VISUAL CHARACTERISTICS OF MATERNAL GESTURING AND ITS ROLE IN EARLY ATTENTIONAL ORGANIZATION

A Thesis

Presented to

The Faculty of the Department

of Psychology

University of Houston

In Partial Fulfillment

Of the Requirements for the Degree of

Masters of Arts

By

Audrey I. Utti

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Audrey I. Utti

APPROVED:

Hanako Yoshida, Ph.D.
Committee Chair

Shishir Shah, Ph.D.
University of Houston

Bhavin Sheth, Ph.D.
University of Houston

Haluk Ogmen, Ph.D.
University of Denver

Antonio D. Tillis, Ph.D.
Dean, College of Liberal Arts and Social Sciences
Department of Hispanic Studies

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ABSTRACT

Many researchers have focused on the types of gestures parents make that are most prevalent during a word learning task, that are most relevant to word learning, and the social benefits surrounding the understanding of gesture behavior. Though we know so much about parental use of gestures and the benefits they have on a child's word learning, we know little about the visual consequences that gestures provide and the processes underlying the benefit. The characteristics of parental gesturing that is relevant to language development have yet to be explored. The current study asks how parents gesture with their infants in a word learning interaction task, and how infants capture and attend to this input. Furthermore, the study looks at object size changes due to gesturing, which may provide perceptually meaningful information that may support word learning, and the impacts that parental gesturing have on an infants' sustained attention.

To address these aims, the proposed study will look at seven types of parental gestures and hand motions, including deictic, symbolic, shaking, looming, upwards, downwards, and other (conventional and beat). Eleven infants ages 5 to 7 months (prelexical group) and eleven infants ages 9 to 11 months (early lexical group) and their parents participated in the study. Parents and children sat across from each other while wearing eye-tracking devices during a word learning play session involving a set of toys. Parents taught their infant eight words they heard over a recording using any toy they choose from toys that were provided, with 40 seconds given for each word.

Results showed that there were no differences in the way parents gestured towards prelexical and early lexical infants, but that they used each gesture type at different frequencies. It was also found that infants attended to relevant cues (hands, objects, or face) differently and that objects were looked at the most compared to parent hands, child hands, and face for both groups. Interestingly, gestures guided the attention of the prelexical group to relevant cues more than the early lexical group. Results also showed that though sustained attention moments for infants in both groups did not account for a significant portion of their looking behavior, a significant portion of these sustained moments were a result of parent gesture. Lastly, there were no significant differences in object size changes in relation to parent gesture, but results suggest that when the size changes more, infants look at a relevant cue more. The thesis concludes with a general discussion of the findings, limitations that may have impacted data analysis, and interesting future directions.

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TABLE OF CONTENTS

Introduction 1

Gesture's Prevalance in Language 4

Gesture's Importance in Early Word Learning 6

Parental Gestures and Links to Word Learning 8

The Process of Visual Development and its Relation to Gestures 13

Study Aims……………………………………………………………………...……15

Approach…………………………………………………………………………………16

Methods………………………………………………………………………………..17

Participants…………………………………………..………………….........17

Design……………………………………………………………………………17

Procedure………………………………………………………………………...18

Video Processing……………………………………………………………...19

Coding……………………………………………………………………………...19

Gestures……………………………………...…………………………….19

Infant Attention and Sustained Attention………………………………….…..20

Parent Speech……………………………………………………….......21

Object Size……………………………………………………………......21

Results…………………………………………………………………………………...21

Parent Gesture Production Towards Prelexical and Early Lexical Infants…………..21

Infants' Capturing of Parent Gestures in View…………………………………...….22

Parent Gestures and Object Size Changes in Infant's View………………...………..24

Parent Gestures and Object Size Changes Impact on Infant Attention to Relevant Objects and Sustained Attention……………..……………………………………….24

General Discussion...25

References……………………………………………………………………………….32

LIST OF TABLES AND FIGURES

Tables and Figures 40

Table 1: Difference Between Frequency in Gesture Type 40

Table 2: Differences in Infant Looks to Relevant Cue Type 41

Figure 1: Four- Quadrant Synced Video 42

Figure 2: Frequency of Parental Gestures 43

Figure 3: Gesture Capture Rate of Prelexical and Early Lexical Infants 44

Figure 4: Frequency of Infant Looks to Relevant Cues 45

Figure 5: Looks to Relevant Cues Resulting from Parental Gestures........................... 46

Figure 6: Duration of Infant Gaze as a Function of Object Size Change...................... 47

Introduction

Gestures are a pervasive part of verbal and non-verbal communication (Kendon, 1980; McNeill, 1992). Given how tightly coupled gestures are with speech (Goldin-Meadow, 2000; Iverson & Thelen, 1999; Kendon, 2004; McGregor, 2008), it is no surprise that gestures are an important aspect of communication and language development (Özçalişkan & Dimitrova, 2013), speaking (McNeill, 1992), and conveying unspoken thoughts (Goldin-Meadow, 2000). In particular, the importance of gestures starting from early infancy has been clearly documented in the literature. For example, children who recognize and understand gesturing behavior from social partners at an earlier point in development have been shown to have increased and faster language acquisition (Carpenter, Nagell, & Tomasello, 1998). Furthermore, studies that focus on the importance of gesturing in language learning have documented a number of positive consequences of gesture use both in immediate and later developmental outcomes (Capone & McGregor, 2004; Goldin-Meadow, 2000; Hani, Gonzalez-Barrero, & Nadig, 2013; Matatyaho & Gogate, 2006), including early understanding of parent speech and communicative intents, and children's effective use of gestures (Özçalişkan & Dimitrova, 2013). This gestural behavior has been demonstrated to be developed through interactions with social partners (Goodwyn & Acredolo, 1998), and parents are in a prime position to play an integral role in this. Research on gestures further identified the existence of a variety of gesture categories often utilized by adults. Some of these gesture types are used by adults while they communicate with their child and have been linked to children's language development (Iverson, Capirci, Longobardi, & Caselli, 1999), each serving their own, sometimes overlapping, communicative functions (Zammit & Schafer, 2011). Examples of these gestures include symbolic and deictic gestures. Specifically, these gestures have been shown to aid infants more during word to object pairings (Özçaliśkan & Dimitrova, 2013) and often include actions such as “shaking” and “looming” accompanied by an object (Matatyaho-Bullaro, Dalit, Gogate, Mason, Cadavid, & Abdel-Mottaleb, 2014). Through the use of ‘gestural motherese’ or ‘motionese’, a proposed mechanism through which parents help make gestures and object showing more accessible for their children, infants are able to benefit greatly from parental gesture use as a means to learn word to object pairings. Furthermore, parents synchronize their speech with gestures during these learning moments, allowing children to not only constrain what they are attending to, but to also hear a label for what they are looking at (Matatyaho & Gogate, 2008). Object name learning may be the result of providing labels for objects at optimal visual moments when there is little referential ambiguity (Yu & Smith, 2012). Indeed, gestures appear to be a powerful tool parents utilize to create these visual moments.

Though the aforementioned gestures have been found to occur for infants during 6 to 8 months and have been linked to word learning, there is no evidence about in what process these gesture types become more effective with infants or if and how they are used by the infant and influence infant attention. To answer these questions, the present thesis will aim to explore the visual input parents provide their infants through gesturing and observe how infants attend to this input. By understanding the visual capabilities of infants as they develop from prelexical infancy (5 months to 8 months) to early lexical infancy (9 months to 17 months), we can explore how different gesture types become more helpful during learning.

Gestures are essentially hands moving in a scene, like an object in motion, grabbing attention (Amano, Kezuka, & Yamamoto, 2004). As such, it is crucial to not only view gestures as, essentially, motion, but to also understand changes in object size. Exploring the gestural input parents provide their infants as they develop will help us look deeper into the visual characteristics of these particular gestures and what they provide to the infant’s visual field. It is possible that different gesture types provide different sizes of an object in an infant’s view. Each gesture type may provide unique changes in object size properties. As Matatyaho-Bullaro et al. (2014) pointed out, it may be that gestures that have higher amounts of motion or provide greater changes in object size are utilized more often by parents of infants who are in the early stages of learning. These changes in object size could lead to longer durations of gazing, or sustained attention (Yu & Smith, 2016). Sustained attention to relevant information in the environment, including objects, has been shown to be important in learning (Ruff & Lawson, 1990). In addition, it is not clear whether or not infants are attending to the gestural input their parent is providing or which types may be capturing infant attention more at different stages of development. The visual characteristics of certain gestures may influence the types of gestures that are most beneficial and attended to more by infants who are beginning to babble and add words to their vocabulary (Gogate, Maganti, & Bahrick, 2015).

In the present thesis, the infants participating ranged in age from 5 to 11 months in an effort to study a broader range of individual and dyad differences. We focused on the first year of life since it is during this time that infants undergo rapid gesture and language development (Crais, Douglas, & Campbell, 2004; Hollich et al., 2000), allowing us to capture both pre-lexical (5 to 7 months) and early-lexical (9 to 11 months) stages. The study will observe infants while they play with their parent in a semi-naturalistic word learning task while wearing eye-tracking devices. The present study aims to explore the gestural input, with and without objects, parents provide their infants and whether or not infants capture this gestural input. Lastly, the present study explores *how* these gestures might aid more with word to object pairings by further characterizing the visual input these gestures provide. By focusing on the first person view of early-lexical infants (9 month olds), when infants are first beginning to produce words, we can begin to understand the object size characteristics of these gestures and the impact object size might have on attention and sustained attention.

Gesture's Prevalence in Language

Gestures, speech, and thoughts are believed to be tightly coupled. In fact, even with individuals who are unable to speak, including deaf children and typically developing infants alike, gestural ability is still evident (Goldin-Meadow & Morford, 1985; Goldin-Meadow & Mylander, 1998; Iverson & Goldin-Meadow, 2005). Different types of information can be gleaned from different types of gestures, and the gesture itself can aid the person using it to articulate their idea better or even help them retrieve words they are trying to say (Casasanto, 2013). Gestures supplement language, providing redundant (Holle & Gunter, 2007; Iverson et al., 1999) or extra information during speech, providing information not readily available in the speech output (Goldin-Meadow, 2000), and directing attention to relevant and important segments in the environment (Iverson et al., 1999). Gestures are quite pervasive in language contexts, developing in young, pre-verbal infants as a means to communicate their needs and wants (Vallotton, 2009). In all, gestures are an integral part of learning language, in communicating, and in conveying thoughts.

Research looking into gestures have identified several gesture categories that adults use, including deictic (Zammit & Schafer, 2011), symbolic (Goodwyn, Acredolo,& Brown, 2000), conventional (Zammit & Schafer, 2011), beat (Özçalişkan & Goldin-Meadow, 2005), and iconic (Zammit & Schafer, 2011). Though many gestures have been defined, many with overlapping definitions in the literature or labeled differently across different research groups, the following gestures have been heavily documented in the literature:

a. Deictic gestures are simpler in nature and are used to draw attention to an object or event from other referents in an environment (Iverson, Longobardi, Spampinato, & Caselli, 2006). Three types of deictic gestures have been heavily studied: pointing, showing, and giving. These gestures express communicative intent that goes beyond the gesture itself; they direct a partner's gaze to something near or far or bring an object to a partner's attention (Capone & McGregor, 2004). These gestures begin to be used by infants by the age of 10 months.
b. Symbolic gestures carry meaning in their form; they typically resemble a concept and can be produced with or without a body part representing said concept or object (Goodwyn, Acredolo, & Brown, 2000). For this reason, symbolic gestures have been viewed as representationally flexible (Goodwyn et al., 2000) and are generally more abstract in nature. These gestures have been found to be expressed at different representational levels in infants from 10- 24 months of age.

c. Conventional gestures are culturally defined in form and meaning and remain consistent in their meaning over time (Özçalişkan, Gentner, & Goldin-Meadow, 2014; Zammit & Schaffer, 2011). These gestures include nodding the head to mean 'yes', putting a fist in the air to mean 'victory', or clapping to mean 'bravo' or 'praise' (Meideros & Winsler, 2014), and the meanings of these gestures are typically recognizable without accompanying speech (Mederios & Winsler, 2014). Research has shown that 24 month old children are able to understand conventional gestures, such as a nod (Fusaro & Harris, 2013).
d. Beat gestures are made up of formless hand movements that move in rhythm but do not hold any linguistic meaning (Özçalişkan & Goldin-Meadow, 2005). These gesture types provide emphasis with accompanying speech (Medeiros & Winsler, 2014; Nicoladis, Mayberry, & Genesse, 1999). They are rarely used in adult-child speech (Iverson et al., 1999) and have been observed being used by children ages 2 to 5 years old (Capone & McGregor, 2004).
e. Iconic gestures show the attributes and actions that are associated with objects, locations, individuals or events (Zammit & Schaffer, 2011). These gestural meanings do not change from situation to situation (Zammit & Schaffer, 2011), but can be abstract in meaning without accompanying speech (Casasanto, 2013). These gestures are evident in children around 25 months old (Özçalişkan et al., 2013).

Gesture's Importance in Early Word Learning

As evidenced in the previous section, gesture categories are produced by children at varying ages and the emergence of these gestures are partly linked to the simplistic or more abstract nature of the gesture categories themselves. Depending on a child's concurrent verbal vocabulary, certain gesture types allow the child to communicate needs and redirect their social partner's attention without the use of verbal language (deictic), while others represent objects that are present or absent from the immediate scene (symbolic, iconic), requiring more linguistic knowledge and support. In general, however, there have been strong implications that gesture usage in children leads to substantial outcomes in vocabulary and communication development, both immediate and later (Capone & McGregor, 2004; Goldin-Meadow, 2000; Hani et al., 2013; Matatyaho & Gogate, 2006), especially considering gesture's tight linkage with speech (Iverson & Goldin-Meadow, 2005).

The ability to gesture develops readily for children, regardless if the child is deaf (Goldin-Meadow, Butcher, Mylander, & Dodge, 1995), blind (Iverson & Goldin-Meadow, 1998), or typically developing. Children begin gesturing around 10 to 13 months of age (Capone & McGregor, 2004), and the gestures produced are typically simple in nature, demonstrating basic needs such as hunger or showing their parents things they find interesting through pointing and showing (Bates, Camaioni, & Volterra, 1975). These gestures, known as deictic gestures, offer children a tool to refer to objects before they have words for those objects. Children take advantage of this and produce deictic gestures for objects approximately 3 months before they produce verbal labels for those objects (Iverson & Goldin-Meadow, 2005). In fact, research has shown that when a child uses a pointing gesture to refer to an object, the child will learn the word for that object shortly after (in a few months' time) (Iverson & Goldin-Meadow, 2005). As such, deictic gestures have been referred to as prelinguistic gestures as they appear before children are able to produce language (Capone & McGregor, 2004) and have been implicated to play an important role in children's noun acquisition (Iverson & Goldin-Meadow, 2005).

Other gesture types produced by children have been shown to aid in language development, including symbolic gestures. Symbolic gestures have been shown to drive early verbal language development (Goodwyn et al., 2000). By the end of the first year (around 12- 13 months), the first signs of symbolic gesture use can be seen. Children are able to interpret their parents' symbolic gestures as object labels around 11 and 15 months of age (Goodwyn et. al., 2000; Namy, Acredolo, & Goodwyn, 2000). In a study by Goodwyn et al. (2000), parents were instructed to work with children to produce target symbolic gestures every day starting at 11 months old. They then followed up with these children from 15 months to 36 months and assessed them on receptive and expressive vocabulary, mean length of utterance, and phonemic discrimination. They found that gesture trained children had accelerated vocabulary growth between 12 and 36 months and allowed for advanced language skills from 15 to 36 months. Together, these results reiterate the impact a child's gesturing can have on their subsequent language development and highlight the importance of gestural experience.

Parental Gestures and Links to Word Learning

Research has demonstrated the strong links between children's gestural behaviors and the positive impacts it has on language development, but we know much less about how the early development of gesture use emerges. Social partners in the child's environment, especially parents, play an important role in this; they are in a prime interactive position with their infants to offer social cues, such as gestures, that help a child build their own gesturing behavior and aid in word to object pairing. Indeed, literature has pointed to the spontaneous nature in which children learn gestures during interactions with their parents (Acredolo & Goodwyn, 1988), and how parents' gestures push the child to begin to make communicative attempts earlier (Goodwyn & Acredolo, 1993). Furthermore, hands in general have been shown to support causal effect learning (Cook, Mitchell, & Goldin-Meadow, 2008), guide attention (Brigham, Yoder, Jarzynka, & Tapp, 2010), and even navigate joint attention (Mundy & Stella, 2000; Rickert, Yu, & Favata, 2010).

Parents have an entire repertoire of gestural categories learned and at their disposal. However, they do not gesture towards their infants in the same way they might gesture towards an adult. In a phenomenon known as *gestural motherese* (Iverson et. al., 1999), adults tend to change the way in which they produce gestures towards their infants in much the same way as they alter their speech pattern in what is known as infant directed speech. During the use of gestural motherese, gestures are produced less frequently and are more concrete in their meaning. For example, studies by Bekken (1989) and Iverson and colleagues (1999) showed that mothers simplified their gesture use with their infants, using more deictic gestures and gestures that reinforce speech. These gestures not only carry repetitive information that can be heard through speech, but also have features that make them attract more attention (Iverson et al., 1999). As literature has noted, infants attend to moving things that stand out against other objects in a scene (Nagata & Dannemiller, 1996) and they use repeated exposure to these highly salient gestures when learning novel words (McGregor, 2008). In fact, research shows that infants have been shown to learn word to object pairings better when an object is moved mechanically as opposed to without any movement (Matatyaho-Bullaro et al., 2014).

A study observing a parent-child interaction during their play showed that mothers of 18 month old children gestured less frequently but produced a higher number of gestures that were conceptually simple (deictic gestures) than they did with adults (Bekken, 1989). Modification of gesture usage was also found in other cultures; Italian mothers produced more gestures with their infants that reinforced what the mother was saying and rarely used those that provided information that they were not currently presenting despite the fact that they used the latter extensively in adult interactions (Iverson et al., 1999). In their study, 16 and 20 month olds were observed in parent-child dyads during at home play sessions. During these 45 minute play sessions, parents were asked to play with new examples of familiar objects, unfamiliar objects, and participate in meal or snack time. Not only did they find that mothers modified their gestures by using conceptually simple gestures (such as deictic gestures), but they found that the gestures that mothers used served to reinforce what they were conveying. This is in stark comparison to the kinds of gestures adults use with one another that adds extra information to the conversation than what is being said. They also found that the nature and frequency of maternal gesturing may have influenced the development of children's gesture and speech production. By producing gestures that are conceptually easier to understand, parents increased the chances that their children could utilize the supporting information these gestures provided, aiding them in establishing word to object mappings and encouraging vocabulary growth.

There are a few gestures and hand motions parents use that have been documented to be more utilized and effective for infants' word-object mapping. These include deictic and symbolic gestures, and looming, shaking, and upward/downward hand motions (Goodwyn et al., 2000; Matatyaho & Gogate, 2006; Medeiros & Winsler, 2014). As described earlier, deictic gestures have communicative intent by nature and bring an object to a social partner's attention. One type of deictic gesture is showing, where an object is brought up to a partner's face, usually centered in their view. Another is indicating, where a person uses touch, tapping, or head indications to single out a person, event, or location. A third type of deictic gesture is pointing, where an individual uses their finger to point towards a target of interest. Deictic gestures are heavily used during parent-child interactions. Özçalişkan and Goldin-Meadow (2005) showed that parents of infants at three time points (14,18, and 22 months) used more deictic gestures during a naturalistic interaction task that included snack time, book reading time, and free play. The simple nature of deictic gestures helps to reduce ambiguity in the environment, especially during a labeling moment.

Symbolic gestures attach properties of a target object to an object that does not share those properties (e.g., using a banana as a phone, or blowing at a toy spoon that has no hot liquid in it) (Ham, 2010). In a study by Zammit and Schafer (2011), they used a task in which mothers were told to describe nouns in word form or pictures to their 9 to 10 month olds. They found that when a mother used labeling along with gesturing (iconic gestures in particular), there was an increase in vocabulary comprehension with those particular words. These studies demonstrate how parents use simpler gesture types when interacting with their infant. In addition, when these gestures are paired with labeling, the nonverbal support they provide allows for further narrowing down of what a word is referring to.

Looming and shaking hand motions are also heavily used by parents with their infants. Looming motions involves an object moving forward and downward from the mother to the infant, while shaking motions have been described as an object moving rapidly in a lateral translation or rotation (Gogate, Maganti, & Laing, 2013). These hand motions are used predominantly by mothers when teaching their 6-8 month old infants novel word to object relations and are often found to accompany labeling moments, moments deemed as synchronous naming (Matatyaho & Gogate, 2008). It has been hypothesized by Matatyaho-Bullaro et al. (2014) that these hand motions lead to heightened learning of word to object pairing because looming motions may allow for increases in the size of an object, while shaking motions highlight an object against a still background (Matatyaho-Bullaro et al., 2014). In their study, video recordings of an experimenter holding and moving an object in front of a black background while naming the object at the same time were used. Infants were put into motion conditions of looming, shaking, upward, sideways, or all-motion and were first habituated to word-object pairs. They were then tested using two mismatched trials and two control trials. The study revealed that the type of motion used during adult communication made a difference in preverbal infants' ability to map words on to objects; shaking and looming gestures led to increased learning of word to object mappings. However, though these results bring us closer to understanding why these gesture types might be so important to infant (6 to 8 month olds) word to object mappings, we still do not know the visual characteristics these gestures have, how they are viewed by the infant, or how these visual experiences may change between prelexical infants and early lexical infants.

In all, these gestures and hand motions make objects and other relevant stimuli in the environment more salient for the child to attend to, possibly through changes in object size. Consequently, these visual experiences produced by these gestures and hand motions could lead to longer durations of gazing, or sustained attention (Yu & Smith, 2016). The attentional phase of sustained attention is marked with three important parts: encoding of information about the stimulus, active attention to the stimulus, and the recruitment of cognitive processes (Richards & Casey, 1992). As such, sustained attention to relevant information in the environment, including objects, has been shown to be important in learning (Ruff & Lawson, 1990); prolonged attention to relevant information in the environment allows a child to map information correctly (Finneran, Francis, & Leonard, 2009).

The Process of Visual Development and its Relation of Gestures

The literature concerning gesture use all points to the effectiveness of gesture use and how parents readily modify their use. A critical remaining question is how these particular gestures become effective with infants? Are these gestures really attracting and guiding attention? In order to fully address the mechanism of how these particular gestures are effective with infants, we need to understand how visual development is related to gestures. As discussed earlier, gestures are like an object in motion, grabbing attention (Amano et al., 2004). As a result, it is important to explore visual development in relation to features such as motion and object size that may be related to how gestures navigate attention. We start with the first month of life.

During the first month, infant attention is driven by external stimuli and infants have a difficult time disengaging from one stimuli and redirecting their attention to another (Johnson, 1990). It is also during this time that we see infants capable of reflexive saccadic eye movements (Richards, 2001), a type of looking that is simply eye movements in response to a stimulus occurring in the environment. This particular eye movement utilizes a pathway that has been described as the old phylogenetic pathway that uses the lateral geniculate nucleus and the primary visual areas (Rosander, Nystrom, Gredeback, & von Hofsten 2007). Reflexive saccadic eye movements dominate the immature visual system as the child continues to develop through 3 months. During this time, the primary visual areas continue to develop, and as each part develops and matures new capabilities arise.

Voluntary saccadic eye movement starts to come into play from the first to the sixth month of infancy as the cortex, visual areas 1, 2, and 4, and the parietal cortex become more mature (Richards, 2001). These types of eye movements are planned, under voluntary control, and are attention directed. The latest eye movement to develop is smooth pursuit, where the smooth tracking of visual stimuli over a large range of visual space emerges. This kind of eye movement requires maturation of the cortex, medial temporal lobe, and the middle superior temporal lobe; these maturational changes occur over a longer period of time. The function of smooth tracking is to help the individual stabilize their gaze on a target. A rudimentary version of this can be seen in neonates (they can smooth track until the stimuli is at a certain angle or at a certain speed) (von Hofsten & Rosander, 1997) and the ability continues to refine itself through the first 5 months.

We have seen that an infants' visual system is continuously developing and maturing, allowing for more processing and control over looking behaviors. By the time they are five months, infants are able to stabilize their gaze on a target, track over a wide range of visual space, and refine their sustained attention ability. These visual capabilities continue to mature over time. Thus, we can see how certain gestures (deictic and symbolic) and hand motions (looming and shaking) might be more beneficial for particular age groups as a result of the visual experiences of an object they provide, especially during the early months of word learning.

Study Aims

Current studies investigating parental gesture use have focused on a few gestures and a very limited range of age. There is also no evidence to date about how parental gestures guide or capture infant attention. Furthermore, though research points to certain gestures as being more helpful for infant word to object mapping, we only have speculations as to why these gestures are helpful. As such, this thesis aims to address four questions. First, I look into the gestural input that parents provide their children and how these frequencies may change across the prelexical and early lexical groups. I hypothesized that overall parent gesturing frequency will be less for prelexical infants compared to early lexical infants. Second, I look into how these gestures capture attention and support sustained attention to relevant cues (object, face, and hands) in the learning environment. Given information from previous literature that infants attend more to larger patterns at younger ages (Fantz & Fagan, 1975), and how infants attend to moving things that stand out against other objects in a scene (Nagata & Dannemiller, 1996), I hypothesized that prelexical infants will attend more to looming gestures more than other gesture types. I further hypothesized that looming and shaking gestures would guide attention more to relevant cues in the learning environment. As previously discussed in the introduction, recent research points to particular gesture types that aid infants more in word learning and it was posited that this might be due to the changes in object size these gestures provide. To explore why certain gestures have been shown to be more helpful to infants compared to others, it is necessary to begin to characterize the visual properties that these gestures provide to an infant's visual field and provide empirical evidence of the changes. For my third question, I ask how different gestures impact object size changes in an infant's view. I hypothesize that there will be a greater difference in object size in a child's view when looming gestures are used compared to other gesture types. This is due to the nature of a looming gesture as defined by Matatyaho-Bullaro et al. (2014), where objects go from the center towards the child in a linear and lateral fashion. Lastly, I ask how the changes in object size and parental gesturing impact the infant's sustained attention. I hypothesize that gestures that provide larger views of an object will lead to more moments of sustained attention.

Approach

The present study aims to characterize the gesture input provided by parents to their prelexical or early lexical and to explore the impact these gestures have on the infant's visual experiences during a parent-child word learning interaction task. I focus on prelexical infants (5 to 7 months), since they have not yet begun to verbally produce words and still heavily rely on gestural communication and early lexical infants (9 to 11 months) since they have begun to produce a few words. Further, I look at several gesture types from the parent's side, including deictic, symbolic, showing, looming, upwards, downwards, beat, and conventional gestures. Lastly, using an eye-tracking device placed on the child's head, infant's visual experiences are explored by looking at the object size changes occurring in the child's view as a result of gestures, and what the infant is attending to (objects, hands, and parent's face) frame-by-frame. From this coding, sustained attention moments will be able to be determined.

Methods

Participants

Twenty-two infants and their parents from Houston, Texas and surrounding areas participated in the study. Infants were recruited from ages 5 – 11 months of age. Children ages 5, 6, and 7 months old were placed in the prelexical group, while children ages 9, 10, and 11 months old were placed in the early lexical group. All children had no developmental delays or neurodevelopmental disorders as reported by parents.

Design

Parents were seated in a small chair across from their infant with a small white table (75cm x 50cm) in between them. They were provided with a box of 8 toys that was available in a tub on the floor for use. Infants were placed in a Bumbo seat appropriate for children 5- 12 months old. Two room cameras (AXIS M1054 1280x800 resolution digital cameras with Motion JPEG compression for fast motion between frames) were used: one camera was attached to the wall on the side and one was attached to the ceiling. The wall-mounted camera was 2.5 meters away from the table and captured a third person view of the entire task. The ceiling camera was placed 2 meters above the table that parent and child were seated at. The eye-tracking device is a product of Positive Science and uses a 640x480 camera with a 42.2° vertical angle and 54.4° horizontal angle for the head view and an IR sensor for monitoring corneal reflections and pupil orientation from the eye. Before the task began, calibration was performed with the child and the eye-tracking device. The calibration procedure involved a calibration board measuring 60 cm x 40 cm and contained 9 dots distributed throughout the view to record adjustments of the orientation of the eye and head cameras. Using a glove with flashing LEDs or an attractive toy, the experimenter pointed to dots one-by-one, ensuring that the infant looked at each one. The Yarbus eye- tracking software is later used for syncing the first person view video and eye video captured for the child for offline estimation of the final tracking data (estimated pixel coordinates, frame-by-frame, corresponding to gaze direction). Using this software and our calibration method, a correlation criteria of 0.9 was established to ensure the estimated position of eye gazes correlated with the actual position of an eye gaze.

Procedure

Parents and infants were seated across from each other with a small table between them. An experimenter distracted the baby while a second experimenter placed a cap with Velcro attached to the front of it on the infant's head. After placing this cap, the second experimenter attached the eye-tracking device to the Velcro and adjusted the view to ensure the first person view camera captured the entire scene and that the eye was clearly visible in the eye video. A third experimenter outfitted the parent with an eye-tracking device while the first experimenter readied the infant for calibration. Once calibration was completed for both parent and child, the parent was told to listen to a recording that said a different word every 40 seconds. A total of 8 words were presented, four of which were nouns and four of which were verbs. Parents were told to use any toys provided in the box of toys next to them on the floor to teach their infants the word they heard. One experimenter remained in the room hidden and quiet behind a curtain to ensure the recordings ran smoothly. The entire visit, from filling out forms to the play session, took about 30-40 minutes.

Video Processing

After the study, videos were exported from the recording computer. As described in the Design section, the first person view and eye video recordings were then synced using Yarbus. Videos from the ceiling and wall were exported into Adobe Premiere, where, along with the synced first person view, they were processed into a four-quadrant, synced video (Figure 1). Once all videos had been synced into their final version, they were exported to begin manual, frame-by-frame, behavioral coding using Datavyu.

Coding

The Datavyu video coding system was used for all coding (Datavyu Team, 2014). Behaviors that were used for the entire study are described as follows. Pre-selected and later determined behaviors and instances were annotated (time stamped) by using the wall mounted camera view (scene view) and head-mounted camera view (child's view). By using the scene view, parents' gesture use was annotated. By using the child's view, instances of each parent's gesture and objects in the scene that were attended to were annotated. To account for the potential of different amounts of speech used, parent's labeling of target objects was also coded.

Gestures. Gestures were coded based on previous researcher's definitions and coding. Shaking, looming, upwards, downwards, deictic, and symbolic gestures were coded. Using coding definitions provided by Matatyaho et al. (2014), looming was coded as movement from the center of the video monitor that came towards the bottom of the video screen in a linear and lateral fashion. Shaking gestures were coded as each object that moved repetitively and quickly in short distances, typically from left to right. Upward gestures were coded as those movements that went from a low to a high position and sideways gestures were coded as those movements that moved from side to side in an infant's visual field. Symbolic gestures were coded as those that acted as play or pretend gestures done with or without objects (pretending to drink liquid out of an empty cup) (Goodwyn et al., 2000). Deictic gestures were defined and coded as showing (directing a child towards an item, putting an object directly in front of the child) and pointing (extending a finger towards object, tapping an object with a finger) in the immediate environment (Medeiros & Winsler, 2014).

Infant Attention and Sustained Attention. Using the synced eye video from Yarbus, every instance of eye gaze was annotated in Datavyu. These included instances where the infant looked at the parent's face, parent's hands, the object, or their own hands. When they were looking, what they were looking at, and how long they maintained attention was recorded. In terms of sustained attention determination, literature concerning sustained attention time thresholds over the course of infancy is sparse. Research conducted by Richards (1985) detailed the decline in sustained attention moments for 3 months (12.5 seconds), 4.5 months (8.3 seconds), and 6 months (7 seconds) in a task that had infants watch stimuli on a screen for 5 minutes. Recently, Yu and Smith (2016) reported a minimum threshold for sustained attention at 3 seconds for 12 month olds. As such, we used 2 seconds as a minimum threshold to code sustained attention moments. These sustained attention moments could be to the parent's face, parent's hands, objects, or the child's own hands.

Parent Speech. Moments of parental labeling, utterances, and dialogue were annotated. These include the target words used in the study, utterances that redirect attention ('Look!'), and statements that call for attention ('Look at the bunny!'). To account for possible differences between groups in the amount of speech during the play session, parents' labeling of target objects and every utterance was coded. There were no significant differences between groups in parent labeling, t (21) = 1.73, $p > .05$. Given our age group, this is in line with research that reports increased, constant, and heightened motherese for young infants (Durkin, Rutter, & Tucker, 1982; Gogate, Bahrick, & Watson, 2000; Kitamura & Burnham, 2003).

Object Size. For every time an object was seen in the infant's first person camera, measurements were taken to determine the object size (in pixels) relative to the frame. First, a screenshot of the desired frame was taken with the object in the child's view and cropped. Using Adobe Photoshop, the object was selected and an 'area' value was determined using the 'Record Measurements' option. Using 'Image Size', measurements for the height and width of the image were recorded. This coding was done frame-by-frame to determine the changes in object size occurring.

Results

Parent Gesture Production Towards Prelexical and Early Lexical Infants

To address the first question concerning the gestural input parents provide between the prelexical and early lexical groups, a mixed ANOVA was used. When comparing the effect of group on the frequency of gestures, there was no significant difference found, $F(1,21) = .053$; $p > .05$. There was a main effect of gesture type on the frequency of gesture, $F(6,21) = 21.534$; $p < .0001$ (Figure 2). Following up with a Tukey's Honest

Significant Difference test, significant differences were found between several gesture types, as can be seen in Table 1. In particular, symbolic gestures were produced significantly more than other gestures. To explore this finding, further analysis was done on the impact word class (noun or verb) may have had on the frequency of different gestures produced. It is possible that verbs lend themselves to more symbolic gestures by nature. Using a two- way ANOVA looking at the effects of word class and gesture type on gesture frequency, no differences were found between the two word classes, $F < 1$. A main effect of gesture type was found, $F(6,21) = 32.20$; $p < .0001$. There was also an interaction effect between word class and gesture type, $F(6,21) = 10.91$; $p < .0001$.

When looking at the frequency of different gesture types performed by parents of both groups, there was no interaction between group and gesture type $F(6,21) = 1.260$; $p > .05$. Another way to look at the differences in parental gesturing behavior is to look at the duration of gestures across both groups. To do this, we used a two-way ANOVA to see the effect of group and gesture type on the duration of gestures. There was a main effect of group, $F(1,21) = 5.549$; $p < .05$, and gesture type $F(6, 21) = 2.63$; $p < .05$.There was no interaction effect between group and gesture type $F < 1$.

Infants' Capturing of Parent Gestures in View.

Next, we look at how parent gestures capture attention between both groups and how different gesture types might be attended to differently. Using a mixed ANOVA to test the effects of group and gesture type on captured attention rate, we found there was no main effect of group, $F(1,21) = 2.149$; $p > .05$, or gesture type, $F < 1$. Though gestures were captured at a high rate for each group (prelexical: 83.5%; early lexical: 85.9%), there was no significant interaction between group and gesture type on captured attention rate, $F < 1$ (Figure 3).

To explore infant gaze to relevant cues in the environment, we used a mixed ANOVA to analyze the effects of group and relevant cue type on infant attention to relevant cue type. There were no main effects of group on infant attention to relevant cue type, $F < 1$. There was a main effect of relevant cue type on infant attention, $F(3,21) = 100.55$; $p < .0001$ (Figure 4). Post hoc comparisons using the Tukey's HSD test indicated several significant differences between cues that children attended to (Table 2). Looks to objects were significantly more than looks to faces ($M = 143.14$; $SD = 13.84$), parent hand ($M = 82.86$; $SD = 13.84$), and child hand ($M = 168.05$; $SD = 13.84$). There was no interaction between group and relevant cue type on infant attention to relevant cue type, $F < 1$.

Given literature concerning the ability for gestures to guide attention in the environment, analysis was done to see what proportion of looks to relevant cues were a result of a gesture. A two-way ANOVA was used to look at group and relevant cue type on the proportion of infant looks to relevant cues that were a result of a parent gesture. There was a main effect of group on the proportion of infant looks to relevant cues that were a result of a parent gesture, $F(1,21) = 14.43$; $p < .001$ (Figure 5), but not for relevant cue type, $F(3,21) = 2.276$; $p > .05$. No interaction effect was found, $F(3,21) = 2.126$; $p > .05$.

When looking at how gestures support sustained attention, first the average amount of sustained attention during the task was determined. For the prelexical group, sustained attention made up 12.1% of total gazes and 11.5% of total gazes for early lexical. When we further looked into the amount of these sustained attention moments that were a result of a gesture, we found that the prelexical group had 65.3% of their sustained attention that was a result of gesture, while the early lexical group had 59.7%. A two-sample t-test was used to see if there were differences between the two groups; none were found, $t(20) = .602$, $p > .05$. Analysis was done to see the effect of group and relevant cue on sustained attention to relevant cues. A main effect of relevant cue was found, $F(3, 21) = 23.17$; $p < .0001$. There were no differences between both groups, $F < 1$. A follow-up Tukey's HSD revealed a number of significant differences, with objects having significantly more sustained attention looks than parent hands, $p < .0001$, and child hands, $p < .0001$.

Parent Gestures and Object Size Changes in Infant's View

For the next two research questions, we focus on ten 9-month-old infants while they learned the word 'bunny' with their parent. To address how different gestures impact object size changes in an infant's view, a one-way ANOVA was used. We looked at the effect of gesture type on the magnitude of the change in size and found that there were no differences between the gesture types, $F(4,21) = .341$; $p > .05$. Given the constrained sample, we also looked at the variance of change in size for each gaze. This analysis yielded no significant differences, $F(4,21) = 1.301$; $p > .05$.

Parent Gestures and Object Size Changes Impact on Infant Attention to Relevant Objects and Sustained Attention

Finally, the last set of analyses looks at the impact parent gestures had on object sizes in the child's view, and how these object size changes impact infant gaze and sustained attention. We used a one-way ANOVA to see the effect of gesture type on the change in object size and found no effect, $F < 1$. We looked at how changes in object size impacts the duration of infant gaze. A simple linear regression was calculated to predict duration of gaze based on the change in object size (Figure 6). A significant regression equation was found, $F(1,21) = 181.2$; $p < .0001$, with an R^2 of .3774.

General Discussion

Literature is saturated with how a child's own gesturing production and how the ability to understand gestures has an impact on their language and communicative development. In contrast, there are a few studies documenting the types of gestures and hand motions parents provide their children from around 6 months and older, though a few gesture types (deictic and symbolic) and hand motions (looming and shaking) have been deemed as particularly helpful during infant word learning. As of yet, there is no empirical evidence as to whether infants are capturing the gestural information their parents are providing, how parent gestures guide attention to relevant cues in the environment (hands, face, objects), and the impact both of the aforementioned may have on infant sustained attention. As Matatyaho and Gogate (2006) postulated, it might be the object size changes in an infant's view that makes certain gestures more helpful than others. For this reason, the study also looked at object size changes and how this impacts a child's duration of gaze. The present study aimed to: 1) explore the gestures parents provide their infants, 2) how infants attended to these gestures and the sustained attention that resulted from parent gestures, 3) the object size changes these gestures provided in the child's view, and 4) the impact object size had on infant gaze duration.

First, we found that parents did not gesture differently across the two groups. Parents of infants in the prelexical group (ages 5 to 7 months) and parents of infants in the early lexical group (ages 9 to 11 months) produced the same amount of gestures for their children during the task. However, further analysis shows that parents used gesture types at different frequencies, with symbolic gestures occurring more frequently than others. Our results suggest that parents did not change the gestures they produced for their child based on age, but rather, based on the type of gesture. Further analysis also suggested that parents of infants in the prelexical group had longer durations of gesturing than parents of infants in the early lexical group. Previous literature documents the use of simpler, exaggerated gestures, known as gestural motherese, with infants ages 16 to 20 months (Iverson, et al.,1999), or motionese, a type of exaggerated, action feature that is done towards a child with an object, from 6 to 13 months (Brand, Baldwin, & Ashburn, 2002). However, these gestures are typically heavy with deictic gestures as opposed to symbolic gestures. The present results are seemingly contradictory with previous research, and these differences could be due to the task demands of the parent teaching their child verbs including eat, drink, open, and put, all of which may promote more symbolic gestures for demonstration towards their child. Our results support this; when looking at the types of gestures produced for nouns and verbs, we found that there were differences in the types of gestures produced for different word classes. In particular, there were more symbolic gestures produced for verbs than for nouns, and more shaking gestures produced for nouns than for verbs. These findings suggest the importance of keeping task demands in mind when studying and interpreting parental gesture behavior.

Second, results showed that infants did not attend to different gestures differently. Regardless of the gesture type produced, infants seemed to attend to them at comparable rates. Infants attended to relevant cues (hands, objects, or face) differently. In particular, objects were looked at the most compared to parent hands, child hands, and face for both groups. This is especially interesting, considering parent gestures were found to be accompanied by objects 96% of the time. Indeed, even with a correlation criteria of 0.9 during eye gaze calibration for the eye-tracking data, gaze position errors could increase over the course of the study as a result of infant movement and shifts in the head camera position. This could lead to a wider range of uncertainty when it comes down to differentiating a gaze that is strictly on an object as opposed to the hand holding the object. Nevertheless, similar results have been found in studies by Yoshida and Smith (2008) and Yoshida and Burling (2011), where it was shown that objects and hands dominate the infant's visual field. For example, it was found that either a child's or parents' hands were in the child's view with an object for at least 80% of the frames (Yoshida & Smith, 2008).

Parents' gestures guided infant attention to relevant cues differently; infants in the prelexical group had higher amounts of looking at relevant cues as a result of a gesture than the early lexical group. These results are in line with findings by Yoshida and Smith (2008), where they found that shifts to a new object followed a hand action about 60% of the time. In the present study, results suggest that parents used gestures to guide their infant's attention to relevant cues, and this method seemed to be more effective with infants in the prelexical group. This particular finding is interesting, and extends findings of a previous paper by Yoshida and Burling (2013) where changes in dominant object handling between 6 and 18 months from the parent to the child were documented. It stands to reason that as the child is still gaining motor control and coordination, parents are responsive in their gestural cues towards their child to bring forth and constrain relevant information for the child. Though these findings provide interesting insights into how infants are attending to relevant cues in their environment, it is possible that all the cues that are produced and entering the child's visual field are not reflected in our analysis. Further coding of the data to take into account all relevant cues available in the environment, and even the intensity of the gestures accompanied with objects provided by parents, would give us a clearer view of what is available in the infant's field of view.

Out of the entire task, sustained attention moments for infants in the prelexical group accounted for 12.1% of total gazes and 11.5% for early lexical. This is interesting, but perhaps not too surprising, considering that sustained attention ability develops gradually over the course of the first year of life (Richards & Casey, 1992; Yu & Smith, 2016) and the present findings may reflect the early stages in which sustained attention is developing. It is possible that if we looked at sustained attention in this task for children ages 12 months and onward, we may see more instances of sustained attention. Interestingly, our results showed that a significant portion of these sustained attention moments were a result of parent gesture and that there were more moments of sustained attention to objects than parent and child hands. This also demonstrates the potential role that parental gestures may play in the development of sustained attention over the first year; the constraint of relevant information in the infant's visual field through gesture use may make it easier for an infant to maintain their eye gaze to objects.

Next, to explore the visual experiences a parent's gesture provides an infant, we looked at changes in object size in the child's view as a result of parental gesturing. There were no differences found for object size changes due to gesturing, and this was further confirmed by looking at the variance in the changes in size of the objects. Previous studies have reported parent object holding behavior and the changes in size they produce for their infant over time (Yoshida & Burling, 2013), making this result unexpected. However, it is possible that these results were obtained due to the limited nature of the data; only ten 9 month olds were used and only the word 'bunny' was analyzed for object size changes. This in itself may have constrained the types of gestures used by parents, and, in fact, upwards and downwards hand motions were not produced by any parent during this trial. However, this is a great start in terms of looking at the visual characteristics given to objects due to gesturing; looking at this over a variety of words and possibly even tasks may shed more light on the infant's visual experiences and how this may correlate with parent produced gesture types that have been deemed as more helpful during word learning.

Lastly, we explored the impact of object size on the duration of infant gaze. Our results suggest that when the magnitude of size change increases, infants look at the relevant cue more. Indeed, changes in size do capture infant attention and lead to longer gazes, an important aspect of attention that aids a child in object-referent mapping.

There are a few limitations that need to be discussed. Overall, the sample size used for the task was small. In particular, the use of only ten 9 month olds proved to be quite detrimental to answering questions concerning object size, gestures, and impacts on child attention. In addition, looking at only the trial 'bunny' constrained the data in terms of the variety of gestures used across parents to teach the word. For example, parents across all ten 9-month-olds did not use upwards or downwards hand motions the entire time they taught the word 'bunny' and used other gestures in similar frequencies. Though the data was selected and coded in this way due to the sheer intensity and time necessary to manually code one child's object size data frame by frame (~24-32 hours per child), including more word learning trials is necessary to see the impact that a variety of gestures, especially ones that have been deemed as more relevant to word learning, may have on object size changes in the child's view.

Next, exploring the motion that a gesture produces in the child's view is necessary. Object size changes are, in essence, motion. Motion could be a key contributor to the development of attention and sustained attention. Gestures produce not only changes in object size, but can also involve having an object in motion, increasing its saliency for the infant. Looking at both object size changes and motion changes due to gestures could bring us closer to understanding the visual characteristics that gestures provide in a child's view and the impacts these characteristics have on attention and sustained attention (which may be one reason why certain gestures are more effective than others).

It would be interesting to explore the differences in parental gesturing across a wider range of children and look at the quality (duration and gesture combinations) and complexity (simplistic and abstract nature) of the gestures done across age groups. In this regard, and given the present findings, it would also be important to look at mothers with depression and the gestures (quality and quantity) they provide to their infants. Previous research has shown that mothers with depression touch their infant less (Field, 1995) and do not use motherese as much (Kaplan, Bachorowski, Smoski, & Hudenko, 2002), both of which negatively impact an infant's cognitive and emotional development. However, there is a dearth of research on the changes in parental gesturing should the parent have depression, and there is no evidence on how this may impact an infant's learning environment. Future research is needed to continue establishing a baseline on the characteristics of gestures that make them so conducive to learning. These baseline findings could help clinicians and researchers target less than optimal gesturing behaviors from mothers with depression and help augment these behaviors to better support their child.

The current study illustrates the potential role that parent gesture may have on guiding infant attention and sustained attention during interactions. We also see the significance of changes in object size on longer durations of gaze to important information in the environment. These findings and further research looking into visual characteristics of objects due to gestures could be particularly useful in understanding the role parent gestures play in organizing sustained attention. Sustained attention has not only been shown to support word learning, but has also been implicated in joint attention (Yu & Smith, 2016), executive functioning (Zelazo, Carter, Reznick, & Frye, 1997), and cognitive outcomes (Rose, Feldman, & Wallace, 1992). Finding a mechanism in which to promote and support this attentional behavior early could have beneficial outcomes for infants and children with language or developmental delays. Given the role that sustained attention to relevant information in the environment plays on word learning, parents and clinicians can focus on the use of gestures as one beneficial way to help support infant word learning.

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Figures

Table 1

Difference between Frequency in Gesture Type				
		Confidence Interval		
Gesture Type	Difference	Lower	Upper	P Adj
looming - deictic	-6.14	-14.06	1.78	p > .05
symbolic - deictic	8.5	0.58	16.42	p < .05*
shaking - deictic	-6.5	-14.42	1.42	p > .05
downwards - deictic	-14.70	-22.60	-6.76	p < .001***
other (conventional & beat) - deictic	-14.22	-22.15	-6.31	p < .001***
upwards - deictic	-14.18	-22.10	-6.26	p < .001***
symbolic - looming	14.64	6.72	22.56	p < .001***
shaking - looming	-0.36	-8.28	7.56	p > .05
downwards-looming	-8.55	-16.46	-0.63	p < .05*
other (conventional & beat) - looming	-8.09	-16.01	-0.17	p < .05*
up-looming	-8.05	-15.96	-0.13	p < .05*
shaking - symbolic	-15	-22.92	-7.08	p < .001***
downwards - symbolic	-23.18	-31.10	-15.26	p < .001***
other (conventional & beat) - symbolic	-22.73	-30.65	-14.81	p < .001***
upwards - symbolic	-22.68	-30.60	-14.76	p < .001***
downwards - shaking	-8.18	-16.10	-0.26	p < .05*
other (conventional & beat) - shaking	-7.73	-15.65	0.19	p > .05
upwards - shaking	-7.68	-15.60	0.24	p > .05
other (conventional & beat) - downwards	0.45	-7.46	8.37	p > .05
upwards - downwards	0.5	-7.42	8.42	p > .05
upwards - other (conventional & beat)	0.05	-7.87	7.96	1

Table 1: Shows the results of the follow up Tukey's HSD test. Several gesture types were found to happen more frequently than others.

Table 2

Differences in Infant Looks to Relevant Cue Type					
		Confidence Interval			
Relevant Cue Type	Difference	Lower	Upper	P adj	SD
Object-Face	143.14	115.46	170.81	p < .001***	13.84
Parent Hand - Face	60.27	32.60	87.95	p < .001***	13.84
Child Hand - Face	-24.91	-52.58	2.76	p > .05	13.84
Parent Hand - Object	-82.86	-110.54	-55.19	p < .001***	13.84
Child Hand - Object	-168.05	-195.72	-140.37	p < .001***	13.84
Child Hand - Parent Hand	-85.18	-112.85	-57.51	p < .001***	13.84

Table 2: Shows the results of the follow up Tukey's HSD test on what relevant cue type infants attended to during the task.

Figure 1: Picture showing an example of the four-quadrant, synced video that is exported to begin manual, frame-by-frame, behavioral coding using Datavyu.

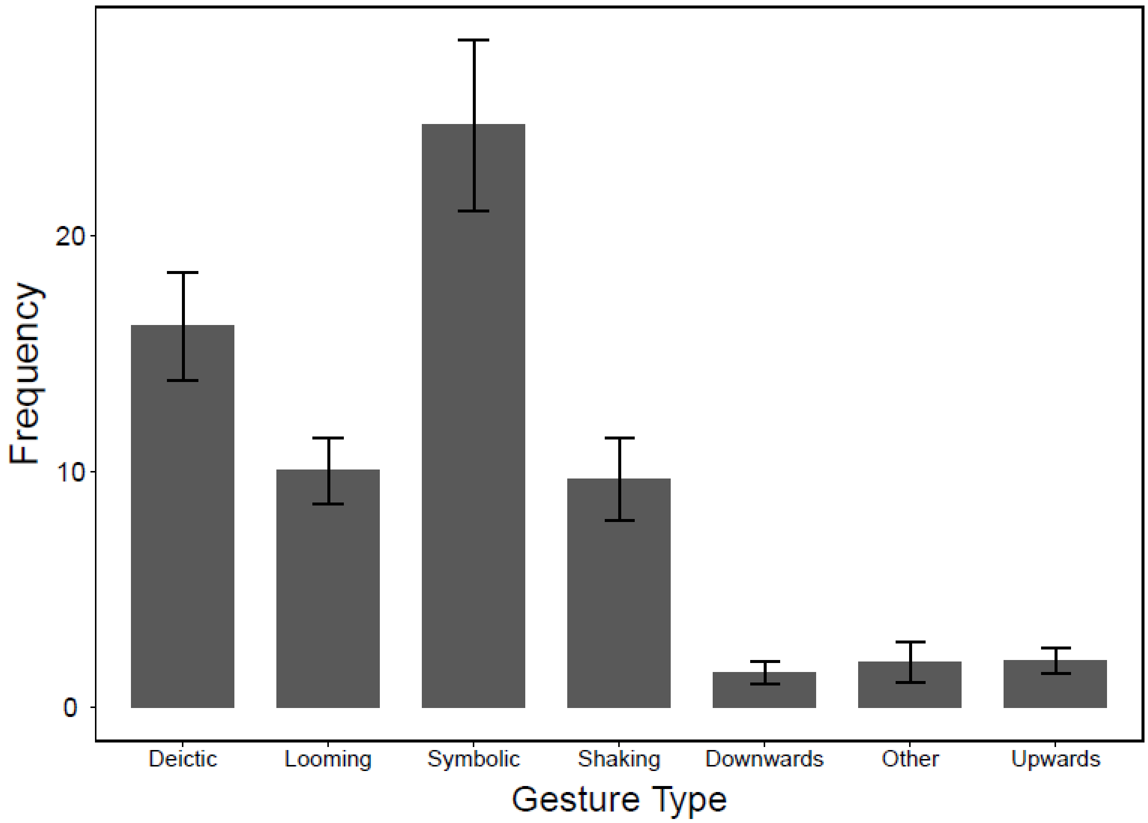

Figure 2: Graph showing frequency of gestures parents produced by gesture type.

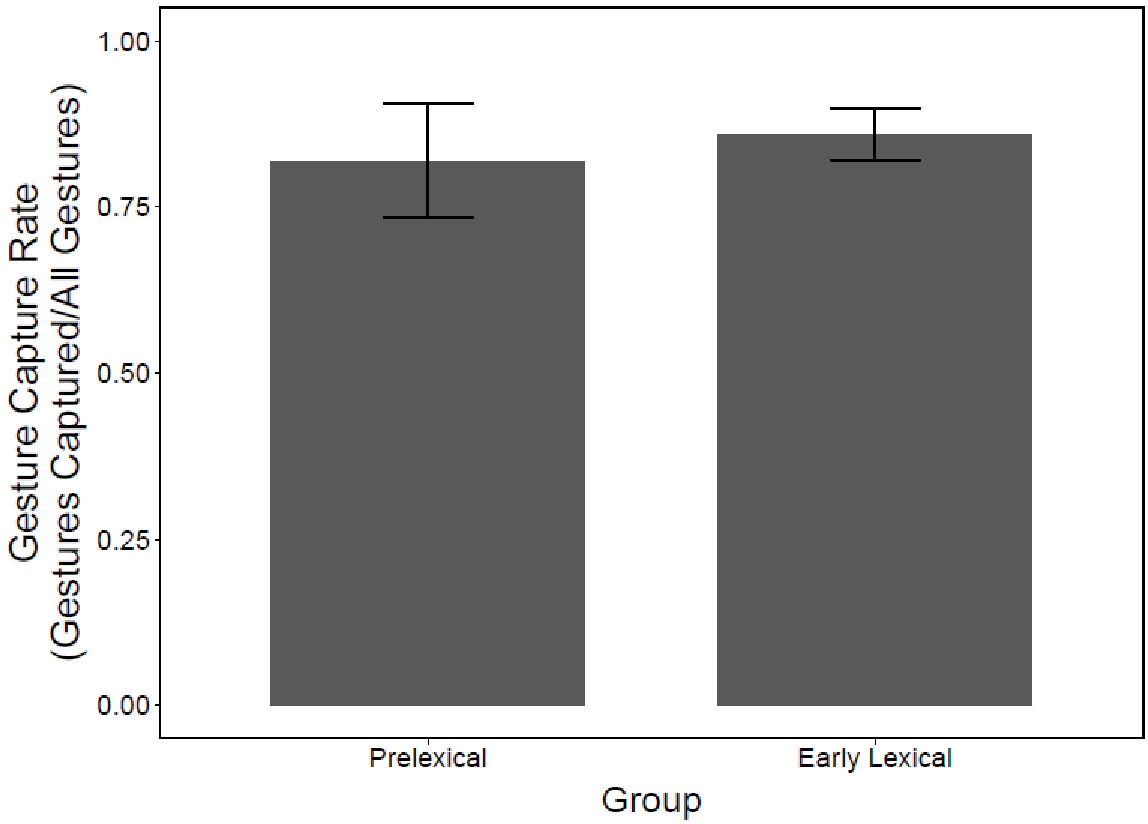

Figure 3: Graph showing the gesture capture rate of infants for both groups.

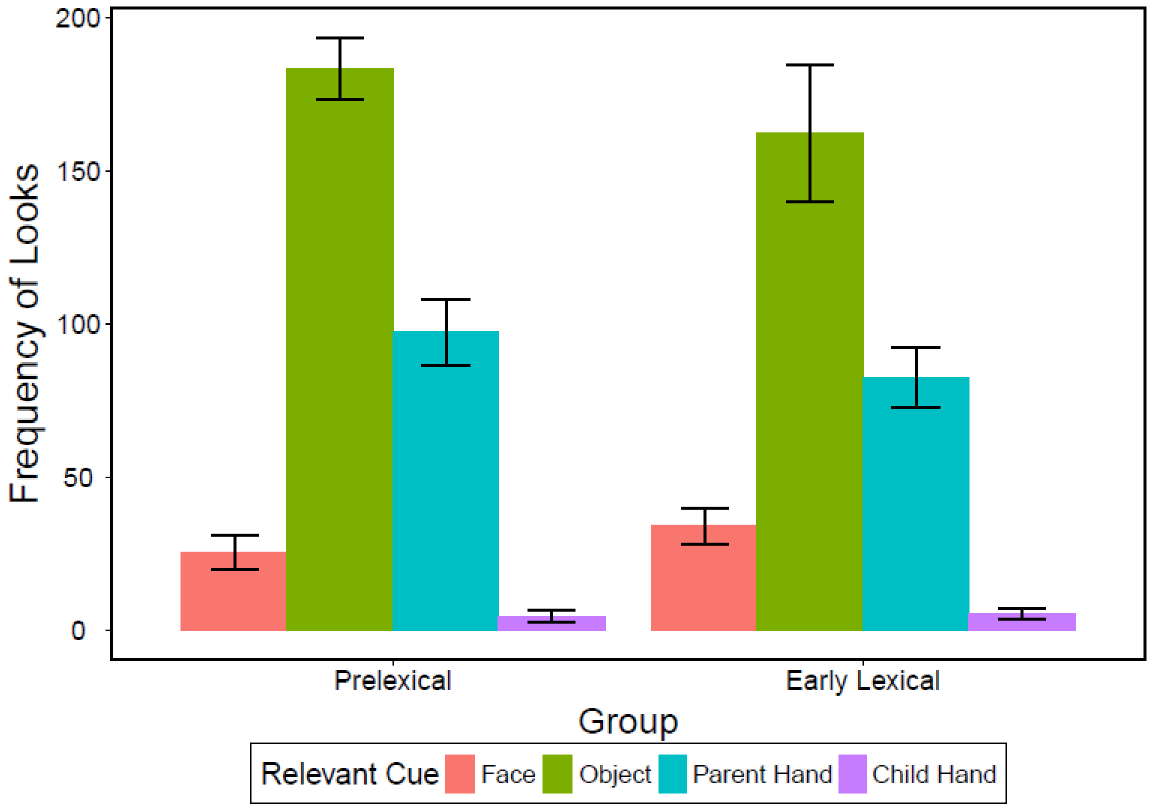

Figure 4: Graph showing the frequency of infant looks to relevant cues in the environment (hands, objects, and parent face). Objects were looked at in high frequencies across both groups.

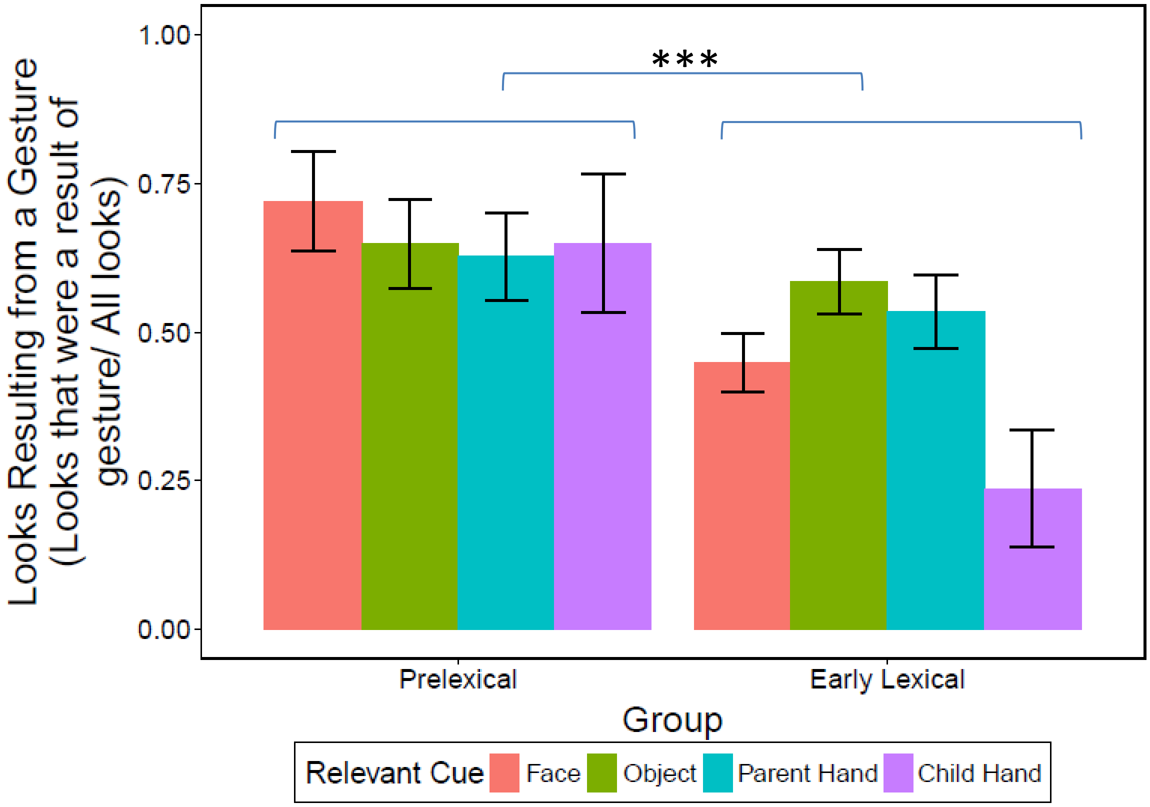

Figure 5: Graph showing infant looks to relevant cues that were a result of parent gesture. Analysis showed an effect of group, with prelexical infants looking more towards relevant cues as a result of a gesture than early lexical infants.

Figure 6: Plot of the changes in object size in an infant's view and the duration of an infant's gaze.