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INFANT GAZE DIRECTION DURING EARLY VOCALIZATIONS AS AN INDICATOR OF VOCABULARY DEVELOPMENT

by
Breanna N. Edwards

A thesis

submitted in partial fulfillment

of the requirements for the degree of

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Committee Approval

To the Graduate Faculty:

The members of the committee appointed to examine the thesis of Breanna N. Edwards find it satisfactory and recommend that it be accepted.

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RE: Your application dated 11/18/2014 regarding study number 4199: Infant Gaze Direction during Early Vocalizations as an Indicator of Vocabulary Development

Dear Ms. Edwards:

I agree that this study qualifies as exempt from review under the following guideline: 4. Analysis of existing data sets. This letter is your approval, please, keep this document in a safe place.

Notify the HSC of any adverse events. Serious, unexpected adverse events must be reported in writing within 10 business days.

You are granted permission to conduct your study effective immediately. The study is not subject to renewal.

Please note that any changes to the study as approved must be promptly reported and approved. Some changes may be approved by expedited review; others require full board review. Contact Tom Bailey (208-282-2179; fax 208-282-4723; email: humsubj@isu.edu) if you have any questions or require further information.

Sincerely,

Ralph Baergen, PhD, MPH, CIP
Human Subjects Chair

Phone: (208) 282-2179 • Fax: (208) 282-4723 • www.isu.edu/research

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I would like to start by expressing my gratitude for my amazing advisor and Thesis Committee Chair, Dr. Ramsdell-Hudock. She has displayed incredible patience and grace as she has provided me with resources, support, and encouragement throughout this entire process. She has taught me to appreciate scientific literature in a way I never thought possible. I will not forget my time working in your lab, learning from you and with you.

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LIST OF ABBREVIATIONS

AACT -- Action Analysis Coding and Training software

ANOVA -- Analysis of Variance

ALGO 3 or ALGO 5 -- automated auditory brainstem response (newborn screening)

CDI -- *MacArthur Communicative Development Inventory*

PPVT -- III -- *Peabody Picture Vocabulary Test*

SALT -- *Systematic Language Transcription Analysis*

AGE GROUP CATEGORIES:

1 Year -- 15-18 months of infant age

2 Years -- 23-27 months of infant age

3 Years—37-40 months of infant age

INFANT GAZE DIRECTION DURING EARLY VOCALIZATIONS AS AN INDICATOR OF VOCABULARY DEVELOPMENT

Thesis Abstract--Idaho State University (2015)

The purpose of this study was to characterize the relationship between infant gaze direction during early vocalizations and vocabulary development in early childhood. It was hypothesized that there would be a relationship between infant looking behaviors and vocabulary size. Archived data from 15 parent/infant dyads that participated in a longitudinal study was explored. Infant utterances were located and looking behaviors coded according to gaze direction (*Directed to Person, Directed to Object, and Not-Directed*). From parent inventories of infant vocabulary, experimenters tallied the number of words produced *and* understood by infants at three points in time (1 year- 15 to 18 months, 2 years- 23 to 27, and 3 years- 34 to 40 months of age). Infant looking behaviors were compared to vocabulary development. Based on the repeated measures ANOVA gaze direction defined in broad terms was not an indicator vocabulary development. However, more research should be conducted on infant gaze behaviors between 15 and 18 months of age in relation to vocabulary development at 3 years (based on significant findings). In addition, the results did indicate that directedness of gaze increases with infant age. Methodology could be refined to better incorporate the interaction between infant and caregiver as it relates to gaze direction and vocabulary. This information may be useful in the formulation of additional studies of infant gaze and childhood vocabulary. Clinical implications, study limitations, and future directions will be discussed.

Chapter I: Introduction

Vocabulary development is intricately linked with language acquisition and academic success. A well-developed vocabulary is necessary for literacy comprehension and communication as a whole (Moghadam, Zainal, & Ghaderpour, 2012). The rate of growth and size of vocabulary varies dramatically for toddlers (Cartmill et al., 2013; Mayor, & Plunkett 2011; Rowe, Özçalişkan, & Goldin-Meadow, 2008). According to normative data, children in the 10th percentile for vocabulary have developed an average of 560.2 words by 30 months of age, while individuals in the 90th percentile display a drastically larger vocabulary of 2032.9 words by 30 months (Mayor, & Plunkett, 2011). Many aspects of an infant's development are responsible for this variability in vocabulary development and can be indicators of vocabulary size in childhood, including: parental interaction, gender, mobility during the first year of life, and non-verbal communication (Mayor, & Plunkett, 2011; Rowe et al., 2008). For speech-language pathologists, increasing the evidence based knowledge available regarding infant behaviors that contribute to vocabulary size can lead to earlier identification of language delay/disorder as well as more comprehensive early intervention approaches.

Non-verbal communication in the first 2 years of life has been shown to be a more accurate indicator of vocabulary size in childhood than early vocalizations (Gold-Meadow, 2007; Rowe et al., 2008). Non-verbal communication includes gesture, gaze direction/visual attention, and facial expressions produced and/or perceived. Copious studies have been completed in order to better understand infants' perception of their communication partners' gaze direction during pre-linguistic communication and how this perception positively contributes to vocabulary development (Butterworth & Jarret

1991; Law, Houston-Price, & Loucas, 2013; Moll & Tomasello, 2004; Morales, Mundy, & Rojas 1998; Morales et al., 2000). In addition, it is well documented that certain pragmatic skills (e.g., joint attention and turn taking) are positively correlated to vocabulary size and complexity in early childhood (Beuker, Rommelse, Donders, & Buitelaar, 2013;Brooks & Meltzoff, 2008; Morales et.al.,1998; Morales et al., 2000). Advanced technology, such as eye tracking software, has been used to determine the facial scanning patterns of infants, and how gaze direction during a communication partner's vocalizations contributes to language development (Hunnis & Gueze, 2004; Young, Merrin, Rogers, & Ozonoff, 2009). However, little is known regarding the direction of the infant's gaze patterns during early vocalizations, and if this is correlated in any way to vocabulary development.

Gesture as Non-verbal Communication

Gesture and vocabulary. Non-verbal communication is multifaceted, and can include looking behaviors, facial expressions, body language, and gestures. Gesture is a valuable tool for early intervention as it can provide insight into a child's communicative repertoire before speech and language develops. Gesture can be divided into two basic categories: deictic gesture and iconic, or representational gesture. Deictic gestures develop before iconic gestures (Brookes & Meltzoff, 2008; Gold-Meadow 2007; Rowe et al., 2008). Deictic gestures are more universal than iconic gestures and consist of showing, pointing, requesting, and protesting gestures that directly indicate the object, or person the child is referring to (e.g., pointing to the radio for it to be turned on). Iconic gestures are more situational (e.g., a child dancing to ask for the radio to be turned on) and vary based on family and culture. Deictic gesture specifically has been identified as a

more accurate indicator of vocabulary development than pre-linguistic vocalization (Rowe et al., 2008; Rowe, Raudenbush, & Goldin-Meadow, 2012.)

Rowe and colleagues (2008) examined the relationship between the deictic gesture of pointing, and vocabulary. Participants included 53 English-speaking infant-parent dyads of varying socioeconomic status' between the ages of 14 and 34 months of age. Data was collected in six 90 min home visits over a period of 20 months. All speech and gestures observed in the sessions were transcribed. Gesture was recorded based on number of gestures, type of gestures (i.e., the number of meanings conveyed in gesture, 3 different gestures for "dog" qualify as one type), proportion of utterances containing only gesture, and proportion of utterances containing speech and gesture. Parent speech and gesture use was also transcribed. The participants were administered the Peabody Picture Vocabulary Test third edition (PPVTIII) (Dunn & Dunn 1997) at 42 months of age as a measure of vocabulary skill. Several analyses were run to determine the primary facilitators of gesture production, as well as the correlation between gesture production and vocabulary. Results of the study demonstrated that child gesture use at 14 months was directly correlated with vocabulary size and content at 42 months. The sheer number of gestures used, the type of gesture used, and the proportion of speech accompanied by gesture were all independently and positively correlated with increased PPVT scores at 42 months of age. In addition, the study determined that parent gesture use was the strongest facilitator of child gesture use at 14 months. This result is important, not only because of the connection observed between gesture and vocabulary growth, but also because of the reliance on parent interaction observed to facilitate gesture use.

Gesture across cultures. Non-verbal communication development has some consistencies across languages and cultures; the correlation between gesture and vocabulary extends beyond the scope of infants in English speaking families. Blake, Vitale, Osborne, and Olshansky (2005) completed a cross-cultural comparison that included English-Canadian, Parisian-French, Japanese, and Italian-Canadian children. Infants were observed at varying intervals, depending on culture, from 9 months of age to 37 months of age. The groups of infants were different sizes and observed at different times, however overarching patterns were evident. All groups showed an increase in comment gestures (e.g., waving bye-bye to another individual), particularly pointing, and object-exchange gestures (e.g., giving a book to a caregiver) with age. In addition, emotive (e.g., bouncing up and down while sitting) and reach-request gestures (e.g., reaching palm extended for something out of reach) were shown to decline. The results also indicated that comment gestures contribute to vocabulary development at age 3. This study hinted at the potential universality to deictic gesture development and to the connections between gesture and vocabulary, as well as to the fact that interventions developed based on this connection will be relevant in multicultural contexts.

Early developing gestures continue to be useful in vocabulary development following the acquisition of first words. A study of Spanish-speaking toddlers revealed a continued use of deictic gestures in conjunction with vocalizations after the toddlers were able to use words alone (Rodrigo, Gonzalez, de Vega, Muneton-Ayala, & Rodriguesz, 2004). This indicates that gesture may help to orient children to objects or people with which they are commenting. Gaze direction plays a similar role in development, orienting children to the conversational partner or stimulus.

Gesture use is a prime example of how non-verbal communication can serve as an indicator of expressive language and vocabulary development (Gold-Meadow, 2007; Rowe et al., 2008). Clinical scales for gesture development, such as the *Bayley Scales of Infant Development* are useful for identifying children at risk for communication difficulties (Bayley, 2005). The proposed study will attempt to determine if gaze direction can be used in a similar fashion. Some research has already been conducted on the impact of infant gaze as it pertains to joint attention and vocabulary development.

Joint Attention

Infants' preference for eye contact and fixation on the eyes of caregivers during the first few months of life is fundamental for the development of joint attention skills (Schietecatte, Roeyers, & Warreyn, 2012). The development of joint attention is a pattern of skills documented cross culturally that consists of sharing, following, and directing the action of others through gaze, pointing, or play (Beuker et al., 2013). As early as 3 months of age, infants begin to show precursors to the skills necessary for joint attention. From 6 to 18 months of age, joint attention skills fully emerge and infants begin to use their gaze to communicate and participate in activities with other individuals: by 9 months of age, infants are demonstrating body following and directing attention with their eyes; by 12 months, they are actively following the gaze of others; and by 18 months, they demonstrate joint visual perception (i.e., sharing a visual target with another individual) (Beuker et al., 2013; Brooks & Meltzoff, 2007). Research indicates that joint attention skills at 6, 8, 10, 12, and 18 months of age are positively correlated with both receptive and expressive vocabulary at 18 months of age and beyond (Morales, et al., 1998; Morales et al., 2000).

D'Entremont, Hains, and Muir (1997) examined 3 to 6 month olds' ability to use joint attention with an adult by having the infants sit in secured chairs and watch the adult in discussion with a puppet. The adult would occasionally turn to look at the puppet while talking. D'Entremont and colleagues (1997) monitored the direction of the infants' eyes, as well as the duration spent looking at the stimulus (puppet or adult). When the caregivers head turns toward the puppet, 73% of infants followed with their eyes; however, the amount of time the infants spent looking at the puppet was very brief. The results of this study suggested that infants were displaying precursors for joint attention and gaze following by following the direction of head turn, but were not fully capturing the essence of joint attention due to the limited duration of their stares. When children follow a head turn, they are demonstrating basic gaze following skills.

Gaze Following

Looking behaviors. The eyes convey a special significance for human communication. Infants display a preference for direct gaze (i.e., a parent looking directly into the infant's eyes) over adverted gaze (i.e., a parent looking off to the side of an infant's face) from birth (Farroni, 2002). There is substantial evidence to suggest that an infant's ability to follow the looking behaviors of another individual is correlated with language development (D'Entremont et al., 1997; Flom, 2007, Brooks & Meltzoff, 2008; Law et al., 2013; Morales et al., 1998; Morales et al., 2000).

Looking behaviors can be broken up into a few key actions. A head-turn is the process by which an individuals' head pivots in the direction of an object to which they intend their focus. Individuals can turn their head toward an object, but the focus of the gaze may be in another direction. Investigation of infant joint attention often uses head

turn as a means of determining gaze following skills. One model is to have the communication partners turn their heads for several trials with open eyes, and several trials with closed eyes to determine if the infants are following the movement of the head turn, or is aware that communication partners are using their eyes to see (Flom, 2007). Eye shift is the movement of the eyes toward or away from a particular stimulus. Eye shift can be completed with, or without the movement of the head. The *Eye Status* paradigm and the *Barriers* paradigm are traditional models used in gaze following experiments. The former considers a combination of head movement and eye movement (i.e., head turn only, head and eyes move together, eye shift only), while the latter modifies the experiment to represent congruent and incongruent considerations (i.e., head and eyes together, head and eyes different) (Corkum & Moore, 1995; Moll & Tomasello, 2004; Moore & Corkum, 1998).

Gaze following and vocabulary. A longitudinal study by Morales and colleagues (1998) successfully linked an infant's ability to follow a parent's direction of gaze with vocabulary development in the first 2 years of life. Here, the participants were 21 infant and mother pairs, from 2-parent, middle to high socioeconomic status homes. The researchers first examined the infants' ability to follow gaze direction at 6 months of age. They used head-turn as the primary looking behavior. Infants were seated across from their mothers and videotaped throughout a 12 minute face-to-face interaction. At two separate points during the interaction the mothers turned their heads three consecutive times toward a referent target 90 degrees to either side of the infant or straight forward looking directly behind the infant. Each time the mothers turned their heads they would say the infants name three times while keeping their eyes on the referent target. Head turn

or eye shift by the infant in the direction of the mothers gaze indicated a correct response. The number of correct and incorrect responses were recorded for each of the infants. After collecting this information, the authors then used the *MacArthur Communicative Development Inventory* (CDI) to document the vocabulary development of the infants at 12, 18, 21, and 24 months (Fenson et al., 1991). Results of the study revealed that a higher number of correct responses on the head-turn task at 6 months of age was positively correlated with a larger receptive vocabulary at 12 months of age, and a larger expressive vocabulary at 18 months of age. These results demonstrate how crucial following a communication partner's looking behavior is during a communicative interaction.

Morales and colleagues (2000) expanded on these results by examining the data to determine an ideal period between birth and 2 years of age where responding to joint attention was most positively correlated with language development (Morales et al., 1998). The results identified a primary period of growth for joint attentional responding skills between 6 and 12 months of age. Following this time period, joint attentional responding seemed to consolidate between 12 and 18 months of age, with most of the infants being fairly accurate with their responses at later ages. More information is needed to confirm these results. This study indicated that the correlation between gaze direction and vocabulary development may be stronger at certain ages (i.e., 6 to 12 months) than others. One problem with both of the above studies is that the authors did not distinguish gaze direction from head turning, and provided a verbal directional cue in addition to the looking behaviors (i.e., the mothers vocalizing the infants' names). Although it is clear that infants are showing joint attentional skills, the multiple

modalities used to indicate direction confound the infants' actual understanding of the interaction.

The level of metalinguistics needed to follow the gaze direction of another individual differs from the level needed to follow a head turn or vocalization. For example, 6 month olds will only follow the gaze of a communication partner to a target that is within their visual field and is the first target in the path of their eyesight (Butterworth & Jarret, 1991). This implies the infant is potentially only following the movement of the head of the communication partner, similar to following a moving toy (e.g., a spinning mobile, or jack-in-the-box), and has no understanding that the individual is seeing something. However, infants as young as 12 months demonstrate an understanding that the looking behaviors of a communication partner contribute to the process of seeing (Moll & Tomasello, 2014).

Gaze following skills do not just contribute to the size of vocabulary in early childhood, but also the speed of vocabulary acquisition. Brooks and Meltzoff (2008) studied 32 infants beginning at 10 or 11 months of age, periodically over time until the age of 2 years. A head turn and eye shift experiment was set up. Infants were assigned either a closed-eyes or open-eyes condition prior to the start of the experiment. Each infant was seated on a caregiver's lap directly across the table from the experimenter. The experimenter played with the infant using a toy before and in-between trials. Each session contained four trials. Just before the start of a trial, the experimenter hid the toy so the infant would not be distracted. To start the trial, the experimenter faced the infant directly. After establishing that the infant was looking at the him/her the experimenter then proceeded to shift both head and eyes toward a target 75 degrees in either direction.

In open-eye condition trials the experimenter's eyes were open throughout the entire trial, in closed-eye condition trails they remained shut. If the infant followed the experimenter's gaze with a head turn or eye shift the score for that trial was recorded as correct. In addition, the duration of time the infant looked at the experimenter during a correct response was recorded.

Many significant results were obtained in this experiment, however, only the following are relevant to the proposed study. The results of the study found no correlation between the number of correct responses and vocabulary development; however, there was a positive correlation between the duration of correct responses and vocabulary development. A longer response is more indicative of true joint attention. In addition, the infants from the open-eye condition demonstrated significantly higher scores than infants from the closed-eye condition, indicating that infants were following the eyes of the experimenter, and not just the head turn. These results indicate that, for gaze to be associated with vocabulary development, more than just simply following head movements is required. Although the infants in this study were videotaped, correct responses were recorded manually. Manual coding of gaze following is an effective method of researching gaze behaviors; however, new technology has given rise to a revival of eye-tracking as a way to document gaze following and infant scanning patterns.

Eye Tracking

A very brief history of eye tracking. Mohamed and colleagues (2007) present a very detailed history of the development of eye tracking technology in *A History of Eye Gaze Tracking.* The highlights are summarized in the remainder of this section, however, for a more comprehensive description of the development of eye tracking technology,

please refer to the previously mentioned article. Eye tracking technology has been available since before the 1900s. Methods were originally very invasive and consisted of a contact lens attached to a metal pointer. Non-invasive eye tracking advancements were made throughout the 1900s, starting with Dodge and Cline in 1901, who developed a way to reflect a light off the cornea to monitor horizontal eye tracking movements. The first head mounted tracker was developed in 1948, further progressing eye tracking as a tool for research. A large wave of eye tracking improvements began in the 1970s, and incorporated connection of eye tracking technology to the computer. This technology has been progressing rapidly ever since.

Most eye tracking technology available today consists of tracking infrared, or ambient light emitted by a device placed on, or in front of the participant (i.e., a head-mounted, or desk-mounted device). This light is reflected off the cornea and retina of the eye and monitored by computer software (Mohamed et al., 2007). Eye tracking software earned a spotlight in infant communication development in the early 2000s. Since that time there has been a huge influx of research on eye tracking as a method of researching all aspects of infant development, including cognition, attention, and, most importantly for the purpose of the current study, gaze direction (Oakes, 2012).

Eye-tracking study results and vocabulary. Eye tracking software has been useful for determining how facial scanning patterns in infants effect language development. The gaze direction of infants during communication aid and assist in learning sounds, and eventually contribute to vocabulary development. Recent studies suggest that infants demonstrate a preference for the mouth and eyes of a communication partner during a communicative interaction from a very young age. In addition,

preference toward the mouth area over the eye area emerges by 26 weeks, and this preference is positively correlated with greater expressive language and vocabulary skills at 2 years of age. (Hunnis & Gueze, 2004; Young et al., 2009).

Hunnis and Gueze (2004) investigated the scanning patterns of infants at 6 to 26 weeks of age. Ten infants participated in the study and gender was evenly distributed. All infants were tested in a state of alert wakefulness over the course of five or six sessions. In each session the infant was given time to acclimate to the environment and then placed in an infant chair 35 cm away from a 21 inch computer monitor. Each infant was presented with two stimuli: an abstract image (i.e., a colorful moving figure derived from a scrambled version of their mothers face) and a video of their mother interacting communicatively (i.e., smiling and nodding). Eye movements were tracked using an ASL Model 504 tracking system. Information received from the eye-tracking system was verified using manual coding. Gaze direction during interaction was coded by assigning a number of zones. Zones assigned included the eyes, mouth, edge (i.e., the edge of the face, the hair line, or lower jaw), background, and body.

Data obtained from the study included the number, duration, and location of fixations. Results for duration of fixation demonstrated a dramatic increase between 6 and 10 weeks of age. The number of times an infant looked away from the stimulus increased dramatically from 6 to 26 weeks, from an average of two adverted gazes at 6 weeks, to an average of six and a half adverted gazes at 26 weeks. This indicated that with increasing age comes the desire and ability to attend to more stimuli during a communicative interaction. Finally, the results of the study indicated a preference for

gazing at eyes and mouth over other zones at 6 weeks of age, but by 26 weeks infants show a clear preference for looking at the mouth over all other zones.

The work of Hunnis and Gueze (2004) was further supported and expanded on by Young, and colleagues (2009). In an attempt to discover a correlation between facial scanning at 6 months of age and autism spectrum disorder, Young and colleagues (2009) used gaze-tracking software and unintentionally discovered a link between infant gaze toward the mouth and vocabulary development. Gaze direction was only a small part of the data analyzed, however, it was the only information that was significant to the study at hand. The participants of the study included 108 6-month old infants. With respect to siblings, 55 of the infants had a sibling with autism, 43 had a sibling who was typically developing, and 10 had an older sibling with some form of developmental delay.

Young and colleagues (2009) videotaped the infants interacting with their mothers using a monitor (i.e., the infants looked at a video of their mothers, and the mothers a video of their infants) for a total interaction time of 3 minutes. In the first minute, the mother was active and responsive to the infant, in the second minute she was neutral, and in the third minute she was responsive again. The Tobii ET-17 bright-pupil corneal-reflection eye-tracker was used to examine the infants' eye movements. Following this event the researchers used a battery of tests to track development at 12, 18, and 24 months of age. Only 55 infants were used in the analysis of gaze-direction as the researchers wanted to exclude any infants with delays or disabilities. The authors calculated the eye-mouth ratio of each of the infants by dividing gaze direction into two specific areas: preference, or fixation on the eyes, and preference, or fixation on the mouth. The researchers discovered that the majority of infants showed a preference for

the mouth over the eyes. These results were analyzed against a parent report of language development on the CDI. The authors found a negative correlation between eye-mouth ratio and expressive language development, indicating that infants with a preference for looking at their mothers' mouths during communication are more likely to have more advanced expressive communication than infants who demonstrated a preference for looking at their mothers' eyes.

Problems with eye tracking in clinical practice. Within the past 15 years, eye tracking has become a very popular tool in researching infant development. In some cases eye tracking has replaced the manual human coding of an infant's gaze direction, and duration of gaze. The question may be posed to ask the significance of using a manual coding system for infant gaze direction when this technology is available. The response is that eye-tracking methods are still limited in regards to clinical relevance and naturalness of the environment.

A review by Oakes (2012) outlines some of the positive aspects of eye tracking, but also some of the problems. Eye tracking has been successfully used to increase our knowledge base of joint attention and memory in infants, and has given us new insight into infant cognition. However, Oakes states several key concerns with eye tracking in her article. These problems include; the equipment is only as good as the calibration, the software is often not compatible with infants, movement errors (e.g., jerking the head out of the range of the camera) are not accounted for, and the data can be very difficult to analyze. She states that this technology does have a place, but that it is not made to replace manual coding.

Oakes only points out the difficulties of eye tracking in relation to research, but the points can be translated to problems for use in clinical practice. An additional problem that arises when transferring this equipment to clinical practice is the cost. A basic, low quality, and fairly unreliable set up for adult eye tracking costs over $800 and requires significant technical knowledge to set up. The cost of technology that is functional for infants increases dramatically, and the availability decreases. The ultimate goal of the present study is to determine if eye gaze is a reliable indicator of vocabulary development, however, an additional goal is to simplify methods of detection used to a level that can be reasonably and efficiently implemented by speech-language pathologist in a clinical setting. For those reasons, in the proposed study, gaze direction will be coded manually and in broad usable terms.

Present Study

There is a growing body of research involving infant/caregiver interaction as it pertains to gaze direction that provides useful information on an infants' typical development and the interaction between gaze and vocabulary. However, few studies use methods that are practical (e.g., cost effective and time efficient) and implementable as identifiers in clinical practice, and few examine infant gaze during pre-linguistic vocalization. The present study aims to consider the extent to which infant gaze direction defined in broad terms (i.e., *Directed to Person, Directed to object,* or *Not-Directed*) during prelinguistic vocalizations is correlated with vocabulary development in early childhood for the study are designed to be accessible and practical in a clinical setting.

Chapter II: Methods

Participants

The present study will explore archived data from 15 parent/infant dyads, who participated in a longitudinal research study (at East Carolina University) from 7 to 18 months of infant age, under the direction of the investigator's mentor. Follow-up assessment was also gathered at 2 and 3 years of infant age. Research advertisements were sent to addresses (obtained from publicly available Register of Deeds records at the Pitt County Court House, Greenville, NC) of families with infants born between November, 2010 and March, 2011. Parents interested in participating in the study with their infants were interviewed, and details of the study, along with informed consent, were discussed. Inclusion criteria for the study consisted of caregivers who experienced normal pregnancies and no significant history of prenatal or perinatal problems; infants not at risk for developmental disorders; families where English was the primary language spoken in the home; families who were able to travel to the laboratory monthly; and families who did not expect to move away from the surrounding area within 2 years of beginning participation in the study. Families received $98.00 in the form of mercantile gift cards as incentive for every 2 months of participation in the study.

All families were of middle socioeconomic status. There were no infant participants born to single parent homes, and both mothers and fathers participated in the study. Eight of the infants were first born, five had one older sibling, one had two older siblings, and one had three older siblings. Siblings ranged in age from 2 years to 12 years at the time of the infants' births.

Six of the 15 infant participants were male, and nine were female. One female infant was African American, and one male infant was Asian American (father of East Indian descent and mother of Vietnamese and Hawaiian descent). One male infant was from a home where English, Indian, and Vietnamese were spoken and one male infant was from a home where both English and Arabic were spoken. All infants were normal hearing: they all passed an automated auditory brainstem response newborn screening (ALGO 3 or ALGO 5 Newborn Hearing Screener System) to click stimuli presented at 35 dB nHL. In addition, full hearing evaluations including tympanometry, transient evoked otoacoustic emissions, and visual reinforcement audiometry were conducted at 7 and 18 months of infant age, with follow-up testing as needed for instances where results were abnormal (i.e., infants presented with middle ear dysfunction) or testing was incomplete. Two of the infants received bilateral myringotomy and pressure equalization tubes during enrollment in the study.

Procedure

The University and Medical Center Institutional Review Board at East Carolina University approved the study prior to data collection. All caregivers gave voluntary informed consent for participation in the study. Exemption was also obtained from the Human Subjects Committee at Idaho State University, as the study purpose was covered in the original consent. Parent/infant dyads were followed over a 14-month longitudinal period through weekly interviews and monthly recordings.

Utterance location. Infant utterance location and coding of audio/video recordings were conducted within a software environment (Action Analysis Coding and Training software) that coordinates frame accurate video and audio presentation with

real-time acoustic displays in TF32 (AACT, 1996). Utterance location boundaries were used to determine video playback (via Windows Media Player) for gaze direction coding in the present study, also using AACT. Infant utterances were located using a breath-group criterion; determined by the direction of airflow. Each vocalization occurred on a single egressive breath (Oller & Lynch, 1992). Vegetative and reflexive sounds, and vocalizations with significant vocal or noise (e.g., toy) overlay were not included.

The number of utterances produced during these interactions varied significantly from infant to infant, as well as between the age groups. For most of the infants, we had access to more recorded sessions in the early age group and/or middle age group than in the late age group. This created significant variation in the number of utterances produced in each group (Table 1).

Table 1
Number of Utterances Produced

Infant	Age Group		
	Early	Middle	Late
1	326	1373	631
2	425	696	483
3	718	680	151
4	623	411	330
5	645	1612	317
6	267	797	306
7	508	907	113
8	207	444	448
9	495	493	326
10	492	257	208
11	485	593	123
12	814	794	307
13	960	434	478
14	445	661	583
15	418	796	318
M	522	730	341
SD	202	360	158

Gaze direction. Once infant utterances were located, they were coded for gaze direction as either *Directed to Person, Directed to Object, Not-Directed,* or *Cannot See.* This coding was conducted by trained laboratory staff in the Infant Vocal Development Laboratory at Idaho State University. The coding was conducted with the sound off, as no auditory support was allowed (so that utterance quality and type did not skew coder judgment). *Directed to Person* was coded when the baby was looking in the direction of an adult in the room at any time during a vocalization. This included vocalizations produced while looking at themselves or another individual in the mirror. Looking at themselves was coded as *Directed to Person* because the majority of infants do not develop a recognition of self until around 24 months of age and all vocalizations were produced at 18 months of age or younger (Anderson, 1984). Eye contact was a sure indicator for the *Directed to Person* code, but looking at the body of a communication partner could have been used as an indicator at the coder's discretion also. *Directed to object* was coded when the baby was looking in the direction of any object in the room (e.g., toy, water bottle, camera) at any time during a vocalization. *Not directed* was coded when the infant was looking into space, at the floor, at the wall, furniture, or at the edge of the mirror; the infant could not be looking at another person in the room, object in the room, or in the mirror at any time during a *Not-Directed* vocalization. *Cannot See* was coded when the infant's gaze direction could not be determined, particularly when the baby's eyes or head orientation were not clear. In these instances, the camera was typically not on the infant at all, given delayed camera movement as a result of quick infant movement, for example. Gaze direction codes were tallied for each infant age group, with the early age group consisting primarily of prelinguistic vocalizations

(between 7 to 10 months of infant age), the middle age group overlapping with both prelinguistic and linguistic vocalizations (between 11 to 14 months), and the late age group consisting of primarily linguistic vocalizations (between 15 and 18 months).

Consensus Coding. Consensus coding was utilized, with 22 coders overall who worked on the data set. The coders worked with infant utterance location and/or gaze direction coding; 18 coders participated in utterance location and 14 participated in gaze direction coding (with some coders involved in both tasks). The present study utilized infant utterances from 202 twenty-minute sessions. Infant utterance types were assigned as follows: two or more of the 18 coders located infant utterances in 167 sessions (not always the same two coders; 82.7% of the total sessions), and in 35 sessions a single coder located utterances (17.1% of the total sessions). In instances where only a single coder located utterances, the coder was a senior coder in the Infant Vocal Development Laboratory, having worked with infant/caregiver data for approximately 20 hours per week for 2 years. Gaze Direction codes were assigned as follows: one of the coders (not always the same coder) coded each of the sessions for gaze direction, following coding of all the sessions a different coder checked the codes for accuracy and consensus. Each gaze direction code was determined to be accurate by at least two laboratory staff.

Vocabulary. Exploration of variables for early identification of late-talkers, using mainly expressive language measures such as vocabulary size, has been conducted with parents whose children are as young as 18 to 32 months of age (Rescorla, 2002; Thal & Tobias, 1992). Parent report has been recognized as both a reliable and valid means of determining speech language development in infants and toddlers (Feldman *et al.*, 2005; Fenson *et al.*, 1994; Heilmann, Ellis Weismer, Evans, & Hollar, 2005; Korkman,

Jaakkola, Ahlroth, Pesonen, & Turunen, 2004; Oller, Eilers, & Bassinger, 2001; Rescorla & Alley, 2001). *The MacArthur-Bates Communicative Development Inventory* (CDI) was the parent report measure of vocabulary for the present study (Fenson et al., 1991). The CDI in particular has several studies to back up its concurrent and predictive validity as a measure of vocabulary (Feldman *et al.*, 2005; Heilmann *et. al.,* 2005). In a study by Feldman and colleagues in 2005, the CDI was shown to have positive and statistically significant concurrent validity when compared to three standardized accepted measures of infant language and cognition (e.g., McCarthy GCI, the McCarthy Verbal scale, and the PPVT – R) and when compared to number of different words and MLU determined by recording parent to child conversations. A study by Heilmann and collegues (2005) found the CDI to be positively correlated with the PLS III, the number of different words produced by the child according to the *Systematic Language Transcription Analysis* (SALT), and the child's mean length of utterance. Results of these studies indicate that the CDI is a valid measure of vocabulary and expressive language in toddlers.

Caregivers completed the CDI *Words and Gestures* bi-monthly from 10 to 18 months of infant age, and *Words and Sentences* in follow-up studies at 2 and 3 years of age. From the inventories, we tallied the number of words produced *and* understood by infants at three points in time (ranges presented because the individual infants varied in age at each point in time): one year (15 to 18 months), two years (23 to 27 months), and three years (37 to 40 months) of infant age.

Analysis

Repeated measures analyses of variances (ANOVAs) with post hoc pairwise comparisons were used to evaluate the variables of interest. The criteron variable of

interest was the number of different vocabulary words produced by children, as reported by caregivers on the CDI. The predictor variables of interest were gaze direction (*Directed to Person, Directed to Object* and *Not-Directed*) and infant age group (early, middle, and late age groups for gaze direction *and* 1, 2, and 3 years for vocabulary).

Chapter III: Results

We aimed to use simple, clinically applicable methods to determine if gaze direction during early vocalizations was an accurate indicator of vocabulary development. Archived data files were coded based on infant utterance and age, parent reports of infant vocabulary were tallied, and several analyses were run to determine relationships between gaze and infant vocabulary. At this time there is little evidence to support that gaze-direction defined in broad terms is an indicator of vocabulary, however there are potential implications for future research.

Data Collection

Gaze Direction. Gaze directed codes were assigned by trained laboratory staff to each utterance. *Cannot See* codes were removed prior to analysis, as no information on infant gaze was available during these infant utterances. The number of codes in each of the remaining categories *(Directed to Object, Directed to Person,* and *Not-Directed*) were tallied and can be viewed in Table 2. The mean number of infant utterances at the early age were as follows: 217 *Directed to Person* utterances, 221 *Directed to Object* utterances, and 191 *Not-Directed* utterances. The mean numbers of infant utterances at the middle age were as follows: 202 *Directed to Person* utterances, 267 *Directed to Object* utterances, and 167 *Not-Directed* utterances. The mean numbers of infant utterances at the late age were as follows: 139 *Directed to Person* utterances, 189 *Directed to Object* utterances, and 102 *Not-Directed* utterances. All utterance types decreased in use from the early age group to the late age group, in alignment with fewer overall utterances produced in the late age group (Table 1).

Table 2
Gaze Direction

Infant	Early Age Group			Middle Age Group			Late Age Group		
	To Person	To Object	Not Directed	To Person	To Object	Not Directed	To Person	To Object	Not Directed
1	180	104	245	337	389	175	101	304	120
2	344	178	192	221	301	148	107	225	70
3	224	174	203	201	180	125	55	101	34
4	114	170	207	125	192	77	119	166	36
5	183	184	170	237	280	249	104	107	63
6	115	69	38	212	314	225	100	62	75
7	153	175	129	271	433	152	107	146	31
8	95	99	72	114	269	126	146	170	65
9	183	181	64	186	181	87	104	123	55
10	158	96	165	127	95	81	51	73	55
11	145	118	137	380	255	314	40	94	10
12	203	286	202	237	279	255	71	18	80
13	160	451	195	100	209	115	129	159	87
14	172	180	96	13	74	129	113	244	133
15	109	143	76	258	315	195	150	127	103
M	169	174	146	201	251	164	100	141	68
SD	61	93	64	95	98	71	33	74	34

Vocabulary. Vocabulary was tallied based on caregiver report using the CDI (Fenson et al., 1991). Infant vocabulary increased with age for every infant (Table 3). The mean vocabulary for infants was 79 words at 1 year, 364 words at 2 years, and 650 words at 3 years. Two of the infants (infants 8 and 13) were missing parent report for vocabulary at 2 years of age; an average of 364 utterances was used to supplement data for these infants. Infants 6 and 14 were missing parent report for vocabulary at 3 years of age; an average of 650 utterances was used to supplement data for these infants.

Table 3
Vocabulary Size

Infant	1 Year	2 Years	3 Years
1	149	549	680
2	151	554	663
3	17	178	645
4	299	577	677
5	181	578	635
6	32	213	650
7	63	277	661
8	5	364	563
9	48	186	660
10	31	222	654
11	16	66	678
12	32	521	624
13	68	364	654
14	20	294	650
15	67	515	661
M	79	364	650
SD	82	173	29

Repeated Measures ANOVAs

Repeated measures ANOVAs with Greenhouse-Geisser corrections were conducted to assess interactions between vocabulary development across ages and gaze direction codes in the early, middle, and late age groups. A statistically significant interaction was found between vocabulary development across ages and vocalizations produced directed to a person in the late age group (between 15 to 18 months of age), such that F (1.311, 14.419) = 6.580, p = 0.016. No other statistically significant interactions were found between vocabulary development across ages and gaze direction codes in the early, middle, and late age groups. Post hoc tests using the Bonferroni correction revealed several statistically significant differences between gaze direction codes across age groups and vocabulary development at 1, 2, and 3 years of age. Significant pairwise comparisons for gaze direction codes across age groups are as follows:

- There were statistically significantly more vocalizations produced directed to a person in the early age group (M = 169.190, SD = 60.509) than in the late age group (M = 99.753, SD = 32.593, p = 0.022).
- There were statistically significantly more vocalizations produced directed to a person in the middle age group (M = 201.155, SD = 95.065) than in the late age group (M = 99.753, SD = 32.593, p = 0.014).
- There were statistically significantly more vocalizations produced directed to an object in the middle age group (M = 251.064, SD = 98.491) than in the late age group (M = 141.325, SD = 74.479, p = 0.021).
- There were statistically significantly more vocalizations produced while not directed to a person or object in the early age group (M = 146.047, SD = 63.701) than in the late age group (M = 67.919, SD = 33.838, p = 0.005).
- There were statistically significantly more vocalizations produced while not directed to a person or object in the middle age group (M = 163.545, SD = 70.914) than in the late age group (M = 67.919, SD = 33.838, p = 0.005).

Significant pairwise comparisons for gaze direction codes within age groups are as follows:

- There were statistically significantly less vocalizations produced directed to a person in the middle age group (M = 201.155, SD = 95.065) than vocalizations produced directed to an object (M = 251.064, SD = 98.491, p = 0.050).
- There were statistically significantly more vocalizations produced directed to an object in the middle age group (M = 251.064, SD = 98.491) than vocalizations

produced while not directed to a person or object (M = 163.545, SD = 70.914, p = 0.015).

- There were statistically significantly more vocalizations produced directed to a person in the late age group (M = 99.753, SD = 32.593) than vocalizations produced while not directed to a person or object (M = 67.919, SD = 33.838, p = 0.005).
- There were statistically significantly more vocalizations produced directed to an object in the late age group (M = 141.325, SD = 74.479) than vocalizations produced while not directed to a person or object (M = 67.919, SD = 33.838, p = 0.003).

Significant pairwise comparisons for vocabulary development are as follows:

- Vocabulary development at 1 year of age (M = 78.600, SD = 81.8795) was statistically significantly smaller than at 2 years of age (M = 363.867, SD = 173.093, $p < 0.001$).
- Vocabulary development at 1 year of age (M = 78.600, SD = 81.8795) was statistically significantly smaller than at 3 years of age (M = 650.333, SD = 28.597, $p < 0.001$).
- Vocabulary development at 2 years of age (M = 363.867, SD = 173.093) was statistically significantly smaller than at 3 years of age (M = 650.333, SD = 28.597, $p < 0.001$).

Chapter IV: Discussion

Vocabulary development plays a significant role childhood success, and there are several non-verbal indicators of vocabulary, including: gesture and joint attentional skills (Mayor, & Plunkett, 2011; Moghadam, Zainal, & Ghaderpour, 2012; Rowe et al., 2008). In addition, infant gaze toward different sections of a communicator's face has been linked to vocabulary development using eye-tracking software (Young et al., 2009). Eye tracking equipment is not practical for most speech-language pathologists in daily practice, however infant gaze may be a useful tool as an identifier of vocabulary development. This study aimed to begin to examine gaze direction defined in broad terms as a potential indicator of vocabulary development using practical methodology. It was hypothesized that there would be an interaction between infant looking behaviors from 7 and 18 months of age *and* vocabulary size at 2 and 3 years of age.

Overall, the findings do not point toward gaze direction, defined in broad terms, as an indicator of vocabulary development, with the exception of vocalizations produced directed to a person in the late age group (15 to 18 months of age), which were related to vocabulary development across ages. Further, types of infant gaze at early ages were shown to relate to other types at later ages and vocabulary development at early ages was shown to relate with vocabulary development at later ages. From here, we will expand on the results and explore ways to improve upon the methodologies for future research of infant gaze and vocabulary. Clinical implications and limitations will be considered.

Gaze Direction and Vocabulary

The interaction between vocabulary development across ages and vocalizations produced directed to a person in the late age group (between 15 to 18 months of age),

may be worthy of additional study. Studies of joint attention and gesture have found that certain periods of non-verbal communication are more indicative of vocabulary development than others. Examining each month of development between 15 and 18 months of age may provide more specific information on the interaction of gaze with vocabulary. It is also interesting to note that infants in this age group were primarily linguistic. The correlation with vocabulary and gaze could pertain to the fact that the infants were already using words to communicate with caregivers. Examining infant caregiver interaction as it pertains to gaze direction at this age would be beneficial.

Implications of Pairwise Comparisons

Vocabulary Across Ages. The raw tally of infant vocabulary as well as significant pairwise comparisons for vocabulary development revealed that vocabulary increased with infant age. This trend would be expected for typically developing children, like those in the study. Most typically developing children experience a large growth in vocabulary at around 18 months of age, a similar pattern was found in the raw vocabulary tally. Vocabulary at 2 years of age was on average 4.6 times larger than at 1 year of age, while at 3 years of age vocabulary was only 1.7 times larger than at 2 years of age. A potential area of continued study would be age as an indicator vocabulary in delayed and disordered populations (i.e., examining plateaus in vocabulary development in toddlers that are consistent with communication disorders).

Gaze Direction Across Ages. Pairwise comparisons of infant gaze across ages revealed that infants produced more *Directed to Person*, and *Not Directed* utterances in the early age group than in the late age group and more *Directed to Person, Directed to Object*, and *Not Directed* utterances in the middle age group than late age group. The

number of *Directed to Object* utterances in the early age group was the only category of gaze direction in either the middle or early group that not significantly larger when compared to the late age group. Overall, these results are fairly consistent with a larger number of vocalizations in the early and middle age groups when compared with the late age group. This is potentially related to the fact that the investigators had more video taped sessions of infants in the early and middle age group than in the late age group. This could also be related to the fact that as infants mature egressive breath utterances get longer and therefore fewer utterances are produced. An additional study examining the length of the infant utterances would provide for further analysis related to the decreasing number of utterances with increasing infant age.

Gaze Direction Within Ages. Comparison of gaze direction codes revealed no significant differences in gaze direction in the early age group. In the middle age group there were more *Directed to Object* codes than *Not Directed* or *Directed to Person* codes. In addition, in the late age group there was a larger number of *Directed to Person* and *Directed to Object* codes than Not-Directed codes. This potentially indicates that as infant's age and mature (i.e., develop joint attention skills), their gaze becomes more directed. The reasoning behind increased directedness is likely an indicator of increasing attentional skills.

Limitations

It is possible that the predictor measure for gaze direction used in the present study did not provide enough information on the interaction between the infant and the person/object at which infant gaze was directed. The methodology of using infant utterances as boundaries resulted in gaze direction being coded only during the exact

moment of infant vocalization. Based on previously discussed information regarding joint attention it may be beneficial to examine the time directly before and directly following infant vocalizations in addition to infant egressive breath utterances.

Another limitation of the study is the loss to follow up for several of the infants. Two of the infants were missing CDI records at 2 years of age, and two different infants were missing this data at 3 years of age. Given designated time windows for follow-up testing, some infants were not able to participate due to time conflicts. This is a common problem with longitudinal data, and putting in averages for these infants may have clouded the overall results. All of the infants had vocabulary information for at least two of the three ages (1, 2, and 3 years); the investigators chose to include them all in the study rather than make the small sample size even smaller. The inclusion may have resulted in bias related to differential rates of retention.

An additional limitation is that the investigators only examined expressive vocabulary when calculating the tally of infant vocabulary. The study by Morales, Mundy, and Rojas (1998) demonstrated that indicators of vocabulary development can impact receptive and expressive vocabulary at different times. They discovered that infant looking behaviors were correlated with receptive vocabulary (based off the CDI) at 12 months and not correlated with expressive vocabulary until 18 months. The CDI includes a check system that is used to indicate which of the age appropriate vocabulary items an infant using. In the words and gestures CDI, there are separate boxes available for "understands" and "understands and says". Only items the infant understood *and* said were tallied for the present study. The words and sentences CDI does not provide and option for documenting receptive vocabulary. It is possible that gaze direction is a more

reliable indicator of receptive vocabulary than expressive vocabulary. The only way to determine this would be complete and additional study of receptive vocabulary. This is an important consideration for future studies of early vocabulary.

One of the complications of working with methodology that is accessible and practical is the potential for human error. All of the laboratory staff who worked on coding gaze direction were trained in the same way by the same individual; however, there was still some subjectivity in the coding system designed for this study (e.g., at the coder's discretion, *Directed to Person* could be coded when the infant was looking at an individuals' body). Measures were taken to minimize bias between coders to increase accuracy, a check system was used and multiple coders were consulted on both utterance location and gaze direction. This minimized the error to the extent possible given the conditions of the study, but it is not as cannot be as reliable as other methods of recording gaze, including gaze tracking equipment.

Another consideration is the sample size and selection of infants used in this study. The sample size for the purpose of this study was 15 infants from an area surrounding East Carolina University. This leaves a lot of room for selection bias. The investigators were working with archived data, therefore expanding the selection of infants was not an option for the purposes of this study. However, for future research, a larger sample of infants from a more expansive area would yield more valid, reliable results for normative research on infant gaze and vocabulary.

Potential Clinical Implications

In some instances, non-verbal indicators of vocabulary have been used to develop screeners for earlier identification of infants at risk for speech and/or language delays

(Bayley, 2005). Gaze toward different sections of communicators' faces have been linked to vocabulary development in certain instances using eye-tracking software (Hunnis & Gueze, 2004; Young et al., 2009). One of the potential clinical applications of this study was the eventual development of a screener based on infant gaze direction. The results suggest that the broad terms we used to identify gaze (*Directed to Person, Directed to Object,* and *Not-Directed*) are not yet useful in the development of such a tool. In addition, the limitations presented in the above section make it difficult to conclude any clinical implications at this time. However, there is still a possibility that gaze direction could be used to develop such a tool if infant/caregiver interactions were examined in more depth, coding categories were refined to more closely match classifications used in previously published eye tracking studies, and if the number of variables associated with infant age were reduced. According to the findings, *Directed to Person* codes from 15 to 18 months of infant age was potentially related to vocabulary development at 3 years of age. Using refined methodology to examine infants from this age bracket with communication delays and disorders may yield more information on whether gaze direction may be useful in developing a screening tool.

Methodological Changes for Future Study of Gaze Direction

The limitations section above (pg.30) discussed the potential problem of the predictor measure for gaze direction used in the present study. One potential change to the coding system that would address the entire interaction between caregiver and parent would be to expand the boundaries of infant utterances to add several seconds before and/or after the utterance. This would help us determine if gaze during the entire interaction is correlated to vocabulary development (i.e., child looks to the parent and

then to the toy and vocalizes). In addition the time before the utterance, during the utterance, and after the utterance could all be examined individually to determine if the timing of gaze played a role in vocabulary development. Finally, it would also be interesting to examine parent gaze during the entire interaction. Parent gesture is one of the primary facilitators of infant gesture (Rowe *et* al., 2008) and parent gaze may play a similar role in influencing infant gaze.

It is possible that the categories used for this study were slightly *too* broad to examine the impact of gaze direction on vocabulary. By fine-tuning the methods of coding gaze direction we may have been able to quiet some of the noise (standard deviation across gaze direction codes) in the study. One way to do that is to remove situations when the infant was looking into the mirror or at a part of the individual other than their face during *Directed to Person* utterances. Studies of gaze direction utilizing eye-tracking software indicate that infants who gaze at the mouth of an individual over the eyes will have a larger vocabulary than those looking at the eyes. Although the mouth itself is too specific to our goal of practical methodology, limiting the category of *Directed to Person* to the face of individuals is possible. This way the infant is more likely to be intentionally looking at an individual for feedback or stimulation instead of simply glancing in an accidental manner. It is also possible that age groupings should not be used in this sort of analysis, but rather it may be fruitful to look at gaze direction across each individual month of development. By doing this we may get more statistical significance with respect to the relationship between gaze direction and vocabulary development.

Another potential edit to the coding system would be breaking up *Directed to Object* codes into specific categories of objects, and then comparing categories to vocabulary words that the child develops. This may provide more detailed information on the quality of vocabulary words instead of just the size of the infant's vocabulary. Rowe and colleagues (2008) examined gesture as an indicator of both size and type of vocabulary. For the purposes of this study we chose to examine size of vocabulary only in relation to gaze direction, but type of vocabulary and gaze is also an area that may warrant future study.

Finally, additional studies of infant gaze and vocabulary should take into consideration the differences in development between expressive and receptive vocabulary. The failure to include receptive vocabulary was a potential flaw of the present study. The words and gestures CDI does allow for expressive and receptive vocabulary to be studied individually. In addition, there are other parent inventories and scales of infant vocabulary that may provide information on the receptive vocabulary of infants at 2 and 3 years of age. Regardless of the tool used for documentation, expressive and receptive vocabulary should be examined individually.

Conclusion

At this time we are unable to determine if gaze direction is coordinated with vocabulary development. More research should be conducted on infant gaze behaviors between 15 and 18 months of age in relation to vocabulary development. A larger sample size of infants, as well as a population of at risk infants should be examined for looking behaviors that may be coordinated with vocabulary. In addition, the study does indicate that gaze directedness increases with age and that infant vocabulary increases

significantly with each year of development. Improvements upon methods of coding and classifying gaze direction in infants may provide additional information on the interaction between infant and caregiver and also relate more directly to vocabulary development. This information may be useful in the formulation of additional studies of infant gaze and childhood vocabulary.

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