
<td>Statement linking two events</td>
<td>“You ate green beans yesterday.”</td>
</tr>
<tr>
<td><em>Connection to Individual</em></td>
<td>Statement referencing non-present third party</td>
<td>“Your sister would love that toy.”</td>
</tr>
<tr>
<td>Parent Utterance</td>
<td>Definition</td>
<td>Example</td>
</tr>
<tr>
<td>------------------</td>
<td>------------------------------------------------</td>
<td>----------------------------------------------</td>
</tr>
<tr>
<td><strong>Comments</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>On Self</em></td>
<td>Comment on own behavior or thoughts</td>
<td>“Mommy’s gonna draw a picture.”</td>
</tr>
<tr>
<td><em>On Child</em></td>
<td>Comment on behavior of the child</td>
<td>“You made a loud noise!”</td>
</tr>
<tr>
<td><em>Praise</em></td>
<td>Praise for the child or their behavior</td>
<td>“Good job!”</td>
</tr>
<tr>
<td><em>Reassurance</em></td>
<td>Reassurance or comfort for child</td>
<td>“It’s okay.”</td>
</tr>
<tr>
<td><em>Exclamation</em></td>
<td>Non-informative exclamatory utterance</td>
<td>“Oh my goodness!”</td>
</tr>
<tr>
<td><em>Acknowledgement</em></td>
<td>Affirming phrase or utterance acknowledging child</td>
<td>“Uh-huh.”</td>
</tr>
<tr>
<td><em>General</em></td>
<td>Comment on task</td>
<td>“Let’s see what other toys there are”</td>
</tr>
<tr>
<td><em>Instructive</em></td>
<td>Abstract information about what is generally “true”</td>
<td>“Baseball is not for inside.”</td>
</tr>
<tr>
<td><strong>Behavior Modifications</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Prohibition</em></td>
<td>Negation of child behavior</td>
<td>“Don’t do that.”</td>
</tr>
<tr>
<td><em>Directive</em></td>
<td>Instruction for behavior</td>
<td>“Be gentle!”</td>
</tr>
<tr>
<td><em>Attention-Directing</em></td>
<td>Instruction to attend to a particular object or event</td>
<td>“Look here.”</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Onomatopoeia</em></td>
<td>Sound-like words</td>
<td>“Quack quack!”</td>
</tr>
<tr>
<td><em>Imitating</em></td>
<td>Mimicking of infant vocalization or babble</td>
<td>“Ba ba”</td>
</tr>
<tr>
<td><em>Modeling</em></td>
<td>Explicit modeling of specific sounds</td>
<td>“Da!”</td>
</tr>
<tr>
<td><em>Ritual</em></td>
<td>Songs or rhymes serving a ritualized function</td>
<td>“E-I-E-I-O!”</td>
</tr>
<tr>
<td><em>Incomplete</em></td>
<td>Interrupted or abandoned utterance</td>
<td></td>
</tr>
<tr>
<td><em>Unclear</em></td>
<td>Parent utterance is unintelligible</td>
<td></td>
</tr>
</tbody>
</table>
In contrast to object-oriented gestures are those that convey meaning regardless of the presence of their referent. For example, the act of flapping arms to indicate “bird” can occur with an actual bird present or not, and the meaning doesn’t change appreciably. These gestural acts are symbols of their referents, and thus indicate a sophisticated communicative ability on the part of the child that I wanted to capture in my coding scheme.

The finalized coding scheme consisted of five main categories: (1) Deictic Gestures (e.g., pointing, giving), (2) Gestural Requests (e.g., reaching), (3) Conventionalized Gestures (e.g., holding both arms to indicate “so big!”), (4) Representational Gestures (e.g., holding circled hands to eyes to indicate “binoculars”), (5) Arbitrary Gestures (i.e., opening and closing hand to produce the ASL sign MILK). The deictic and request categories also included subtypes to further distinguish specific gestures of interest (e.g., pointing vs. showing). A full list of gesture categories and subtypes to be coded can be found in Table 2. Krippendorff’s α = .93 for category and .91 for subtype.

Because a primary aim of the current study is to examine contingent linkages between parent speech and infant gestures, each gesture was also coded to indicate whether the gesture was independently produced by the child or prompted by the mother. If the gesture was determined to be independently produced, the codes associated with the parent utterance immediately following the gesture were recorded. If the gesture was identified as being prompted by the parent, the codes associated with
the utterance immediately preceding the gesture were recorded. In both cases, if a parent utterance was not produced within 2 seconds of the onset or offset of the child’s gesture, then no parent utterance was recorded.

Table 2: Classification of child gestures.

<table>
<thead>
<tr>
<th>Child Gesture Type</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Deictic</strong></td>
<td></td>
</tr>
<tr>
<td>Proximal Pointing</td>
<td>A well-formed, clear, and intentional finger extension that physically touches the object of interest</td>
</tr>
<tr>
<td>Distal Pointing</td>
<td>A single-finger extension toward a specific person, object, location, or event</td>
</tr>
<tr>
<td>Indicating</td>
<td>A gesture that serves to single out a person, object, location, or event through movements of the whole hand, the head, or direct contact with target (e.g., chin point, moving object)</td>
</tr>
<tr>
<td>Showing/Giving</td>
<td>Movement of an object of interest into the center of the gesture space, or into the direct eye line of the partner</td>
</tr>
<tr>
<td>Acting on other</td>
<td>An active manipulation of the hand or arm of the other partner to indicate a target of interest</td>
</tr>
<tr>
<td><strong>Requestive</strong></td>
<td></td>
</tr>
<tr>
<td>Reaching</td>
<td>A whole-hand extension that may be accompanied by grasping motion of the fingers</td>
</tr>
<tr>
<td>Up/Down</td>
<td>Arms uplifted toward the parent, or extended toward the ground to indicate a request to be picked up or put down, respectively</td>
</tr>
<tr>
<td><strong>Conventionalized</strong></td>
<td>Gestures indicative of practiced routines or cultural norms. (e.g., lifting arms to indicate “so big!”; shaking head to indicate “no”)</td>
</tr>
<tr>
<td><strong>Representational</strong></td>
<td>Gestures that represent objects, persons, locations or events through hand or body movements (e.g., holding circled hands to eyes for “binoculars”)</td>
</tr>
<tr>
<td><strong>Arbitrary</strong></td>
<td>Gestures whose form has no clear representational relationship to the target referent (e.g., American Sign Language)</td>
</tr>
</tbody>
</table>
3. Results

3.1 Developmental patterns

The first aim of the proposed study is to examine developmental changes in infant gesture and parent speech over the course of the second year. To accomplish this goal, a series of mixed-model ANOVAs and MANOVAs including child Sex and Age as predictors were conducted. First, the effect of child age on parent talk was assessed. Outcome variables included global measures (NDW, WPM) as well as the proportions of parent utterances falling into each main category (Labels, Questions, Extensions, Comments, Behavior Modifications).

Subsequently, the effect of child age on child gesture use was assessed. Outcome variables included total number of child gestures produced, as well as proportions of child gesture use within main categories. For the purposes of these analyses, the Deictic category was split into “Points” (includes proximal and distal pointing) and “Deictic” (includes showing/giving, indicating and acting on other), while Conventionalized, Representational and Arbitrary gestures were collapsed into a single “Symbolic” category. Request gestures remained as coded.

Finally, the effect of child age on child vocabulary was assessed, with both Receptive and Expressive vocabulary as outcome variables.
3.1.1 Parent Talk

In order to assess changes in global measures of parent talk over time, a 2 x 4 mixed-model MANOVA was conducted, with Sex (male vs. female) as a between-subjects variable and Age (10, 14, 18, 22 months) as a within-subjects variable and parent Number of Different Root Words (NDW) and Words per Minute (WPM) as dependent variables. Multivariate tests revealed a main effect of Age, Wilk’s $\lambda = .337$, $F(2, 40) = 11.78$, $p < .001$, multivariate $\eta^2 = .663$. No main effects or interactions based on child sex emerged.

Univariate analyses revealed an effect of Age on both NDW, $F(3, 123) = 20.86$, $p < .001$, $\eta^2 = .337$, and WPM $F(3, 123) = 25.37$, $p < .001$, $\eta^2 = .382$. Planned contrasts were conducted to examine more specifically how parent talk changed based on child Age. The results of these analyses revealed that the Number of Different Root Words parents produced was significantly higher when their child was 18-months-old ($M = 161.74$, $SD = 33.43$) as compared to 14-months-old ($M = 140.47$, $SD = 32.45$), $F(1, 41) = 29.48$, $p < .001$.

There was also a significant increase in the Words per Minute at 18 months ($M = 58.61$, $SD = 18.48$) as compared to 14 months ($M = 51.82$, $SD = 17.97$), $F(1, 41) = 10.13$, $p = .003$, and at 22 months ($M = 66.13$, $SD = 17.36$) as compared to 18 months, $F(1, 41) = 29.86$, $p < .001$. All other repeated-measures contrasts were non-significant ($p > .05$).

In order to examine changes in the content of parent talk over the second year, a second 2 x 4 mixed-model MANOVA was conducted, with child Sex (male vs. female) as
a between-subjects variable and Age (10, 14, 18, 22 months) as a within-subjects variable and parent Proportion of Utterance Type (Label, Question, Extension, Comment, and Behavior Modification) as dependent variables. Multivariate tests revealed a main effect of Age, Wilk’s $\lambda = .239$ $F(5, 37) = 5.739$, $p < .001$, multivariate $\eta_p^2 = .761$. No main effects or interactions based on child sex emerged.

Univariate analyses revealed an effect of Age on all five dependent variables (see Table 3). Planned contrasts were conducted to examine more specific effects of child Age on parent Proportion of Utterance Type. Results revealed that between 10 and 14 months, proportions of Labels and Extensions used by parents decreased, while proportions of Comments and Behavior Modifications increased. Between 14 and 18 months, proportions of Labels used by parents increased, while proportions of Comments and Behavior Modifications decreased. Between 18 and 22 months proportions of Labels used by parents decreased, while proportions of Questions increased. Figure 1 depicts the results of planned contrasts, and F-statistics and Mean values for significant contrasts can be found in Appendix B. All other repeated-measures contrasts were non-significant ($p > .05$).
Table 3: Univariate statistics for the effect of child age on proportion of parent utterance type.

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>$df, df_{error}$</th>
<th>$F$</th>
<th>$p$-value</th>
<th>$\eta^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion of Labels</td>
<td>3, 123</td>
<td>4.90</td>
<td>.003</td>
<td>.107</td>
</tr>
<tr>
<td>Proportion of Questions</td>
<td>3, 123</td>
<td>6.76</td>
<td>&lt;.001</td>
<td>.142</td>
</tr>
<tr>
<td>Proportion of Extensions</td>
<td>3, 123</td>
<td>3.71</td>
<td>.013</td>
<td>.083</td>
</tr>
<tr>
<td>Proportion of Comments</td>
<td>3, 123</td>
<td>9.98</td>
<td>&lt;.001</td>
<td>.196</td>
</tr>
<tr>
<td>Proportion of Behavior Modifications</td>
<td>3, 123</td>
<td>9.79</td>
<td>&lt;.001</td>
<td>.192</td>
</tr>
</tbody>
</table>

Figure 1. Planned contrasts of proportions of parent utterance types by child age

Note: * = $p < .05$, ** = $p < .005$; Means and F-statistics reported in Appendix B.
3.1.2 Measures of child communication

3.1.2.1 Child gesture use

In order to assess changes in child gesture use over time, a 2 x 4 mixed-model ANOVA was conducted, with Sex (male vs. female) as a between-subjects variable and Age (10, 14, 18, 22 months) as a within-subjects variable and Number of Child Gestures as the dependent variable. Results revealed a main effect of Age, $F(3, 123), p < .001, \eta^2_p = .420$, as well as an Age x Sex interaction, $F(3,123), p = .002, \eta^2_p = .114$.

Planned contrasts show that the mean Number of Gestures children used increased significantly between 10 months ($M = 2.30, SD = 2.95$) and 14 months ($M = 8.65, SD = 7.42$), $F(1, 41) = 35.50, p < .001$. Gesture use also increased between 14 and 18 months ($M = 13.07, SD = 8.12$), $F(1, 41) = 13.54, p = .001$, but appeared to level off between 18 and 22 months ($M = 13.77, SD = 8.67$), $F(1, 41) = .223, p = .640$. In order to probe the Age x Sex interaction, post-hoc comparisons of gesture rates by child sex at each time point were conducted. These revealed a significant difference in mean rates of gesture between males and females at 14 months (males: $M = 4.62, SD = 5.91$; females: $M = 11.96, SD = 7.05$) $t(42) = 3.72, p = .001$ (Figure 2). All other planned and post-hoc contrasts were non-significant ($p > .05$).
In order to explore changes in children’s use of particular gesture types over time, a 2 x 4 mixed-model MANOVA was conducted, with Sex (male vs. female) as a between-subjects variable and Age (10, 14, 18, 22 months) as a within-subjects variable and child Proportion of Gesture by Category (Deictic, Point, Request and Symbolic). Multivariate tests revealed no main effects of Age or child Sex. However, because I was specifically interested in examining patterns of change in particular gesture categories over time, planned contrasts were conducted. These analyses revealed significant increases in the proportion of Deictic gestures used by children between 10 months ($M = .55, SD = .40$) and 14 months ($M = .71, SD = .23$), $F(1, 30) = 4.48, p = .043$, and significant

![Figure 2. Rates of gesture use by male and female children at each observation](image)

In order to explore changes in children’s use of particular gesture types over time, a 2 x 4 mixed-model MANOVA was conducted, with Sex (male vs. female) as a between-subjects variable and Age (10, 14, 18, 22 months) as a within-subjects variable and child Proportion of Gesture by Category (Deictic, Point, Request and Symbolic). Multivariate tests revealed no main effects of Age or child Sex. However, because I was specifically interested in examining patterns of change in particular gesture categories over time, planned contrasts were conducted. These analyses revealed significant increases in the proportion of Deictic gestures used by children between 10 months ($M = .55, SD = .40$) and 14 months ($M = .71, SD = .23$), $F(1, 30) = 4.48, p = .043$, and significant
decreases between 14 and 18 months ($M = .56, SD = .26$), $F(1, 30) = 6.44, p = .017$. In contrast, children showed significant increases in the proportion of Point gestures used between 14 months ($M = .16, SD = .18$) and 18 months ($M = .28, SD = .24$), $F(1, 30) = 6.05, p = .020$. All other repeated-measures contrasts were non-significant ($p > .05$).

3.1.2.2 Child vocabulary

In order to assess changes in child vocabulary over time, a 2 x 4 mixed-model MANOVA was conducted, with Sex (male vs. female) as a between-subjects variable and Age (10, 14, 18, 22 months) as a within-subjects variable and child Receptive and Expressive Vocabulary as the dependent variables. Multivariate tests revealed a main effect of Age, Wilk’s $\lambda = .042, F(2, 36) = 11.78, p < .001$, multivariate $\eta^2 = .958$. No main effects or interactions based on child sex emerged.

Univariate analyses revealed an effect of Age on both Receptive Vocabulary, $F(3, 123) = 23.60, p < .001$, $\eta^2 = .365$, and Expressive Vocabulary $F(3, 123) = 148.58, p < .001$, $\eta^2 = .784$. Planned contrasts conducted to examine more specifically how child Vocabulary changed based on child Age revealed consistent increases in both Receptive and Expressive Vocabulary through 18 months. Between 18 and 22 months, Expressive Vocabulary continued to increase, while Receptive Vocabulary showed a significant decrease (see Table 4).
Table 4: Significant results of planned contrasts of receptive and expressive vocabulary by Age.

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>df, df\text{error}</th>
<th>F</th>
<th>p-value</th>
<th>Child Age</th>
<th>M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receptive Vocabulary</td>
<td>1, 41</td>
<td>49.03</td>
<td>&lt;.001</td>
<td>10 months</td>
<td>9.51</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>14 months</td>
<td>24.23</td>
</tr>
<tr>
<td></td>
<td>1, 41</td>
<td>12.13</td>
<td>.001</td>
<td>14 months</td>
<td>24.23</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>18 months</td>
<td>31.93</td>
</tr>
<tr>
<td></td>
<td>1, 41</td>
<td>14.03</td>
<td>.001</td>
<td>18 months</td>
<td>31.93</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>22 months</td>
<td>21.40</td>
</tr>
<tr>
<td>Expressive Vocabulary</td>
<td>1, 41</td>
<td>48.89</td>
<td>&lt;.001</td>
<td>10 months</td>
<td>.95</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>14 months</td>
<td>4.98</td>
</tr>
<tr>
<td></td>
<td>1, 41</td>
<td>55.26</td>
<td>&lt;.001</td>
<td>14 months</td>
<td>4.98</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>18 months</td>
<td>19.09</td>
</tr>
<tr>
<td></td>
<td>1, 41</td>
<td>102.14</td>
<td>&lt;.001</td>
<td>18 months</td>
<td>19.09</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>22 months</td>
<td>48.86</td>
</tr>
</tbody>
</table>

3.2 Patterns of engagement

The second aim of the current study was to explore the contingent, moment-to-moment nature of dyadic communicative interactions in which children communicate using gestures (what I will refer to as “gestural interactions”). First, I was interested in determining who is driving child gesture use during gestural interactions, and whether initiation patterns change between 10 and 22 months. To accomplish this, a mixed-model ANOVA assessing change in the proportions of child-led gestural interactions was conducted.

Second, I was interested in examining what types of utterances parents produce during gestural interactions, and whether this varied based on initiation style (i.e., parent-led vs. child-led). Proportions of utterance types within parent-led and child-led
gestural interactions at all four ages were calculated. A series of paired-samples t-tests were then conducted to determine the whether particular utterance types were significantly more likely to occur in parent-led vs. child led interactions.

Finally, I was interested in classifying patterns of development in dyadic communicative interactions using a more holistic approach. To accomplish this, a person-centered approach was utilized (Magnusson, 1998). First, hierarchical cluster analysis was utilized to classify dyads based on children’s use of Deictic and Point gestures in child-led gestural interactions, and the proportion of Informative parent responses to child gesture (Ward, 1963). In order to assess patterns of stability and change in mother-child interactions across development, I employed I-States as Objects Analysis (ISOA; Bergman, Nurmi & von Eye, 2012; Magnusson, 1998). ISOA is based on the assumption that approximately the same patterns of clusters emerge at all time points, while the proportion belonging in each cluster is variable, and dyads may move between clusters at different time points. Thus, this approach is particularly well-suited for short-term longitudinal studies, and was considered an appropriate analytical tool for assessing changes in parent-child interaction styles in the current study.

### 3.2.1 Contingencies in gestural interactions

In order to assess patterns of initiation in gestural interactions over the course of the second year, a 2 x 4 mixed-model ANOVA was conducted, with Sex (male vs. female) as a between-subjects variable and Age (10, 14, 18, 22 months) as a within-
subjects variable and Proportion of Child-Initiated Interactions as the dependent variable. Results revealed no significant main effect of Age or Sex and no interactions, indicating that the proportion of child initiation is relatively stable over time. Indeed, children initiated the majority of communicative interactions in which they gestured at all ages, with mean proportions as follows: 10 months ($M = .89, SD = .22$); 14 months ($M = .82, SD = .24$); 18 months ($M = .83, SD = .19$); 22 months ($M = .85, SD = .18$).

To better understand how the types of utterances parents produce differ in parent-led vs. child-led gestural interactions, a series of paired-samples t-tests were conducted. Each test compared the proportion of parent utterance type in parent-led interactions to the proportion of the same utterance type in child-led interactions. Significant results ($p <.05$) are presented in Table 5. All other tests were non-significant ($p > .05$).
### Table 5: Significant results of paired-samples t-tests comparing proportion of utterance types in parent-led and child-led gestural interactions

<table>
<thead>
<tr>
<th>Child Age</th>
<th>Dependent Variables</th>
<th>df</th>
<th>t</th>
<th>p-value</th>
<th>Gestural Interaction</th>
<th>M</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 months</td>
<td>Labels</td>
<td>8</td>
<td>-2.749</td>
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<td>.00</td>
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<tr>
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<td>Questions</td>
<td>8</td>
<td>2.701</td>
<td>.027</td>
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<td>.61</td>
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<tr>
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<td>Labels</td>
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<td>.003</td>
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<td>.07</td>
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<tr>
<td></td>
<td>Questions</td>
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<td>2.469</td>
<td>.022</td>
<td>Parent-led</td>
<td>.46</td>
</tr>
<tr>
<td></td>
<td>Comments</td>
<td>21</td>
<td>-2.871</td>
<td>.009</td>
<td>Parent-led</td>
<td>.05</td>
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<tr>
<td>18 months</td>
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<td>.032</td>
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<td>.15</td>
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<td>Questions</td>
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<td>3.922</td>
<td>.001</td>
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<td>.51</td>
</tr>
<tr>
<td></td>
<td>Labels</td>
<td>28</td>
<td>-4.287</td>
<td>&lt;.001</td>
<td>Parent-led</td>
<td>.07</td>
</tr>
<tr>
<td>22 months</td>
<td>Questions</td>
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<td>4.273</td>
<td>&lt;.001</td>
<td>Parent-led</td>
<td>.53</td>
</tr>
<tr>
<td></td>
<td>Behavior Modifications</td>
<td>28</td>
<td>2.162</td>
<td>.039</td>
<td>Parent-led</td>
<td>.17</td>
</tr>
</tbody>
</table>

#### 3.2.2 Person-centered analyses of dyadic engagement

All observations in which children gestured at least once were included in the ISOA (N = 159). Variables included in the ISOA were standardized values of: (1) the frequency of object exchange gestures used by children (giving/showing and requests), (2) the frequency of pointing gestures used by children (proximal and distal pointing), and (3) the proportion of informative responses mothers provided to child gestures.
(Labels and Extensions). Prior to standardization, outliers were detected for the frequency of pointing, as well as for the frequency of deictic gesturing and were winsorized in order to maintain the full sample without exerting undue influence on cluster formation (Ghosh & Vogt, 2012). I examined cluster solutions with 2 to 5 clusters. The agglomeration schedule suggested that a solution including either three or four clusters would be most appropriate. The four-cluster solution produced the smallest number of clusters that accounted for at least 50% of the variance in each of the clustering variables. The four-cluster solution divided the first cluster from the three-cluster solution into two distinct clusters that mapped on to theoretically-relevant parent and child communicative behaviors. Conversely, a five-cluster solution further split the first cluster into two groups that were not pragmatically different from one another.

Using all these methods, a four-cluster solution was ultimately selected.

3.2.2.1 Cluster characteristics

The final cluster solution produced four clusters based on patterns of children’s gestural behaviors and parents’ responses to those gestures. The profiles of these clusters can be seen in Figure 3.
Figure 3. Final four-cluster solution showing mean standardized scores of the three clustering variables

The first cluster contained i-states classified as “Deictic” ($n = 62$). These individuals had average rates of child pointing and parent informative response, but were higher than the other clusters in their use of object exchange gestures (i.e., showing, giving, requests). The second cluster contained i-states that were within one standard deviation of the mean on all variables, and thus were classified as “Average” ($n = 36$). The third cluster contained i-states classified as “Point” ($n = 11$) due to the high frequency of child pointing gestures, and average scores on other variables. The final
cluster, termed “Informative” ($n = 50$) contained i-states in which the proportion of informative responses used by the parents is relatively high and other variables are near the mean. Because the ISOA clustering was only conducted using observations containing child gestures, a “No Gesture” group was also independently classified in order to include these dyads in subsequent analyses.

3.2.2.2 Shifts in cluster membership

Due to the relatively small number of dyads in each cluster at each time point, statistical tests of specific patterns of change in cluster membership could not be reliably conducted. However, Figure 4 provides a visual representation of these shifts. Thin arrows represent a movement of 1-5 dyads, and thick arrows represent a movement of 5-10 dyads. General trends reveal increases in the number of dyads over time in the Deictic and Point clusters, and decreases in the Average, Informative and No Gesture groups.
Figure 4. Visual representation of dyadic movement between clusters at each age.

Note: Thick arrows indicate a movement of 5-10 dyads, and thin arrows indicate a movement of 1-4 dyads.
3.3 Relations to vocabulary

The final aim of the current study is to examine relationships between dyadic characteristics and child vocabulary in order to determine which factors are most influential in predicting vocabulary growth and outcomes in the second year.

First, clusters identified in the ISOA were included as predictors in a series of one-way, MANOVAs predicting both concurrent and prospective measures of receptive and prospective vocabulary. Because I was particularly interested in contrasting the influence of the Deictic group with the Point group, and the influence of the Average group with the Informative group, a series of independent-samples t-tests examining differences in vocabulary at each time point were also conducted.

The second analysis assessed concurrent and prospective relationships between global measures of parent speech (number of different root words) and child gesture (overall frequency), and reports of child vocabulary. The measure of NDW for parent talk was specifically selected based on evidence showing that this measure is a strong predictor of child vocabulary growth in the second year (Bornstein, Tamis-LeMonda & Haynes, 1999). To examine these relationships, a cross-lagged panel design was employed (Biesanz, 2012). This design involves an examination of two or more variables across time, in which each variable is a function of previous values of all other variables. The longitudinal nature of cross-lagged panel designs allows for stronger causal inference, should significant prospective relationships emerge.
Finally, I examined whether specific types of parent utterances (Label, Question, Comment, Extension, Behavior Modification) were differentially associated with child vocabulary, concurrently or prospectively, across ages.

### 3.3.1 Cluster membership

I was interested in examining whether the more holistic dyad-based grouping variables that emerged using cluster analysis could be reliably used to predict vocabulary. First, I conducted a series of one-way MANOVAs with group membership at each time point (Deictic, Average, Point, Informative and No Gesture) as predictors, and Expressive, Receptive and Total Vocabulary at concurrent and subsequent time points as dependent variables. The results of these MANOVAs revealed no multivariate or univariate effects at any age (all $p's > .05$).

Because I was specifically interested in contrasting the Deictic group with the Point group, and the Average group with the Informative group, follow-up analyses were conducted. First, I examined whether there were significant differences in vocabulary based on membership in one of the two gesture-defined groups (Deictic and Point) using a series of independent-samples t-tests, beginning at the 14-month time point. Each test compared child scores on receptive, expressive and total vocabulary across these two groups. No significant differences were found in vocabulary based on membership in the Deictic vs. Point group at any age (all $p's > .05$).
Next, I examined whether differences in vocabulary could be attributed to membership in one of the two parent-response groups (Average and Informative). Again, a series of independent-samples t-tests were used. Children in the Average group at 14 months had larger total vocabularies at the same time point than children in the Informative group, \( t(21) = 2.148, p = .044 \) (\( M_{\text{Average}} = 32.86, SD = 15.19; M_{\text{Informative}} = 20.56, SD = 9.82 \)). Conversely, children in the Average group at 18 months had smaller expressive vocabularies at the same time point than children in the Informative group, \( t(18) = -2.321, p = .032 \) (\( M_{\text{Average}} = 15.25, SD = 12.67; M_{\text{Informative}} = 28.38, SD = 11.92 \)). No other significant differences emerged (all \( p \)'s > .05).

### 3.3.2 Global measures

The relations between parent NDW, child gesture frequency and child total vocabulary were investigated using cross-lagged panel design, which is depicted as a path model in Figure 5. The overall fit of the model was assessed using CFI, RMSEA, and SRMR. Generally, good-fitting models should have a CFI greater than .95, an RMSEA below .08, and SRMR less than .08 (Bentler, 1990; West, Taylor, & Wu, 2013).
Initial model fit was poor ($CFI = 0.91$, $RMSEA 90\% CI [.055, .184]$, $SRMR = .07$). Modification indices suggested that allowing parameters to be estimated for the regression of Parent NDW at 18 months on Parent NDW at 10 months, as well as for the regression of Child Gesture at 18 months on Child Gesture at 10 months would improve model fit. Indeed, when these paths were included, model fit improved substantially ($CFI = 1.00$, $RMSEA 90\% CI [.000, .081]$, $SRMR = .04$). The final model is represented with
all significant pathways displayed in Figure 6. It must be noted, however, that because the model had fewer known values than unknown parameters, it is underidentified, and while findings from the model provide an indication of what is going on in parent-child play interactions over the second year, the results may not be generalizable and should be interpreted with caution.

Figure 6. Final cross-lagged model
3.3.3 Content of parent speech

Finally, I examined whether the content of parent speech could be used to explain variability in children’s vocabulary scores. First, concurrent associations between proportions of parent utterance types and children’s vocabularies at each time point were examined using correlations. At 10 months, the proportion of Behavior Modification utterances used by parents was positively correlated with the child’s expressive vocabulary \( r(45) = .517, p < .001 \). At 18 months, the proportion of Extensions utterances used by parents was negatively correlated with the child’s expressive vocabulary \( r(44) = -.324, p = .032 \). No other significant concurrent associations between parent utterances and child vocabulary emerged at any age (all \( p's > .05 \)).

Next, prospective relationships between child vocabulary and parent utterance types were assessed. Because of the numerous predictors and outcomes involved, correlations were again used to provide a better overall picture of the relations between these variables. The analyses were conducted such that child vocabularies at the final three observations were assessed in relation to parent utterances at each previous observation (e.g., child vocabulary at 22 months correlated with parent utterance types at 10, 14 and 18 months).

This approach yielded positive associations between children’s vocabularies at the 14- and 18-month observations and a number of parent speech variables. At 14 months, child expressive vocabulary was negatively associated with the proportion of
Question utterances parents produced at 10 months $r(44) = -.378, p = .011$. At 18 months, child expressive vocabulary was positively associated with the proportion of Behavior Modifications at 10 months $r(44) = .394, p = .008$ and 14 months $r(44) = .444, p = .003$. Conversely, 18 month expressive vocabulary was negatively associated with the proportion of Extensions at 10 months $r(44) = -.324, p = .032$. Similarly, receptive vocabulary at 18 months was negatively associated with the proportion of Extensions at 14 months $r(44) = -.303, p = .048$. No significant associations between child vocabulary measures at 22 months and preceding parent speech variable emerged. All other prospective associations were non-significant ($p$’s $>.05$).

4. Discussion

The motivation for the current study originated from two major gaps in the literature on infant communicative development. First, while there is a great deal of research demonstrating significant and persistent relationships between child gesture and language, there is no single study detailing developmental changes in the nature and impact of these relationships within individuals over several observations. While it may be possible to piece together a general developmental picture from the existing literature, the addition of a true longitudinal examination is long overdue. Second, up to this point, research on the impact of child gesture and parent speech has largely focused on individual contributions to language development. While a few studies have delved into examinations of dyadic contributions in the form of maternal responsiveness to
children’s gestures (Goldin-Meadow, et al., 2007; Masur, 1982), the samples were small, and again a consideration of development over time is lacking. If the ultimate goal is to understand how parent and child behaviors contribute to vocabulary growth in young children, we must seek to understand these processes as part of a dynamic system that involves the unique and joint impacts of parents and children, in the context of development and change over time.

Thus, the current study sought to fill these gaps, guided by three primary aims: (1) To describe the developmental patterns of infant gesture use and parent talk during a joint play interaction, (2) To examine the impact that communicative behaviors during joint play have on the partner in a moment-to-moment evaluation, (3) To determine which factors are the most valuable in predicting child language development. The results of this study, and the implications for our understanding of early communicative development, are discussed below.

### 4.1 Describing Developmental Change

The first aim of the current study was to describe the effects of age on a number of measures of parent and child communicative behavior that have not been systematically documented in the second year. While previous literature has demonstrated general increases in both the amount (Rowe, Pan, & Ayoub, 2005) and diversity (Bornstein, Tamis-LeMonda & Haynes, 1999; Rowe, Pan & Ayoub, 2005) of parent talk over the second year, few studies have specifically examined how the content...
of parent talk to their children changes over the child’s second year (Kalia, Johnson, & Wilbourn, under review).

In terms of child gesture use, it is possible to form a general picture of the developmental trajectory by piecing together information from several different studies. We know that most children begin gesturing around 12 months (Bates, Camaioni & Volterra, 1975; Camaioni, Perucchini, Bellagamba, & Colonnesi, 2004) and that there are marked increases in the amount of deictic gestures produced between 9 and 15 months (Blake, 2000; Blake, Olshansky, Vitale & Macdonald, 1997; Blake, Osborne, Cabral & Gluck, 2003), and a mean onset of symbolic gesturing around 15 months (Acredolo & Goodwyn, 1988). However, a full assessment of gestural development using observational measures of the same children in naturalistic interactions has thus far been lacking from the literature.

The current study assessed changes in global measures of parent talk and child gesturing, as well as changes in the content of these communicative behaviors over time. The results of this assessment revealed a progression from 10 to 22 months that includes several non-linear patterns of growth. These results, and their implications for our understanding of communicative development are discussed in detail below.

**4.1.1 Parent Communication**

The first set of analyses focused on global measures of parent communication, in order to assess whether the results of this study generally matched those of other
researchers. The number of different root words parents produced showed a general increase between 10 and 22 months, which corresponds with findings from other studies of parent talk over the second year (Bornstein, Tamis-LeMonda & Haynes, 1999; Rowe, Pan & Ayoub, 2000). Similarly, parent-produced words-per-minute increased over the course of the study, which was expected based on other assessments of the total number of word tokens parents produce during the same developmental period (Rowe, Pan & Ayoub, 2000). While previous studies assessed at two observations in the second year, the current study assessed 4 unique ages, which allows for more fine-tuned assessments of where changes in global measures of parent speech occur. Planned contrasts revealed that the overall increase in NDW was due to a significant jump in lexical diversity between 14 and 18 months. Similarly, changes in WPM only began to emerge after the 14-month assessment. This cognizance of specific developmental changes in parent speech allows us to more accurately pinpoint potentially transformative moments in dyadic interactions that may play a major role in infant communicative development.

However, I was interested in going beyond global measures of parent verbosity and lexical diversity, to truly understand the quality of parent speech to infants in terms of content. Therefore, parent utterances were all coded in terms of communicative function, and changes in the proportions of parent utterances within each category across all four observations were assessed. The results of these analyses revealed a far
less linear pattern than was observed in the examination of global measures of parent speech.

Parents’ use of Labels, in particular, showed a very interesting pattern. While consistently the largest proportion of parent utterances at all four observations, Labeling showed significant decreases at 14 and 22 months, and a significant increase at 18 months to return to the 10-month baseline. At face value, this pattern is quite perplexing, however when examined in comparison to changes in the proportions of other utterance types, the picture becomes a bit clearer. Specifically, the proportions of Comment and Behavior Modification increase significantly at 14 months, which indicates that, at that time point, parents may be shifting their priorities away from labeling to other types of utterances that serve particular functions, based on changing demands. For instance, most children begin walking at around 12 months (Bayley, 1969). It is plausible that, when confronted with a newly mobile child, parents are less concerned with teaching word meanings, and more concerned with directing behavior, than they were at 10 months. This may explain why parents’ use of Behavior Modification utterances to direct or prohibit particular types of behavior shows an uptick at this time.

Changes in the proportions of Extension and Question utterances, on the other hand, appear to be relatively stable over the course of the second year, with a couple exceptions. Specifically, the proportion of Extensions shows a significant decrease between 10 and 14 months, and the proportion of Question utterances shows a marked
increase between 18 and 22 months. Both of these changes likely reflect changes in parent talk that match the developmental abilities of their children. Previous literature has shown that parents “fine-tune” the quality of their speech by shortening the mean length of utterances (MLU) when children are on the cusp of first words (Murray, Johnson & Peters, 1990). The results of the current study provide additional evidence that parents decrease complexity of speech when their children begin to speak, in this case in what they say, by reducing their use of Extensions. Conversely, the proportion of Question utterances used by parents remains relatively low through the second year, and increases dramatically between 18 and 22 months. This likely reflects a scaffolding tactic: parents are engaging their children in the conversation through the use of more eliciting talk as their children become capable of responding appropriately. In fact, previous research examining parent-toddler interactions has shown positive associations between mothers’ use of eliciting talk and children’s expressive vocabularies (Kalia, Johnson, & Wilbourn, under review).

4.1.2 Child communication

As with parent talk, the first set of analyses examining developmental changes in child communication focused on global measures in the forms of vocabulary and gestural frequencies. Results demonstrated a general increase in the size of parent-reported child vocabularies between 10 and 22 months, which aligns with existing literature documenting the rates of child vocabulary growth over the second year.
(Fenson, et al., 1994). There is a split in the growth patterns in receptive and expressive vocabulary between 18 and 22 months, where expressive vocabulary continues to increase, while receptive vocabulary decreases, though this is likely due to the fact that measurement of these scales is mutually exclusive, so at some point increases in expressive vocabulary necessitate decreases in endorsements of receptive vocabulary items.

The number of gestures children produced during the task also showed increases between 10 and 18 months, which roughly aligns with patterns found by others in the field (Blake, 2000; Blake, Olshansky, Vitale & Macdonald, 1997; Blake, Osborne, Cabral & Gluck, 2003). Between 18 and 22 months, the rate of gesture use stabilizes, which is to be expected as children begin to rely more on spoken forms of communication (Fenson, et al., 1994).

As with parent speech, the general linear pattern in child gesture use begins to break down when analyses are split by gesture category, particularly when the Deictic and Pointing categories are examined. Between 10 and 14 months, there is a sharp increase in the proportion of Deictic gestures children produce. Because Deictic gestures are by and large the most frequent types of gestures children are producing throughout the study, it is likely that this dramatic shift signals children’s first foray into gestural communication. Interestingly, the proportion of Deictic gestures shows a significant drop at the next time point, between 14 and 18 months, at which time the proportion of
Pointing gestures children produce shows a significant increase. The contrast between Pointing and Deictic gestures is an interesting one, because even though both categories are referential, Deictic gestures are far more likely than pointing gestures to serve an imperative function (e.g., a “Giving” gesture can signal to the parent an imperative to take the object the child is holding). On the other hand, the use of pointing gestures are more often conceptualized as serving a declarative function, or a form of early name-giving to engage the attention of another (Bates, et al., 1975; 1980). Taken together, it appears that while children begin gesturing deictically, as their communicative abilities develop, their gesture use becomes more fine-tuned and socially-motivated, as evidenced by the shift to a higher relative proportion of Point gestures at 18 months.

The non-linear shifts in the types of gestures children produce also bear striking parallels to the shifts seen in the types of utterances parents produce at the same time point. Specifically, at 14 months there is an increase in the proportion of Deictic gestures used by children, a decline in the proportions of Labels parents produce, as well as a simultaneous increase in the proportion of Comments and Behavior Modifications. At 18 months, children’s use of Deictic gestures declines, and Point gestures increase, with parent Labeling increasing as well. It is possible that when children first begin to gesture, parents’ primary goal is not to provide labels, but rather to establish a conversational routine. Thus, the proportion of Comments, which often serve to acknowledge child behavior, spikes when children begin communicating using gestures.
As children become more sophisticated and directed in their gestural repertoire, utilizing Points to engage parents in joint attention, parents return to providing names for these referents. However, in order to determine whether this pattern plays out, it is necessary to examine the contingencies in gestural interactions over time.

4.2 Assessing dyadic interaction

The second aim of the current study was to move beyond individual measures of communication in order to better understand the nature and impact of dyadic engagements in mother-child gestural interactions during the second year. Previous research demonstrates that, by the second year, children are beginning to actively engage their parents (Wu & Gros-Louis, 2014) and parents are generally responding appropriately to these communicative bids (Bornstein, Tamis-LeMonda, & Haynes, 1999; Carpenter, Nagell & Tomasello, 1998; Dunham, Dunham & Curwin, 1993; Tamis-LeMonda, Bornstein, & Baumwell, 2001). Furthermore, what parents say in response to these bids for attention has been shown to link directly to children’s vocabulary: when parents respond with information, in the form of labels or translations, children’s vocabulary is enhanced (Goldin-Meadow, et al., 2007; Masur, 1982).

However, as with the previous aim, to date there has been no assessment of how dyadic parent-child interactions, specifically involving child gestures, change over the course of the second year within the same individuals. Furthermore, this lack of developmental assessment prevents us from determining whether particular patterns of
engagement and response are universally impactful on child language, or whether these influences may be constrained to particular developmental periods.

The current study examined the patterns of engagement and response in gestural interactions in order to explore the dynamic nature of early communicative interactions. By examining the types of parent utterances parents use contingent to children’s gestures, as well as the overall patterns of engagement and response through the use of person-centered approaches, I show that dyadic interactions are more than the sum of their parts.

4.2.1 Contingencies in moment-to-moment interactions

The first set of analyses in the second aim examined initiation patterns in gestural interactions over time. The results showed that the vast majority of gestural interactions at all time points were infant-led, ranging from 82% to nearly 90%. This runs counter to research on joint attention, which finds that bouts of joint attention during the same developmental period are most often parent-led (Carpenter, Nagell & Tomasello, 1998). This indicates that there is something special about gestural interactions that supports children’s agency in dyadic engagements.

Following the assessment of who was leading the interactions, I was interested in what was being said, and whether this differed based on who was leading the interaction. Results demonstrated that, at all ages, Questions were far more likely to occur in parent-led interactions, and Labels were more likely to occur in child-led
interactions. This provides confirmation that these engagements are actually based on contingency, and not merely chance behaviors that occur in temporal proximity.

Further, it indicates that child-led interactions are likely particularly potent moments for the acquisition of vocabulary through parents’ provision of Labels. On the other hand, parent-led gestural engagements may act as an informal assessment of child vocabulary; parents request information or actions from their children, and children respond using gestures.

Interestingly, at 14 months, there was a significant difference in the proportion of Comment utterances in child-led utterances vs. parent led interactions. This difference maps onto the non-linear developmental changes in parent speech and child gesture use in the previous aim. Specifically, parent Comment utterances showed a significant spike at 14 months, which is the age at which children show a major increase in their production of Deictic gestures. The results of the current analysis provide confirmation that these behaviors are contingently linked; the increase in parents’ use of Comments at 14 months is a direct response to the gestures their children are producing. These findings highlight the importance of moment-to-moment assessments of parent-child interactions to better understand developmental changes in individual behaviors.

The emergence of a significantly larger proportion of Behavior Modifications in parent-led interactions at 22 months, on the other hand, likely indicates another scaffolding behavior by the parent. As children’s understanding of the world around
them grows, parents provide directions for their behavior, and the children use their gestures to respond to these instructions. Overall, the results of these analyses highlight the importance of the need to assess moment-to-moment contingent interactions in parent-child communication.

4.2.2 Person-centered approaches to studying dyadic interactions

Cluster Analysis and I-States as Objects Analysis were used to determine whether groups of dyads could be reliably grouped together based on characteristics of their gestural interactions. Specifically, these characteristics included the two most frequent types of child gesture: Deictic and Pointing, and the proportion of Informative responses mothers provided to these gestures (i.e., Label or Extension responses). The use of observed variables in the cluster analysis emphasizes the dynamic systems nature of development and the way that many variables jointly and uniquely work to produce change. In fact, the ISOA approach is conceptually quite similar to the way that attractor states function in a dynamic system, which makes it ideal for studying stability and change in developmental systems over the short term.

The results of the ISOA produced 4 distinct groups: two that generally clustered around child gesture, and two that generally clustered around parent responses. When changes in group membership were assessed, while there was certainly a great deal of variability, there appeared to be a general migration toward belonging in one of the gesture-based groups. In fact, the Deictic and Point groups were the only ones showing
consistent, linear increases in group membership across all four ages. What this may indicate is a general transfer of agency from the parent to the child over time. What this means for communicative development and vocabulary acquisition, however, is yet to be discovered.

### 4.3 Predicting Vocabulary Acquisition

The final aim of the current study was to link the variables and patterns discovered and described in the previous sections to child vocabulary. Specifically, I was interested in determining whether this nuanced methodological and statistical approach can provide a better understanding of how parent, child and dyadic characteristics relate to vocabulary acquisition in the second year. In general, the literature documenting the influence of child gesture and parent speech on children’s vocabulary acquisition appears straightforward and linear: more gestures, more language exposure, more words. However, for each study that shows a positive relationship, there is another that fails to find it, or only finds it in particular developmental stages, or specific contexts.

Thus, the current study sought to measure relationships between child gesture, parent talk and child vocabulary in three distinct ways. First, the clusters identified in the ISOA were used as predictors, to assess the utility of holistic categorizations of parent-child interaction patterns. Second, a cross-lagged model, which included only global measures of parent speech and child gesture, was employed, to determine whether the patterns that have traditionally been shown in the literature emerged in the
current study. Third, associations between specific types of parent utterances and vocabulary were assessed, to determine whether an assessment of the content of parent speech could lead to reliable estimates of measures of child vocabulary.

4.3.1 Based on group membership

I was interested in determining whether the differential patterns that emerged in the clusters in terms of child gesture production and parent response types could be reliably linked to differences in child vocabulary over time. First a series of one-way MANOVAs with all grouping variables included as predictors revealed no systematic effect of group membership, concurrently or prospectively, on child vocabulary scores.

However, because I was interested in comparing specific groups, I then assessed the differential impact of Deictic versus Point group membership on vocabulary across all four time points. Again, no differences based on grouping variables emerged. Finally, I compared vocabulary scores between the Average and Informative groups across all four ages. The results revealed that while membership in the Average group appeared to be a boon to vocabulary at 14 months, by 18 months, those in the Average group had lower expressive vocabularies than their peers with more Informative mothers.

Taken together these findings seem to indicate that, at least at 14 and 18 months, it’s what mom says that matters. While children in this age are certainly active in engaging their mothers, the way in which they do so does not differentially impact their vocabulary outcomes. In contrast, the content of maternal responsiveness is
differentially linked to child vocabulary, based both on context and on age. Mothers who engage in low proportions Informative responses at 14 months are likely to have children with larger vocabularies, while mothers who remain in this group at 18 months will have the opposite effect. While at first this may seem counterintuitive, it is important to consider that across measures of parent speech and child gesture, 14 months has been a signal of transformation in both child gesture and parent speech. In particular, we see an increase in the amount of gestures produce, as well as a shift from Labels to Comments in parent speech. The results of this analysis indicate that this shift away from Informative responses is not only normative, it may actually be beneficial to children’s burgeoning vocabularies. By 18 months, when children have settled into their gestural repertoires, an increase in informative responses is better incorporated into their vocabulary knowledge.

4.3.2 Based on global measures

The use of a cross-lagged panel design was motivated by the fact that while a vast number of studies have documented relationships among these global measures of parent speech, child gesture and child vocabulary, no studies have assessed these relationships across four stages of development, accounting for patterns of relationships in previous stages (Bates, et al., 1977; Bornstein, Tamis-LeMonda & Haynes, 1999; Huttenlocher, et al., 1991; Iverson & Goldin-Meadow, 2005; Pan, Rowe, Singer, & Snow, 2005; Rowe, Ozcaliskan, & Goldin-Meadow, 2008; Rowe, Pan & Ayoub, 2005).
While the small sample size necessitates cautious interpretations, the findings of the model are interesting nonetheless. Overall, the model failed to yield any of the “more is more is more” relationships that have come to be expected in the literature on child language development. While a few concurrent relationships emerged, there was a marked lack of the cross-lagged, predictive patterns that would be expected based on the extant literature. There are a couple of possible explanations for this finding. The first is that the small sample size in my model failed to produce enough power to detect these significant relationships. However, based on the generally low values of parameter estimates, this explanation is unlikely. The more likely possibility is that, when all possible relationships are accounted for in a model such as this, previously significant relationships fall away. The significant findings that emerged in previous studies may simply be products of a model that did not account for the entire story.

Interestingly, the significant paths that do emerge in this model reinforce the importance of 14 and 18 months in dyadic interactions. Autoregressive and correlational paths which fail to emerge anywhere else in the model are suddenly present beginning at 14 months. Conversely, the autoregressive path connecting parents’ Number of Different Words is non-significant only between 14 and 18 months. Moreover, the only significant cross-lagged path to emerge in the model shows parent lexical diversity at 14 months predicting rates of child gesture at 18 months. The findings in this model
reinforce the need to further examine the period of dramatic transformation in parent-child communication that occurs between 14 and 18 months.

4.3.3 Based on what mothers say

Finally, I examined whether specific types of parent utterances (Label, Question, Comment, Extension, Behavior Modification) were differentially associated with child vocabulary, concurrently or prospectively, across ages. The results revealed two significant concurrent relationships at 10 months: a positive association between vocabulary and Behavior Modifications, and a negative association between vocabulary and Extensions. The effects of these parent utterance types on vocabulary were found to be stable and far reaching: Behavior Modifications at 10 and 14 months yielded positive associations with 18 month vocabulary, while 10 and 14 month Extensions continued to negatively impact vocabulary as far as 18 months. A negative prospective relationship between the proportion of Questions at 10 months and child vocabulary at 18 months also emerged.

Generally, these results suggest that Behavior Modifications are good, and Extensions are bad for children’s vocabulary, at least between 10 and 18 months. These results are surprising, given that Behavior Modifications are not necessarily rich in linguistic content, while, by definition, Extensions consist of rich, cross contextual abstract speech that should be a boon to a learning toddler, especially as they get older. One explanation for this finding is that the infants just aren’t old enough, and parents
who engage in higher proportions of Extension utterances at 10 and 14 months are setting the bar too high, rather than providing scaffolded support in the child’s Zone of Proximal Development (ZPD; Vygotsky, 1980). This would also explain why parents who engage their children in a high proportion of Question utterances at 10 months have children with lower vocabularies later on.

On the other hand, Behavior Modifications provide clear instructions for child behavior and easily testable label-referent links. For example, if a parent tells an infant to “grab the pot”, and the child picks up a spoon, parents will typically provide an instant disconfirmation of the child’s attempt: “No that’s not the pot.” Moreover, parents will often then re-organize their statement or request to give their children more clues as to the proper label-referent link: “The red pot, by the bookshelf!” The findings relating specific types of parent speech to vocabulary, when global measures showed no relation highlights the need for detailed examination of parent-child interactions at various stages in development.

4.4 Conclusions and Future Directions

The overarching goal of the current study was to employ a multi-wave longitudinal design, and detailed coding and analyses to better understand the development of parent-child communicative interactions and their impact on child vocabulary acquisition over the course of the second year. Generally, our hypotheses regarding the development of parent and child behaviors were upheld: both the amount
and diversity of parent speech, and the rate of child gesturing showed linear increases over the second year. Further, detailed examinations of the types of individual and dyadic behaviors in which dyads engaged showed that parents appear to be altering their behaviors based on the developmental and behavioral patterns of their children.

Interestingly, the relationships to vocabulary that would have been predicted based on the existing literature failed to emerge. Neither global measures of parent talk nor child gesture showed any direct, predictive relationships to later child vocabulary at any of the ages tested. Furthermore, the types of parent utterances that did show stable predictive relationships to later vocabulary were not Labels or Extensions, but Behavior Modifications, which generally are not thought of as rich sources of linguistic information for learning children. While the absence of significant hypothesized relationships is puzzling, these results are an important contribution that provide a basis for further exploration in order to determine the contextual, developmental and individual factors that lead to the discovery of significant paths in some studies, and the absence of these same paths in others.

Overall, the contributions of the current study are three-fold. First, the methodology utilized in the study demonstrates that it is possible to take a systems-based approach to studying vocabulary acquisition that does not sacrifice the detail and scientific rigor so valued in research. In understanding how an infant acquires word meanings, the key to uncovering individual variability lies in an examination of the
myriad of components involved in the process. Second, the results of this rigorous approach demonstrate that the accepted child gesture > parent speech > child language relationship that has persisted in the literature for decades may not be as powerful as previously demonstrated. The results of the current study revealed strong autoregressive relationships between parent speech and child vocabulary measures over time, and very few cross-lagged predictive relationships. Furthermore, a high level of referential (labeling) and sophisticated speech did not have the clear, predictive relations to child vocabulary that would be expected; instead, regulatory speech (behavior modifications) were the only consistent predictors of child vocabulary, both concurrently and over time. Finally, this study demonstrates that the types of communicative behaviors parents and children engage in during joint play are variable based on the level of child development, and children actively shape the input they receive from parents through their gestural communication.

Future research should further the contribution of the current study by examining the patterns of development and engagement across a variety of contexts. While free play was chosen based on its ubiquity in parent-child interactions, examining whether similar patterns emerge in book-reading, play, and interactions with multiple partners (e.g., father, siblings) will help to elucidate how cross-contextual stability or change affects these relationships. More importantly, future research must examine similarities and differences in dyadic engagement across racial and socio-economic
groups, particularly those at risk for language delays (e.g., low-income and African-American populations). It is unwise to assume that one pattern or model will fit all groups, and by examining which paths or behaviors are most impactful in these specific groups, we can create more targeted plans for reducing risk in these groups.
Appendix A

Stimuli used during the task at each of the four time points. The selection of toys was partially based on an accompanying book-reading task not reported in the current study.

<table>
<thead>
<tr>
<th>Time Point and Book</th>
<th>Toys in Book</th>
<th>Toys Not in Book</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 Months</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>No, David!</em></td>
<td>Potato</td>
<td>Rabbit</td>
</tr>
<tr>
<td>(Shannon, 1998)</td>
<td>Wooden Spoon</td>
<td>Whisk</td>
</tr>
<tr>
<td></td>
<td>Broccoli</td>
<td>Frog</td>
</tr>
<tr>
<td></td>
<td>Duck</td>
<td>Measuring Cup</td>
</tr>
<tr>
<td></td>
<td>Pot</td>
<td>Banana</td>
</tr>
<tr>
<td></td>
<td>Etch-a-Sketch</td>
<td>Apple</td>
</tr>
<tr>
<td>14 Months</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Selected pages from:</td>
<td>Llama</td>
<td>Onion</td>
</tr>
<tr>
<td><em>Llama Llama Red Pajama</em></td>
<td>Rolling Pin</td>
<td>Goldfish</td>
</tr>
<tr>
<td><em>Llama Llama Mad at Mama</em></td>
<td>Carrot</td>
<td>Bird</td>
</tr>
<tr>
<td><em>Llama Llama Misses Mama</em></td>
<td>Block</td>
<td>Ball</td>
</tr>
<tr>
<td><em>Llama Llama Holiday Drama</em></td>
<td>Truck</td>
<td>Bell Pepper</td>
</tr>
<tr>
<td>(Dewdney, 2005; 2007; 2009; 2010)</td>
<td>Car</td>
<td>Lobster</td>
</tr>
<tr>
<td>18 Months</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>On My Way to School</em></td>
<td>Airplane</td>
<td>Fish</td>
</tr>
<tr>
<td>(Maizes &amp; Paraskevas, 2014)</td>
<td>Glasses</td>
<td>Measuring Cup</td>
</tr>
<tr>
<td></td>
<td>Camera</td>
<td>Pot</td>
</tr>
<tr>
<td></td>
<td>Lemur</td>
<td>Helicopter</td>
</tr>
<tr>
<td></td>
<td>Frog</td>
<td>Bowl</td>
</tr>
<tr>
<td></td>
<td>Car</td>
<td>Hammer</td>
</tr>
<tr>
<td>22 Months</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Just a Little Critter Collection</em></td>
<td>Baseball</td>
<td>Polar Bear</td>
</tr>
<tr>
<td>(Mayer, 2005)</td>
<td>Cookie</td>
<td>Bunny Ears</td>
</tr>
<tr>
<td></td>
<td>Mouse</td>
<td>Football</td>
</tr>
<tr>
<td></td>
<td>Cowboy Hat</td>
<td>Tomato</td>
</tr>
<tr>
<td></td>
<td>Guitar</td>
<td>Stethoscope</td>
</tr>
<tr>
<td></td>
<td>Phone</td>
<td>Octopus</td>
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Appendix B

Means and F-statistics for significant planned contrasts of Parent Utterance types by Child Age

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>$F(1, 41)$</th>
<th>$p$-value</th>
<th>Child Age</th>
<th>$M$ (proportions)</th>
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<td>.002</td>
<td>10 months</td>
<td>.31</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>14 months</td>
<td>.28</td>
</tr>
<tr>
<td></td>
<td>9.39</td>
<td>.004</td>
<td>14 months</td>
<td>.28</td>
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<td></td>
<td></td>
<td></td>
<td>18 months</td>
<td>.33</td>
</tr>
<tr>
<td></td>
<td>8.29</td>
<td>.006</td>
<td>18 months</td>
<td>.33</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>22 months</td>
<td>.29</td>
</tr>
<tr>
<td>Questions</td>
<td>7.21</td>
<td>.01</td>
<td>18 months</td>
<td>.22</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>22 months</td>
<td>.25</td>
</tr>
<tr>
<td>Extensions</td>
<td>9.56</td>
<td>.004</td>
<td>10 months</td>
<td>.10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>14 months</td>
<td>.07</td>
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<tr>
<td>Comments</td>
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<td>.002</td>
<td>10 months</td>
<td>.16</td>
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<td></td>
<td></td>
<td></td>
<td>14 months</td>
<td>.20</td>
</tr>
<tr>
<td></td>
<td>22.90</td>
<td>&lt;.001</td>
<td>14 months</td>
<td>.20</td>
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<td></td>
<td></td>
<td></td>
<td>18 months</td>
<td>.15</td>
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<tr>
<td>Behavior Modifications</td>
<td>8.95</td>
<td>.005</td>
<td>10 months</td>
<td>.16</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>14 months</td>
<td>.19</td>
</tr>
<tr>
<td></td>
<td>22.18</td>
<td>&lt;.001</td>
<td>14 months</td>
<td>.19</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>18 months</td>
<td>.14</td>
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</table>
References


Biography

Kristin M. Johnson was born in the City of Olongapo, Philippines on October 6, 1989. She graduated with honors with a Bachelor of Science in psychology from North Dakota State University in December, 2010. She obtained her Master of Arts in psychology from Duke University in September, 2015. She is the primary author of “Give me a hand: Adult involvement during object exploration affects object individuation in infancy” published in Infant and Child Development. She has received mentorship fellowships through the Duke Psychology & Neuroscience Vertical Integration Program, as well as multiple travel scholarships from the Department of Psychology and Neuroscience and the Duke Graduate School. She is also a member of the Cognitive Development Society, the International Congress on Infant Studies, and the Society for Research in Child Development.