Photocopy and Use Authorization

In presenting this thesis in partial fulfillment of the requirements for an advanced degree at Idaho State University, I agree that the Library shall make it freely available for inspection. I further state that permission for extensive copying of my thesis for scholarly purposes may be granted by the Dean of the Graduate School, Dean of my academic division, or by the University Librarian. It is understood that any copying or publication of this thesis for financial gain shall not be allowed without my written permission.

Signature _____

Date _____

Gaze Direction and Vocabulary Development: Part III

by

Samantha Crowe

A thesis to be

submitted in partial fulfillment

of the requirements for the degree of

Master of Science in the Department of Communication Science and Disorders

Idaho State University

Spring 2019

Copyright

Committee Approval

To the Graduate Faculty:

The members of the committee appointed to examine the thesis of Laila Samaha find it satisfactory and recommend that it be accepted.

_____

Dr. Heather Ramsdell-Hudock,
Major Advisor

_____

Joni Loftin,
Committee Member

_____

Dr. Fan Chunghau,
Graduate Faculty Representative

Human Subjects Committee Approval

October 26, 2018

Samantha Crowe
Comm Sci Disorders/Deaf Educ
MS 8116

RE: regarding study number IRB-FY2019-89 : Gaze Direction and Vocabulary Development: Part 3

Dear Ms. Crowe:

I have reviewed your request for expedited approval of the new study listed above. This is to confirm that I have approved your application.

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

You may conduct your study as described in your application effective immediately. The study is subject to renewal on or before October 26, 2019, unless closed before that date.

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; email humsubj@isu.edu) if you have any questions or require further information.

Sincerely,

Ralph Baergen, PhD, MPH, CIP
Human Subjects Chair

Table of Contents

List of Tables ii

Abstract i

Chapter 1: Body of Thesis 2

Gaze following. 2

Joint attention. 5

Eye tracking technology. 8

Purpose 9

Chapter 2: Methods 10

Participants 10

Materials and Procedures 11

Laboratory setting. 11

Gaze direction. 12

Vocabulary ability. 13

Design 13

Chapter 3: Results 13

Expressive Vocabulary at 1 ½ Years 14

Receptive Vocabulary at 1 ½ Years 14

Expressive Vocabulary at 2 Years 15

Expressive Vocabulary at 3 Years 16

Effect Size 17

Reliability Testing 17

Chapter 4: Discussion 18

Implications 19

Correlation analyses. 19

Multiple regression analyses. 19

Effect size 20

Limitations and Future Directions 21

Clinical Application 24

Chapter 5: Conclusion 24

References 25

Tables 30

Appendix A 37

List of Tables

Table 1 Frequency of Gazes per Predictor Variable across Infants 30

Table 2 Vocabulary Size by Infants across Ages 31

Table 3 Summary Statistics, Correlations, and Results from the Regression Analysis (Dependent Variable = Expressive Vocabulary at 1 1/2 year) 32

Table 4 Summary Statistics, Correlations, and Results from the Regression Analysis (Dependent Variable = Receptive Vocabulary at 1 1/2 year) 33

Table 5 Summary Statistics, Correlations, and Results from the Regression Analysis (Dependent Variable = Expressive Vocabulary at 2 years) 34

Table 6 Summary Statistics, Correlations, and Results from the Regression Analysis (Dependent Variable = Expressive Vocabulary at 3 years) 35

Table 7 Effect Sizes (Cohen's d) between Criterion and Predictor Variables 36

Gaze Direction and Vocabulary Development: Part III

Thesis Abstract—Idaho State University (2019)

This study attempted to identify gaze direction as a predicator for future language development using clinical applicable methodology. Data was obtained from a longitudinal study of 15 infants from 6 to 18 months of age, with follow-up measures of vocabulary development in the same children at 1 ½ , 2, and 3 years of age measured by the *MacArthur-Bates Communicative Development Inventories* (CDI). Correlation and multiple regression analysis were conducted to analyze the relationship between the criterion and predictor variables. Results indicated duration of gazes (for all variables with the exception of cannot see gazes) at 8, 12, and 16 months had an extremally large effects on expressive vocabulary at 1 year of age; while the frequency of gazes (for all variables) at 8, 12, and 16 months had an extremely large effect on receptive vocabulary at 1 and expressive vocabulary at 2 and 3 years of age.

Key Words: vocabulary development, eye gaze, prelinguistic communication, gaze direction, gaze following, joint attention, eye tracking technology, expressive vocabulary, receptive vocabulary, speech language pathology

Gaze Direction and Vocabulary Development: Part III

Early lexical development is vital to future academic success. Vocabulary development, in particular, is critical for reading comprehension and writing. As children become older, reading and writing become increasingly complex (Qian, 2002; Verhoeven & Leeuwe, 2008). Eye gaze is thought to be a strategy used for learning new words. Eye gaze can be defined as encompassing both intentional visual fixation (i.e., gaze direction) or tracking a target based on following another's gaze (i.e., gaze following) which can each provide numerous language learning opportunities. Therefore, eye gaze provides an infrastructure for language development that can facilitate academic advancement. Most children begin to produce their first words (expressive language) by 1 year of age. By the end of the second year of life, children are typically producing anywhere from 50 to 100 words, or more, and stringing two words together (Reznick & Goldfield, 1992). According to normative data, by 30 months of age, children in the 10th percentile have developed an average of 560.2 words, while children in the 90th percentile have developed an average of 2032.9 words (Mayor & Plunkett, 2011). Many factors can influence this variability in vocabulary development. For example, individual differences in speech processing (Brooks & Meltzoff, 2008), a familial history of language impairment (Merin, Young, Ozonoff, & Rogers, 2007), socioeconomic status (SES; Cartmill et al., 2013), and an infant's prelinguistic communication skills (such as eye gaze) can influence later language learning and vocabulary growth (Brooks & Meltzoff, 2005; Brooks & Meltzoff, 2008; Brooks & Meltzoff, 2014; Law, Houston-Price, & Loucas, 2012).

Prelinguistic Development

Prelinguistic communication consists of both verbal and nonverbal acts prior to the production of first words, including eye gaze, gestures, facial expressions, and vocalizations. Infants are frequently observed to direct their gaze to desirable items or follow another's gaze direction, point or sign gestures, use facial expressions, and produce prelinguistic vocalizations (such as babbling) as a means of purposeful communication. Prelinguistic communication consists of meaningful communicative acts that are fundamental components of early interaction and aide in the development of language (Brooks & Meltzoff, 2008). By the time children produce their first words (early linguistic behavior), they have already participated in many social communicative acts with their caregivers.

Gaze following. Researchers have highlighted a variety of prelinguistic communicative acts that are predictors of language development (Akhtar & Gernsbacher, 2007; Baldwin, 1991; Brooks & Meltzoff, 2008; Goldstein, Schwade, Briesch & Syal, 2010; Iverson & Goldin-Meadow, 2005). Specifically, gaze following has been identified as an early prelinguistic act that has aided in the understanding of typical and atypical development; gaze following is foundational in the development of communication and language acquisition. Gaze following develops from the ability to physically track an adult head turn (with eyes closed) at 9 months of age, to distinguish between opened and closed eye conditions (and only follow a head turn in opened eye conditions) at 10 months of age, and to identify the referent of a novel word using the speakers gaze direction by 18 months of age (Brooks & Meltzoff, 2005; Brooks & Meltzoff, 2008; Law et al., 2012). This knowledge of development is critical because it allows for clinicians to identify atypical behavior in infancy based on eye gaze and aids in the development of language assessments and interventions. Further research could assist in the establishment of

infant milestones to aid in early identification and the formation of language assessments/treatment methods. Research on prelinguistic acts have provided a better understanding of infant development.

Non-verbal communication skills are an infant's first behaviors leading to active participation in their world, and have been shown to predict lexical growth (Goldin-Meadow, 2007). Some have demonstrated that infant gaze following positively correlates with vocabulary development (Brooks & Meltzoff, 2005; Brooks & Meltzoff, 2008; Brooks & Meltzoff, 2014; Law et al., 2012). In support of this position, Brooks and Meltzoff (2005) presented research on infant gaze following and its relationship to later language and communication abilities. Ninety-six infants participated in this study at 9, 10, and 11 months of age, with 32 infants at each age. Infants were to observe an individual gazing toward an object with his/her eyes opened or closed. To identify the age at which infants can distinguish between opened and closed eyes conditions (as measured by gaze following toward the opened-eyes condition versus no gaze following toward the closed-eyes condition), the researchers examined infant gaze following across the three age groups. In addition, spontaneous vocal production in conjunction with correct gaze (gaze following of the opened-eyes condition) was indicated. Results were compared to the infants' scores on the *MacArthur-Bates Communicative Development Inventory* (Fenson et al., 1994) when they reached 14 and 18 months of age. Infants at 9 months responded similarly regardless of eyes opened/closed conditions, and simply followed adult head turn. Infants at 10 and 11 months, however, were found to discriminate between the two conditions by gazing at the researchers target specifically when she turned with opened eyes, a behavior that positively correlated with subsequent language and communication abilities. Brooks and Meltzoff (2005)

concluded that infants who are advanced in recognizing the connection between the two eye conditions and objects may have an advantage in future word comprehension/production.

Furthermore, simultaneous vocalizations produced by the infant in combination with gaze following in the eyes opened condition predicted later vocabulary comprehension, thus indicating that prelinguistic skills (e.g., gaze following) and prelinguistic vocalizations play a critical role in language acquisition

Brooks and Meltzoff (2008), conducted a longitudinal study of 32 children where gaze following was tested at 10 and 11 months of age. Infants were also followed longitudinally for language assessment. The infants were assessed by having the experimenter slightly turn her head and eyes with a neutral expression toward one of two objects. Caregivers completed the *MacArthur Bates Communicative Developmental Inventories* (Fenson, et al., 1994). The "Words and Gestures" subtest was administered at 0;10 or 0;11 months, 1;2 month, and 1;6 months of age. The "Words and Sentences" subtest was administered at 1;6 months and 2;0 years of age. Some children completed more assessment subtests then others, therefore a growth curve analysis was implemented. Infants, at ages 10 and 11 months, who followed the experimenter's head turn with an above average attention latency demonstrated a larger vocabulary at later ages. These infants had an estimated vocabulary of 186 more words than infants who looked at the target for a shorter amount of time. Thus, there was a significant advantage for infants who were observed to follow adult gaze to the correct target and focus on said target for a prolonged amount of time. In addition, communicative pointing (combination of eye contact and pointing) was observed to occur in some infants spontaneously without a model given. Communicative pointing was found to be predicative of larger vocabulary growth. It is likely that these

prelinguistic acts provide word learning opportunities as they encourage communicative partners to attend to a shared focus and produce labels of this focus.

Other attempts have been made to assess the relationship between gaze following and vocabulary development. Law and colleagues (2012), sought to measure an infant's ability to learn new words through gaze following as a predictor of later vocabulary knowledge. Infants participated in gaze following and word learning tasks, and completed a retention test to determine whether or not they were able to follow the gaze of a speaker and use gaze following information to infer the referent of an unfamiliar label. At the first time of testing, the researchers analyzed 48 infants (20 boys and 28 girls with an average age of 18 months and 12 days); at the second time of testing, 42 infants returned (17 boys and 25 girls with an average age was 24 months and 19 days); and at the third time of testing 36 infants returned (16 boys and 20 girls with an average age of 30 months and 15 days). Two large, opened boxes with an unknown item inside were placed in front of the infant. The experimenter sat in between the boxes and would turn her head slightly toward the target object while stating the object's name (e.g., "Modi). Then, the experimenter would ask the infant to identify the object (e.g., "Where is Modi"). Results indicated that by 18 months, infants were able to use the gaze of a speaker to identify labels for unfamiliar objects, a skill that was positively related to future vocabulary scores. Law and colleagues (2012) concluded that a child's ability to follow a caregiver's gaze to learn novel object labels during the second year of life is important for later language development, specifically acquisition of vocabulary. Therefore, identifying a child's typical gaze following behavior is important for the field of speech-language pathology.

Joint attention. Joint attention plays a critical role in early language development, and gaze following is an essential precursor to the development of joint attention. Joint attention

refers to situations where the child and adult are focused on the same thing (e.g., object, person, event, etc.). True joint attention includes an awareness on the part of the caregiver and infant that the focus of attention is a shared experience (Baldwin, 1995). Also, in order for an infant to engage in joint attention, the infant must shift his/her gaze between the target of interest and the caregiver. For example, if a caregiver is engaging a child's attention with a new puppy, the child must be able to alternate his/her gaze between the caregiver and the puppy in order for the exchange to be considered joint attention. Importantly, joint attention allows infants to connect the language that they are hearing from a caregiver with the shared target. Joint attention has been shown to be an important prelinguistic communication act, as it elicits information about objects of interest to be discussed (Butterworth, 1991).

Several studies have documented a positive correlation between joint attention and vocabulary development (Akhtar & Gernsbacher, 2007; Tomasello & Farrar, 1986; Tomasello & Todd, 1983). Morales and colleagues (2000) analyzed infant participation in joint attention episodes and their relation to later vocabulary development. In this longitudinal study, 22 infants participated at 6, 8, 10, 12, and 18 months (10 boys and 12 girls). Joint attention between caregiver and infant was assessed with a "Toy, Tickle, Look" procedure at 6 months. During the toy sequence, the caregiver would hold a mechanical toy at shoulder height, out of reach from the infant, and activate it three times with short pauses in-between. During the tickle sequence, the caregiver would tickle the infant three times with short pauses in-between. During the look sequence, the caregiver presented thee look trials where she would look at the infant, and then turn and look toward a target object while producing the infants name empathetically three times. From 8 to 24 months, after the "Toy, Tickle, Look" procedure, three consecutive trials were administered for the joint attention task. The caregiver would turn, gaze, and point toward a

target object while producing the child's name empathetically three times consecutively. Three independent coders analyzed the data by rating video clips. An infant's gaze following was scored as a correct response if it was in the same direction as the adult's head turn. The infant's language was assessed by the *MacArthur Communicative Development Inventory* (Fenson, et al., 1994), the *Peabody Picture Vocabulary Test-Revised* (Dunn & Dunn, 2007), and the *Expressive Vocabulary Test* (Williams, 1997). Results indicated that the infant's ability to participate in gaze following increased with age, and that joint attention skills at 6, 8, 10, 12, and 18 months of age were positively correlated with receptive and expressive vocabulary (Morales et al., 2000).

In another study of 94 infants between the ages of 16 and 19 months, Baldwin (1991) sought to determine if joint reference and the use of nonverbal cues allowed for the identification of unknown objects. Here, infants were taught labels for novel toys in two different scenarios. In the first scenario, the experimenter would name a novel toy when the infant independently looked toward it. During the second scenario, the experimenter would look and name a different toy than the infant was focused on. Comprehension questions were given to gage the infants understanding of the novel labels (e.g., "Can you point to Peri?"). The findings demonstrated that by 16 months of age, infants use the skill of gaze following to guide their understanding of the novel labels; that infants have already learned to communicate through joint attention, and are benefiting from these interactions through vocabulary growth. Corkum and Moore (1998) extended this work by examining the development of joint attention in 63 infants between the ages of 6 and 11 months. The experiment was conducted in a cubicle with two toys, one located on each side of the cubicle. The toys were identical black and white dogs located in a black box. When activated, the stuffed dog would light up, providing the infants with visual feedback. Infants were engaged in face-to-face interaction with an experimenter for 28 trials, during which

the experimenter alternated her look toward the toy on the left and on the right under visual feedback and no feedback conditions. Results showed that by 10 to 11 months of age, infants were likely to turn their heads in the same direction as the experimenter, thereby using adult head turns as a cue for gaze following. Gaze following is a fundamental skill necessary for sharing joint attention and vocabulary growth.

Eye tracking technology. Many researchers have found eye tracking to be an efficient way to analyze human development (Gredebäck, Johnson, & von Hofsten, 2009; McMurray & Aslin, 2004; Oakes 2012). Eye tracking is a technique used to measure an individual's eye movements, enabling researchers to know where participants are looking. Developmentally, gaze direction is one of the first behaviors to emerge early in infancy and is argued to provide understanding into an infant's cognition and language development. Although there have been significant advancements in eye tracking technology over the past century, it is not optimal for use with infants in a clinical or natural setting (one reason being that infants do not sit still on command). However, past efforts at eye tracking have led to other efficient and accurate methods of measuring gaze direction. Many software programs are available for remote eye tracking. One of the most popular technologies available is called corneal reflection eye tracking (Gredebäck et al., 2009). This device calculates gaze direction with elaborate algorithms based on the reflection of light from the cornea of the pupil. These programs are very accurate and efficient with respect to time, however, they are not without fault (e.g., if a subject were to move out of sight from the device, data could be incorrect; Gredebäck et al., 2009). Alternative to eye tracking software and rigid research procedures, an observation-based method could be used for coding infant gaze direction. An observation-based method would be more time consuming and open room for human error, but errors can be minimized through the establishment of well-defined procedures.

Coded skills from observation-based methods have continuously proven to be predictive of developmental outcomes (Brooks & Meltzoff, 2005; Cartmill et al., 2013; Law et al., 2012). Observation-based methods would allow for the analysis of infant gaze direction in a naturalistic manner, potentially aiding in the translation from research findings to clinical practice as little is known regarding the direction of the infant's gaze toward specific stimuli in a natural setting and its relationship with future vocabulary outcomes.

Purpose

Early identification of atypical behaviors in infants is vital to ensure provision of services aiding in later development. It is clear, and widely accepted that limited vocabulary can negatively impact a child's future academic success. There is a growing body of research involving infant/caregiver interaction indicating that infant gaze direction supports later vocabulary knowledge. However, few studies use methods that are practical (e.g., cost effective and time efficient) and implementable in a clinical setting. Accordingly, the long-term goal of this research is to analyze infant gaze direction using efficient and clinically applicable methodology, to allow for the identification of significant predictors of language development at an earlier age. The present proposal looks to explore infant gaze direction (toward caregiver, another person, the mirror, a toy or book, an object, cannot see, eyes closed, and not directed) from 6 to 18 months of age. The objective is to determine how gaze direction contributes to later vocabulary development. The methods for the study are designed to be accessible and practical in a clinical setting, to aid in the translation between research and clinical practice. An overview of related work in this line of research, providing background to the present study, is detailed in the Appendix (see Andreasen, & Ramsdell-Hudock, 2018; Edwards & Ramsdell-Hudock, 2016).

Methods

In this study, archived data was obtained from longitudinal research conducted by Dr. Heather Ramsdell-Hudock at East Carolina University (ECU). This study was approved by the University and Medical Center Institutional Review Board at ECU before initial testing of participants and voluntary consent was given by all caregivers. Exemption was sought from Human Subjects at Idaho State University (ISU) prior to data preparation and analysis.

Participants

The participants were recruited from families with infants born between November, 2010 and March, 2011 via research advertisements. Participants included 16 parent/infant dyads from 6 to 18 months of age. However, one infant was excluded from this study sample due to atypical development. As a result, participants for the present study consist of 15 parent/infant dayds including 6 males and 9 females. One of the male infants was Asian American, one of the female infants was African American, and all other infants were Caucasian. Two male infants were from homes where multiple languages were spoken, with English as the primary language. All infants were from middle socioeconomic status per parent report. In addition, the infants had no major birth complications or postnatal hospitalizations, hearing loss, or risk for developing a language delay. In order to ensure the infants maintained typical hearing, evaluations were administered at 6 and 18 months of age. The evaluations consisted of tympanometry, transient evoked otoacoustic emissions, and visual reinforced audiometry. If abnormal or incomplete results occurred, follow-up hearing evaluations were performed. Two infants underwent a bilateral myringotomy and had pressure equalization tubes placed while participating in the study. Regardless of language background or hearing status, all infants (with one exception previously stated) demonstrated typical speech and language development during the recording period, a

point supported by speech and language abilities within normal limits on follow-up testing conducted at 3 ½ years of age. Each family received a gift of $98 for every 2 months they participated in the study.

Materials and Procedures

Laboratory setting. Infants and caregivers came to the lab at ECU once a month for hour-long recordings. For the purposes of this study, we coded the middle 20 minutes of recordings at 8, 12, and 16 months of infant age. Caregivers were instructed to interact and play with their infants as they typically would in a home setting during recordings.

The lab was designed to simulate a natural environment, such as a nursery in a home; it included stuffed animals, toys, and various objects that would allow both parent and child to feel comfortable. This setting attempted to encourage natural interactions between caregivers and infants, to facilitate capture of a representative sample of the infant's vocal abilities. The lab was equipped with both video and audio recording capabilities. For video data, the recording room contained eight Sony EVI-D70/W wall-mounted cameras with pan and tilt capabilities. Further, three walls contained three by four-foot mirrors to optimize camera angles in recordings. For audio data, caregivers wore lapel mics and infants wore a vest housing a high fidelity wireless microphone to control mouth-to-microphone distance (Buder & Stoel-Gammon, 2002). A signal-to-noise ratio of up to 96 dB was made possible with 16-bit quantization, and with signals digitized at sampling rates of 44.1 or 48 kHz. All video and audio from the recording playroom was relayed to an adjacent control room. Throughout recordings, laboratory staff would attempt to record two of the eight available camera angles, choosing those with the best view of the infant's face and the best view of the interaction between caregivers and infants.

Gaze direction. Infant activity was coded for gaze direction as either directed to the caregiver, directed to another person, directed to the mirror, directed to a toy or book, directed to an object, cannot see, eyes closed, and not directed. This coding was conducted by trained laboratory staff in the Infant Vocal Development Laboratory at ISU. 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 the caregiver* was coded when the baby was looking toward the caregiver. *Directed to another person* was coded when the baby was looking in the direction of another person in the nursery other than the caregiver. *Directed to a mirror* was coded when the baby was looking in the direction of a mirror. However, if the infant looked at themselves in a mirror then this was coded as *Directed to Person* because infants do not typically develop recognition of self until 24 months of age (Anderson, 1984). *Directed to a toy or book* was coded when the baby was looking in the direction of a toy or book. *Directed to an object* was coded when the baby was looking at an object, such as furniture, the frame of a hanging wall mirror, or the door. *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. *Eyes closed* was coded when the infant closed their eyes. *Not directed* was coded when the baby was looking into space (but not looking at another person in the room, at the mirror, or at an object). Gaze direction codes were tallied for each infant age to determine frequency and duration of codes. Consensus coding was used, with each gaze direction code determined accurate by at least two laboratory staff. Furthermore, inter-observer agreement was evaluated for 15% of infant recordings from the ages of 6, 12, and 18 months.

Vocabulary ability. *The MacArthur-Bates Communicative Development Inventory* (CDI) was the parent report measure of infant/child vocabulary for the present study (Fenson et al., 1994). 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, expressive vocabulary was tallied at three points in time, and receptive vocabulary was tallied at 1 year.

Design

Correlation and multiple regression analyses were conducted to examine the relationship between all criterion and predictor variables. The criterion variables of interest were expressive and receptive vocabulary at 1 ½ years of age, and expressive vocabulary at 2 and 3 years of age. The predictor variables of interest were the frequency and duration of gazes directed to the caregiver, another person, the mirror, a toy or book, an object, cannot see, eyes closed, and not directed throughout 20 minute recordings, and infant age at 8, 12, and 16 months. A significance level (*p)* was set at 0.05 for the purpose of this study.

Results

The 15 participants shifted their gaze a total of 11,373 times (frequency) in the middle 20 minutes of 60 minute recordings (duration) at 8, 12, and 16 months of age. Further, the raw number of predictor variables (frequency of gaze direction - directed to the caregiver, directed to another person, directed to the mirror, directed to a toy or book, directed to an object, cannot see, eyes closed, and not directed - across 8, 12, and 16 months of age) are shown in Table 1. Durations were not included in the Table as all durations totaled approximately 20 minutes given the duration of the recordings. The number of gazes was variable within and across ages. The majority of gazes were directed to a toy or book, followed by directed to the caregiver, to an

object, not directed, to another person in the room, to the mirror, could not see, and eyes closed. Table 2 shows the vocabulary scores of each infant as indicated on the CDI. Results show an increase in vocabulary with an increase in infant age, which follows typical developmental patterns.

Expressive Vocabulary at 1 ½ Years

Table 3 summarizes the descriptive statistics and analysis results when examining the relationship between expressive vocabulary at 1 ½ years with all potential predictor variables. As can be seen, expressive vocabulary at 1 ½ years of age was not significantly correlated with any of the predictor variables. In the multiple regression model with all predictors at 8 months of age, frequency of gaze produced an $R^2 = 0.676$, F (8, 6) = 1.561, $p = 0.302$, and duration of gaze produced an $R^2 = 0.740$, F (8, 6) = 2.133, $p = 0.186$; at 12 months of age, frequency of gaze produced an $R^2 = 0.606$, F (8, 6) = 1.155, $p = 0.443$, and duration of gaze produced an $R^2 = 0.344$, F (8, 6) = 0.393, $p = 0.889$; and at 16 months of age, frequency of gaze produced an $R^2 = 0.263$, F (8, 6) = .267, $p = 0.955$, and duration of gaze produced an $R^2 = 0.289$, F (8, 6) = 0.305, $p = 0.938$. The frequency and duration of gaze direction (directed to the caregiver, directed to another person, directed to the mirror, directed to a toy or book, directed to an object, cannot see, eyes closed, and not directed), and infant age at 8, 12, and 16 months did not significantly contribute to the multiple regression model for expressive vocabulary at 1 ½ years.

Receptive Vocabulary at 1 ½ Years

Table 4 summarizes the descriptive statistics and analysis results when examining the relationship between receptive vocabulary at 1 ½ years with all potential predictor variables. As can be seen, receptive vocabulary at 1 ½ years of age was not significantly correlated with any of the predictor variables. In the multiple regression model with all predictors at 8 months of age,

frequency of gaze produced an $R^2 = 0.456$, F (8, 6) = 0.628, $p = 0.735$, and duration of gaze produced an $R^2 = 0.441$, F (8, 6) = 0.592, $p = 0.759$; at 12 months of age, frequency of gaze produced an $R^2 = 0.644$, F (8, 6) = 1.357, $p = 0.365$, and duration of gaze produced an $R^2 = 0.696$, F (8, 6) = 1.719, $p = 0.263$; and at 16 months of age, frequency of gaze produced an $R^2 = 0.383$, F (8, 6) = 0.465, $p = 0.844$, and duration of gaze produced an $R^2 = 0.674$, F (8, 6) = 1.549, $p = 0.306$. The frequency and duration of gaze direction (directed to the caregiver, directed to another person, directed to the mirror, directed to a toy or book, directed to an object, cannot see, eyes closed, and not directed), and infant age at 8, 12, and 16 months did not significantly contribute to the multiple regression model for receptive vocabulary at 1 ½ years.

Expressive Vocabulary at 2 Years

Table 5 summarizes the descriptive statistics and analysis results when examining the relationship between expressive vocabulary at 2 years with all potential predictor variables. As can be seen, the frequency and duration of cannot see gazes at 8 months were positively and significantly correlated with expressive vocabulary at 2 years of age, indicating that higher values in this category were related to a larger expressive vocabulary. Expressive vocabulary at 2 years of age was not significantly correlated with any of the other predictor variables. In the multiple regression model with all predictors at 8 months of age, frequency of gaze produced an $R^2 = 0.771$, F (8, 6) = 2.523, $p = 0.138$, and duration of gaze produced an $R^2 = 0.556$, F (8, 6) = 0.940, $p = 0.546$; at 12 months of age, frequency of gaze produced an $R^2 = 0.549$, F (8, 6) = 0.912, $p = 0.561$, and duration of gaze produced an $R^2 = 0.323$, F (8, 6) = 0.358, $p = 0.910$; and at 16 months of age, frequency of gaze produced an $R^2 = 0.263$, F (8, 6) = 0.267, $p = 0.955$, and duration of gaze produced an $R^2 = 0.368$, F (8, 6) = 0.437, $p = 0.862$. As can be seen in Table 5, the frequency of gazes directed to toys or books at 8 months of age had a significant positive

regression weight, indicating that infants who looked more often toward toys or books throughout the recording sessions at this age were expected to have larger expressive vocabularies at 2 years after controlling for other variables in the model. All other predictor variables at 8, 12, and 16 months of infant age did not significantly contribute to the multiple regression model for expressive vocabulary at 2 years.

Expressive Vocabulary at 3 Years

Table 6 summarizes the descriptive statistics and analysis results when examining the relationship between expressive vocabulary at 3 years with all potential predictor variables. As can be seen, the frequency of gazes directed to objects at 12 months of age was negatively and significantly correlated with expressive vocabulary at 3 years of age, indicating that higher values in this category were related to a smaller expressive vocabulary. Expressive vocabulary at 3 years of age was not significantly correlated with any of the other predictor variables. In the multiple regression model with all predictors at 8 months of age, frequency of gaze produced an $R^2 = 0.725$, F (8, 6) = 1.977, $p = 0.211$, and duration of gaze produced an $R^2 = 0.518$, F (8, 6) = 0.806, $p = 0.622$; at 12 months of age, frequency of gaze produced an $R^2 = 0.531$, F (8, 6) = 0.849, $p = 0.596$, and duration of gaze produced an $R^2 = 0.458$, F (8, 6) = 0.634, $p = 0.731$; and at 16 months of age, frequency of gaze produced an $R^2 = 0.640$, F (8, 6) = 1.335, $p = 0.373$, and duration of gaze produced an $R^2 = 0.542$, F (8, 6) = 0.886, $p = 0.575$. The frequency and duration of gaze direction (directed to the caregiver, directed to another person, directed to the mirror, directed to a toy or book, directed to an object, cannot see, eyes closed, and not directed), and infant age at 8, 12, and 16 months did not significantly contribute to the multiple regression model for expressive vocabulary at 3 years.

Effect Size

While correlation and regression analyses resulted in mostly statistically nonsignificant findings, large effect sizes were found between most criterion and predictor variables, as can be seen in Table 7 (with criterion variables listed horizontally and predictor variables listed vertically). This means that the majority of the differences between variables were large, implying strong relationships and suggesting clinical importance. In particular, it appears that the duration of gazes (for all variables) at 8, 12, and 16 months had a larger effect on expressive vocabulary at 1 year of age than the frequency of gazes; while the frequency of gazes (for all variables) at 8, 12, and 16 months had a larger effect on receptive vocabulary at 1 and expressive vocabulary at 2 and 3 years of age than the duration of gazes. Significance tests can be confounded by sample size, while effect size simply quantifies the difference between two groups. As such, it could be that the small sample size of 15 infants in the present study obscured our ability to quantify statistically significant results, while the magnitude of the effect sizes observed shows that the frequency and duration of gazes at 8, 12, and 16 months of infant age are exhibiting a strong influence over later vocabulary outcomes.

Reliability Testing

Reliability testing was conducted for 15% of the recordings in addition to the consensus coding. The recordings were coded by at least two different laboratory staff (consensus coding) and 15% was completed by myself (reliability testing). An independent sample t-test was completed to compare the gaze direction frequency and duration between the average consensus coding and the additional reliability coding results across the three age groups (8, 12, and 16 month of age). There was not a statistically significant difference with all predicators for frequency of gaze direction across all ages; 8 months ($M=39.45$, $SD=2057.20$), $t(6) = 0.06$, $p=$

0.95, 12 months (M=37.50, SD=2158.53), t (6) = -0.14, p= 0.90, and 16 months (M=38.27, SD=2126.01), t (6) = 0.73, p= 0.50. Additionally, there was not a statistically significant difference with allpredictors for duration of gaze direction across all ages: 8 months (M=215880.90, SD=109494448669.08), t (6)= -0.19 , p= 0.86, 12 months (M=238283.22, SD=148615916395.20), t (6)= -0.08, p= 0.94, and 16 months (M=237780.63, SD=136627630451.52), t (6)= -0.20, p= 0.85. Therefore, the results indicate that interobserver agreement with the coders demonstrated no significant difference between coded gaze directions.

Discussion

Infant gaze direction has been linked to vocabulary development using contrived research procedures (Brooks & Meltzoff, 2005; Brooks & Meltzoff, 2008; Brooks & Meltzoff, 2014; Law et al., 2012) and eye-tracking software (Brady, Anderson, Hahn, Obermeier, & Kapa, 2014). However, these methods not practical for most speech-language pathologists to utilize in daily practice. Despite the practicality of the equipment, infant gaze can inform practitioners about potential later vocabulary ability, which in turn can predict academic success and social adjustment. This study is one in a line of projects exploring the utility of an observation-based methodology for examination of infant gaze direction as a potential predictor of later vocabulary development. Based on prior research findings, it is hypothesized that later vocabulary development (expressive and receptive vocabulary size at 1 ½ years of age and expressive vocabulary size at 2 and 3 years of age) will vary dependent upon the frequency and duration of gaze direction (toward caregiver, another person, the mirror, a toy or book, an object, cannot see, eyes closed, and not directed) at 8, 12, and 16 months of age.

Prior literature indicates that word learning is facilitated by gaze direction. As expected, results from this study indicate similarly that there is a connection between gaze direction and

future language development. While correlation and regression analyses provided limited statistically significant findings, these results were potentially influenced by a small sample size. Effect sizes, on the other hand, not subject to the same influence from sample size, demonstrated a strong relationship between the criterion and predictor variables in the present study. Effect sizes are increasingly becoming more recognized by statistician-researchers when interpreting the main findings for quantitative studies (Sullivan & Feinn, 2012).

Implications

Correlation analyses. The correlation analyses provided limited and variable results. Most pertinent of the findings, for children at 12 months of age, the frequency of gazes directed to objects negatively and significantly correlated with expressive vocabulary at 3 years of age. This indicates that the more often infants gazed toward objects at 12 months of age, the smaller their expressive vocabulary size at 3 years. It may be possible that infant gazes directed toward objects (defined as such things as doors, mirror frames, chairs, and the like for the purposes of this study) at 12 months of age are to likely elicit less language learning opportunities compared to more desirable objects such as toys and books.

Multiple regression analyses. The multiple regression analyses indicated that infants who looked more often toward toys or books at 8 months of age were expected to have larger expressive vocabularies at 2 years of age. This finding is supported by previous research. Specifically, toys and books provide the foundation for learning and therefore are significant for language development. Early opportunities for engagement with toys are critical for vocabulary development. Tomopoulos and colleagues (2006), identified toys and books to be associated with future language outcomes. Toys have shown to be predictors of future receptive language outcomes; specific categories of toys have shown to be more important for early vocabulary. For

example, at 6 months of age, toys with patterns or mirrors, were related with language development. However, at 18 months, toys that were adaptive and allowed for opportunities for symbolic play predicted later language. Furthermore, maternal responses to infant toy initiations positively relate to later language development (Newland, Roggman, Pituch, & Hart, 2008). For instance, when an infant begins to initiate interaction with a desired toy, such as a stuffed elephant, caregiver responses may verbally detail characteristics related to the elephant and/or physically move the elephant, ultimately engaging the infant in joint attention. Infants who participate in toy play have an advantage over those who do not; toys allow for the expansion of topics for discussion, exposure to a wider variety of vocabulary, and opportunities for shared interactions with caregivers. For example, many children can identify animals that they may see on a safari, despite never having been exposed to these animals in the real word. Children can name lions and warthogs because they have been introduced though toys and books. Accordingly, the toys and books have increased lexical repertoires and ultimately enhanced opportunity for future academic achievement. Thus, toys and books allow for more complex and diverse language input from caregivers.

Effect size. The effect size results indicated that the duration of gazes at 8, 12, and 16 months of age were strongly related with expressive vocabulary at 1 year or age. This suggests that looking at people or items for longer durations of time was important for the building of early vocabulary expression in these infant participants. Other findings that have analyzed the duration of gaze are consistent with these findings. Research shows that children who visually inspect aspects of their environment for prolonged periods of time will have a larger vocabulary that develops more quickly than children who do not perform the same sort of inspection (Brooks & Meltzoff, 2008). For example, when a child visually inspects a desirable object, such

as a toy truck, for a prolonged period, then they are likely to have developed more vocabulary when compared to other same aged peers who do not participate in this longer looking time. It is likely that these infants are benefiting from cognitive processes, such as an increased attention span.

Effect size results for frequency of gazes across all categories at 8, 12, and 16 months of age were strongly related with receptive vocabulary at 1 ½ year of age and expressive vocabulary at 2 and 3 years of age. This development transition is noteworthy. Specifically, it indicates that switching gaze direction (alternating looking patterns frequently) in the first years of life holds practical, or clinical significance with respect to early language comprehension and later language production. Visual exploration of an environment requires the shifting of gaze. The number of times infants gaze toward people/objects is likely to play a role in their exposure to the environment, and as a result, influence their vocabulary development. For example, any infant that is continuously analyzing their environment through gaze direction is introduced to a larger number of people/places/things and provided more opportunities for language learning. Research in regards to shifting of gaze is limited.

Limitations and Future Directions

Several limitations of the study must be considered when interpreting the results. First, relatively few infants participated in the study. The study began with 16 infants, however one infant had to be excluded due to atypical development, limiting the study to only 15 participants. The small sample size decreased the potential for observation of statistical significance. Furthermore, the majority of the infants were Caucasian and were predominately from a middle socioeconomic status surrounding East Carolina University, which increased the risk of selection bias and decreased the strength of generalization to individuals beyond participants studied.

Future investigation should be conducted with a larger and more diverse participant sample in order to increase the external validity of the research.

Another limitation is camera angles. The laboratory setting was constructed to promote a natural interaction between infant and caregiver. Mirrors were used to optimize camera angles. Although, during the recording, there were instances where the baby was out of sight. This was typically seen with more mobile (e.g., crawling and walking) 12- and 16-month-old infants, and impacted the results. When infants were moving quickly or out of site, we could not code their gazes as directed to anything substantive. As a result, data was lost and this limitation may have impacted the outcomes of the study. Better camera angles are necessary to capture all gazes and provide more accurate representation of gaze direction.

Another issue is the methodology implemented for coding gaze direction. Gaze direction was coded using an observation-based method conducted by trained laboratory staff; however, the method was highly subjective. Different coders were likely to have different perspectives on the gaze direction of the infants, especially with limited camera angles. Methods were implemented to minimize discrepancies between coders by utilizing consensus coding where each code was confirmed by at least two coders. Further, reliability coding was conducted on a subset of the data (15% of the recordings), but the secondary observer was not blinded to the hypothesis of the research. To implement observation-based coding of gaze direction, a clear and precise procedure must be applied in order to decrease subjectivity and increase reliability.

Another potential limitation in the study is that we did not control for caregiver interactions, which could have contributed to the infant's gaze direction and language development. The caregiver's engagement with their infants could have allowed for the facilitation of more language learning opportunities. For example, when infants communicate

interests through prelinguistic communication, opportunities are created for caregivers to interact using words. Infants benefit from these interactions and learn words for objects and activities surrounding them (Tamis-LeMonda, Kuchirko, & Song, 2014). The quality of linguistic caregiver input to infants is positively related to early lexical acquisition (McGillion et al., 2013; Wu & Gros-Luis, 2014). Wu and Gros-Luis (2014) determined mother responses to pointing and vocalizations related to language development. Redirecting the infants focus inhibited the infant's language as opposed to following the child's lead. In support of this, McGillion and colleagues (2013) found that maternal responsiveness to vocalizations that incorporated semantically and temporally linked responses were related to infant expressive vocabulary. For example, parents that provide responses directly related to the child's target interest in a short time period (2-5 seconds) after the child's initiation are benefiting from this interaction. Thus, infants are taking advantage of their caregiver input and accelerating their expressive vocabulary development. It is evident that parent responsiveness to infant prelinguistic communication predicts vocabulary development. Natural observations are valuable because they provide critical data on natural interactions between caregivers and infant, however it makes replication more difficult.

Further investigation should be expanded to include children with atypical development (e.g., autism and intellectual disabilities). Expansion for these variables will provide a better understanding of the connection between gaze direction and language development. Once it is known that lack of gaze direction may negatively impact a child's language, assessments can be created to identifying these children at younger ages and tailored treatment strategies using gaze direction can aid in early intervention for infants with a language delay. Furthermore, research needs to be conducted in order to investigate potential treatment strategies eliciting gaze

direction in a separate population of participants. Only then can clinicians begin to implement evidence-based approaches in facilitating specific techniques to elicit gaze and further promote the development of language.

Clinical Application

Gaze direction has been demonstrated to be a significant prelinguistic skill necessary for vocabulary development. Although, there are few early childhood language screeners that assess prelinguistic communication, specifically gaze direction. The creation of a screener for the identification of gaze direction can assist clinicians in determining infants at risk for language disorders at a much earlier age. However, first we have to find a clinically practical way to assess eye gaze (i.e., not through the use of eye tracking software), such that statistically significant relationships with vocabulary are observed. While we did find large effect sizes in the present study, we were not able to demonstrate statistically significant relationships between the variables of interest.

Conclusion

Published research has documented a relationship between infant gaze direction and later language development (Brookes & Meltzoff 2005; Brookes & Meltzoff 2008; Law et al., 2012). Longer looking times predict larger vocabulary sizes (Brookes & Meltzoff, 2008). Using an observation-based, clinically applicable methodology for tracking gaze direction, we were able to demonstrate a link between gaze direction and vocabulary development via large effect sizes. Subsequent research should focus on further development of observation-based methods for tracking gaze direction to facilitate early identification and intervention, and to support future language development.

References

Anderson, J.R. (1984). The development of self-recognition: A review. *Developmental Psychobiology, 17*(1) 35-49.

Andreasen, C., & Ramsdell-Hudock (2018). *Infant gaze direction, early vocalizations and vocabulary development (*Unpublished master's thesis). Idaho State University, Pocatello, ID.

Akhtar, N., & Gernsbacher, M. A. (2007). Joint attention and vocabulary development: A critical look. *Language and Linguistics Compass, 1*(3), 195-207.

Baldwin, D. A. (1991). Infants' contribution to the achievement of joint reference. *Child Development, 62*(5), 874-890.

Baldwin, D. A. (1995). Understanding the link between joint attention and language. In C. Moor & P. Dunham (Eds.), *Joint Attention: Its Origins and Role in Development*, 131-158. New York, NY: Psychology Press.

Brady, N. C., Anderson, C. J., Hahn, L. J., Obermeier, S. M., & Kapa, L. L. (2014). Eye tracking as a measure of receptive vocabulary in children with autism spectrum disorders. *Augmentative and Alternative Communication, 30*(2), 147-159.

Brooks, R., & Meltzoff, A. N. (2005). The development of gaze following and its relation to language. *Developmental Science, 8*(6), 535-543.

Brooks, R., & Meltzoff, A. N. (2008). Infant gaze following and pointing predict accelerated vocabulary growth through two years of age: A longitudinal, growth curve modeling study. *Journal of Child Language, 35,* 207-220.

Brooks, R., & Meltzoff, A. N. (2014). Gaze following: A mechanism for building social connections between infants and adults. In M. Mikulincer & P.R. Shaver (Eds.),

Mechanisms of Social Connection: From Brain to Group (pp. 167-183). Washington DC: American Psychological Association.

Buder, E. H., & Stoel-Gammon, C. (2002). Young children's acquisition of vowel duration as influenced by language: Tense/lax and final stop consonant voicing effects. *Journal of the Acoustical Society of America, 111,* 1854-1864.

Butterworth, G. (1991). The ontogeny and phytogeny of joint visual attention. In A. Whiten (Ed.), *Natural theories of mind: Evolution, development, and simulation of everyday mindreading* (pp. 223-232). Oxford, England: Blackwell.

Cartmill, E. A., Armstrong, B. F., Gleitman, L. R., Goldin-Meadow, S., Medina, T. N., & Trueswell, J. C. (2013). Quality of early parent input predicts child vocabulary 3 years later. *Proceedings of the National Academy of Sciences, 110*(28), 11278-11283.

Corkum, V., & Moore, C. (1998). The origins of joint visual attention in infants. *Developmental Psychology, 34*(1), 28-38.

Dunn, L. M., & Dunn, D.M., (2007). *Peabody picture vocabulary test* (4th ed.). Minneapolis, MN: Pearson.

Edwards, B., & Ramsdell-Hudock (2016). *Infant gaze direction during early vocalizations as an indicator of vocabulary development* (*Unpublished master's thesis).* Idaho State University, Pocatello, ID.

Fenson, L., Dale, P. S., Reznick, J. S., Bates, E., Thal, D. J., Pethick, S. J., . . . Stiles, J. (1994). Variability in early communicative development. *Monographs of the Society for Research in Child Development, 59*(5) i-185.

Goldstein, M. H., Schwade, J., Briesch, J., & Syal, S. (2010). Learning while babbling: Prelinguistic object-directed vocalizations indicate a readiness to learn. *Infancy, 15*, 362-391. doi: 10.1111/j.1532-7078.2009.00020.x

Gredebäck, G., Johnson, S., & von Hofsten, C. (2009). Eye tracking in infancy research. *Developmental Neuropsychology, 35*(1), 1-19.

Iverson, J. M., & Goldin-Meadow, S. (2005). Gesture paves the way for language development. *Psychological Science, 16*(5), 367-371.

Law, B., Houston-Price, C., & Loucas, T. (2012). Using gaze direction to learn words at 18 months: Relationships with later vocabulary. *Language, 4*, 3-14.

Mayor, J., & Plunkett, K. (2011). A statistical estimate of infant and toddler vocabulary size from CDI analysis. *Developmental Science*, *14*(4), 769-785.

McGillion, M. L., Herbert, J. S., Pine, J. M., Keren-Portnoy, T., Vihman, M. M., & Matthews, D. E. (2013). Supporting early vocabulary development: What sort of responsiveness matters? *IEEE Transactions on Autonomous Mental Development*, *5*(3), 240-248.

McMurray, B., & Aslin, R. N. (2004). Anticipatory eye movements reveal infants' auditory and visual categories. *Infancy*, *6*(2), 203-229.

Merin, N., Young, G. S., Ozonoff, S., & Rogers, S. J. (2007). Visual fixation patterns during reciprocal social interaction distinguish a subgroup of 6-month-old infants at-risk for autism from comparison infants. *Journal of Autism and Developmental Disorders, 37*(1), 108-121.

Morales, M., Mundy, P., Delgado, C. E., Yale, M., Messinger, D., Neal, R., & Schwartz, H. K. (2000). Responding to joint attention across the 6-through 24-month age period and early language acquisition. *Journal of Applied Developmental Psychology, 21*(3), 283-298.

Newland, L. A., Roggman, L. A., Pituch, K. A., & Hart, A. D. (2008). Play and attention: Social foundations of early language. *International journal of psychology: a biopsychosocial approach, 2008, [Vol.] 2, p. 29-54*.

Oakes, L. (2012) Advances in eye tracking in infancy research. *Infancy, 17*(1), 1-8.

Qian, D. (2002). Investigating the relationship between vocabulary knowledge and academic reading performance: An assessment perspective. *Language Learning, 52*(3), 513-536.

Reznick, J. S., & Goldfield, B. A. (1992). Rapid change in lexical development in comprehension and production. *Developmental Psychology, 28*(3), 406-413.

Sullivan, G. M., & Feinn, R. (2012). Using effect size—or why the P value is not enough. *Journal of Graduate Medical Education, 4*(3), 279-282.

Tamis-LeMonda, C. S., Kuchirko, Y., & Song, L. (2014). Why is infant language learning facilitated by parental responsiveness? *Current Directions in Psychological Science, 23*(2), 121-126.

Tomasello, M., & Farrar, M. J. (1986). Joint attention and early language. *Child Development, 57*, 1454-1463.

Tomasello, M., & Todd, J. (1983). Joint attention and lexical acquisition style. *First Language, 4*(12), 197-211.

Tomopoulos, S., Dreyer, B. P., Tamis-LeMonda, C., Flynn, V., Rovira, I., Tineo, W., & Mendelsohn, A. L. (2006). Books, toys, parent-child interaction, and development in young Latino children. Ambulatory Pediatrics, 6(2), 72-78.

Verhoeven, L., & Leeuwe, J.V. (2008). Prediction of the development of reading comprehension: A longitudinal study. *Applied Cognitive Psychology, 22*(3), 407-423.

Williams, K. T. (1997). *Expressive Vocabulary Test.* Circle Pines, MN: American Guidance Service.

Wu, Z., & Gros-Louis, J. (2014). Infants' prelinguistic communicative acts and maternal responses: Relations to linguistic development. *First Language, 34*(1), 72-90

Tables

Table 1 Frequency of Gazes per Predictor Variable across Infants

Gaze Direction	Infant Age			Total
	8	12	16	
Caregiver	746	837	630	2213
Other Person	626	455	422	1503
Mirror	385	193	166	744
Toy or Book	966	927	1085	2978
Object	580	643	476	1699
Cannot See	206	219	204	629
Eyes Closed	18	3	7	28
Not Directed	597	458	524	1579

Table 2 Vocabulary Size by Infants across Ages

Infant	1 Year Expressive	1.5 years Receptive	2 Years Expressive	3 Years Expressive
1	149	283	548	680
2	151	275	550	661
3	18	213	178	655
4	301	365	574	677
5	181	301	576	635
6	32	267	212	651
7	61	130	277	662
8	4	57	363	562
9	51	177	186	662
10	32	405	222	655
11	17	216	66	677
12	32	215	521	623
13	69	230	363	653
14	23	274	293	651
15	68	307	514	658
M	79	248	363	651
SD	82	87	172	29

Table 3 Summary Statistics, Correlations, and Results from the Regression Analysis (Dependent Variable = Expressive Vocabulary at 1 1/2 year)

Predictor Variables			*M*	*SD*	*r* (Pearson Correlation)	Multiple Regression Weights		*t*	*p* (sig)
Infant Age in Months	Frequency /Duration	Gaze Direction				*B*	*β*		
8	Frequency	Caregiver	49.733	23.091	0.092	-1.402	-0.395	-0.958	0.375
		Other Person	41.733	27.112	-0.170	-0.437	-0.145	-0.391	0.709
		Mirror	25.667	17.947	0.030	0.102	0.022	0.066	0.949
		Toy or Book	64.400	27.307	0.017	1.214	0.404	0.859	0.423
		Object	38.667	30.165	0.326	0.519	0.191	0.413	0.694
		Cannot See	13.733	6.829	0.481	7.136	0.595	1.922	0.103
		Eyes Closed	1.200	1.971	0.455	9.542	0.229	0.501	0.634
		Not Directed	39.800	23.785	0.396	1.974	0.573	0.904	0.401
	Duration	Caregiver	131639.000	58310.741	0.100	0.000	-0.131	-0.419	0.690
		Other Person	162067.200	136122.085	-0.173	0.000	-0.650	-1.952	0.099
		Mirror	103569.267	88049.544	0.132	0.000	-0.375	-1.311	0.238
		Toy or Book	555241.200	285450.728	-0.343	0.000	-1.011	-0.823	0.442
		Object	153579.333	129750.271	0.299	0.000	-0.524	-0.544	0.606
		Cannot See	54905.800	42138.921	0.457	0.001	0.500	1.742	0.132
		Eyes Closed	2566.533	4492.855	0.268	0.006	0.313	0.661	0.533
		Not Directed	97230.733	70134.637	0.441	0.000	0.426	0.838	0.434
12	Frequency	Caregiver	55.800	23.094	-0.484	-2.989	-0.842	-2.179	0.072
		Other Person	30.333	35.614	-0.075	-1.370	-0.595	-1.439	0.200
		Mirror	12.867	8.839	0.134	-2.193	-0.236	-0.748	0.483
		Toy or Book	61.800	16.001	-0.145	0.069	0.014	0.043	0.967
		Object	42.867	38.050	-0.337	-0.522	-0.242	-0.503	0.633
		Cannot See	14.600	7.633	-0.121	-6.885	-0.641	-1.652	0.150
		Eyes Closed	0.200	0.414	-0.160	-135.813	-0.686	-1.822	0.118
		Not Directed	30.533	22.171	-0.098	3.060	0.828	1.578	0.166
	Duration	Caregiver	128654.467	63100.982	-0.362	-0.003	-2.331	-0.461	0.661
		Other Person	98439.333	114382.842	-0.009	-0.002	-3.005	-0.332	0.751
		Mirror	51353.000	42773.547	0.176	-0.002	-0.863	-0.265	0.800
		Toy or Book	623245.133	273073.362	0.118	-0.002	-6.803	-0.327	0.755
		Object	191170.600	145892.720	-0.100	-0.002	-3.207	-0.293	0.779
		Cannot See	61954.867	34443.491	0.116	-0.001	-0.488	-0.201	0.848
		Eyes Closed	264.867	801.282	-0.084	-0.031	-0.299	-0.694	0.513
		Not Directed	76497.400	44567.666	-0.093	-0.003	-1.525	-0.414	0.693
16	Frequency	Caregiver	42.000	12.734	0.000	1.118	0.174	0.291	0.781
		Other Person	28.133	39.199	0.167	-0.013	-0.006	-0.006	0.995
		Mirror	11.067	7.226	-0.400	-3.853	-0.340	-0.862	0.422
		Toy or Book	72.333	19.245	0.159	0.975	0.229	0.237	0.821
		Object	31.733	24.341	-0.257	-1.585	-0.471	-0.477	0.650
		Cannot See	13.600	6.905	-0.030	1.736	0.146	0.288	0.783
		Eyes Closed	0.467	0.915	-0.113	4.536	0.051	0.094	0.928
		Not Directed	34.933	14.719	-0.167	0.629	0.113	0.129	0.902
	Duration	Caregiver	92845.067	46701.809	-0.223	0.000	0.104	0.203	0.846
		Other Person	71501.200	98099.156	0.098	-1.719E-05	-0.021	-0.056	0.958
		Mirror	42954.333	48157.103	-0.168	0.000	-0.134	-0.352	0.737
		Toy or Book	649768.133	276989.025	0.039	-9.120E-05	-0.308	-0.688	0.517
		Object	139136.467	137771.227	-0.254	-8.567E-05	-0.144	-0.267	0.798
		Cannot See	62769.800	33081.094	0.009	0.002	0.633	0.909	0.399
		Eyes Closed	806.133	1746.345	-0.099	-0.017	-0.371	-0.571	0.589
		Not Directed	98642.000	52343.284	-0.319	-0.001	-0.707	-1.112	0.309

*p < .05, **p < .01, ***p < .001

Table 4 Summary Statistics, Correlations, and Results from the Regression Analysis (Dependent Variable = Receptive Vocabulary at 1 1/2 year)

Predictor Variables			*M*	*SD*	*r* (Pearson Correlation)	Multiple Regression Weights		*t*	*p* (sig)
Infant Age in Months	Frequency /Duration	Gaze Direction				*B*	*β*		
8	Frequency	Caregiver	49.733	23.091	-0.229	-2.037	-0.539	-1.008	0.352
		Other Person	41.733	27.112	-0.302	-1.168	-0.363	-0.758	0.477
		Mirror	25.667	17.947	-0.065	-0.871	-0.179	-0.408	0.698
		Toy or Book	64.400	27.307	-0.042	1.192	0.373	0.611	0.563
		Object	38.667	30.165	0.014	-0.020	-0.007	-0.011	0.991
		Cannot See	13.733	6.829	0.399	4.664	0.365	0.910	0.398
		Eyes Closed	1.200	1.971	-0.062	-24.988	-0.564	-0.952	0.378
		Not Directed	39.800	23.785	0.042	4.038	1.100	1.340	0.229
	Duration	Caregiver	131639.000	58310.741	-0.070	-0.001	-0.437	-0.956	0.376
		Other Person	162067.200	136122.085	0.048	-2.792E-05	-0.044	-0.089	0.932
		Mirror	103569.267	88049.544	0.002	0.000	-0.441	-1.052	0.333
		Toy or Book	555241.200	285450.728	-0.156	-0.001	-2.374	-1.318	0.235
		Object	153579.333	129750.271	-0.014	-0.001	-2.146	-1.520	0.179
		Cannot See	54905.800	42138.921	0.227	0.000	0.218	0.520	0.622
		Eyes Closed	2566.533	4492.855	-0.181	0.004	0.225	0.324	0.757
		Not Directed	97230.733	70134.637	0.123	3.504E-05	0.028	0.038	0.971
12	Frequency	Caregiver	55.800	23.094	-0.313	-1.963	-0.519	-1.413	0.207
		Other Person	30.333	35.614	0.108	0.367	0.150	0.380	0.717
		Mirror	12.867	8.839	-0.285	-5.738	-0.581	-1.932	0.102
		Toy or Book	61.800	16.001	0.023	0.143	0.026	0.086	0.934
		Object	42.867	38.050	-0.012	-0.286	-0.125	-0.272	0.795
		Cannot See	14.600	7.633	0.324	1.178	0.103	0.279	0.789
		Eyes Closed	0.200	0.414	-0.332	-178.491	-0.846	-2.364	0.056
		Not Directed	30.533	22.171	-0.029	2.295	0.583	1.168	0.287
	Duration	Caregiver	128654.467	63100.982	-0.122	-0.005	-3.316	-0.964	0.372
		Other Person	98439.333	114382.842	0.213	-0.004	-4.754	-0.771	0.470
		Mirror	51353.000	42773.547	-0.183	-0.004	-2.005	-0.905	0.400
		Toy or Book	623245.133	273073.362	-0.118	-0.004	-11.950	-0.843	0.431
		Object	191170.600	145892.720	0.037	-0.004	-6.221	-0.836	0.435
		Cannot See	61954.867	34443.491	0.473	-0.002	-0.747	-0.451	0.668
		Eyes Closed	264.867	801.282	-0.394	-0.069	-0.632	-2.155	0.075
		Not Directed	76497.400	44567.666	0.058	-0.005	-2.396	-0.957	0.376
16	Frequency	Caregiver	42.000	12.734	0.285	3.210	0.468	0.858	0.424
		Other Person	28.133	39.199	-0.300	-0.013	-0.006	-0.007	0.995
		Mirror	11.067	7.226	0.255	2.643	0.219	0.607	0.566
		Toy or Book	72.333	19.245	-0.181	-1.658	-0.365	-0.414	0.694
		Object	31.733	24.341	-0.045	-1.177	-0.328	-0.363	0.729
		Cannot See	13.600	6.905	0.144	7.846	0.621	1.337	0.230
		Eyes Closed	0.467	0.915	-0.088	-33.213	-0.348	-0.707	0.506
		Not Directed	34.933	14.719	-0.129	0.438	0.074	0.092	0.930
	Duration	Caregiver	92845.067	46701.809	0.093	0.001	0.565	1.623	0.156
		Other Person	71501.200	98099.156	-0.291	0.000	-0.481	-1.917	0.104
		Mirror	42954.333	48157.103	0.384	0.000	0.269	1.042	0.338
		Toy or Book	649768.133	276989.025	-0.116	0.000	-0.414	-1.364	0.221
		Object	139136.467	137771.227	0.074	0.000	0.191	0.522	0.620
		Cannot See	62769.800	33081.094	0.221	0.004	1.329	2.816	0.031
		Eyes Closed	806.133	1746.345	-0.003	-0.041	-0.821	-1.865	0.111
		Not Directed	98642.000	52343.284	-0.019	-0.002	-1.047	-2.433	0.051

*p < .05, **p < .01, ***p < .001

Table 5 Summary Statistics, Correlations, and Results from the Regression Analysis (Dependent Variable = Expressive Vocabulary at 2 years)

Predictor Variables			M	SD	r (Pearson Correlation)	Multiple Regression Weights		t	p (sig)
Infant Age in Months	Frequency /Duration	Gaze Direction				B	β		
8	Frequency	Caregiver	49.733	23.091	0.272	-3.897	-0.522	-1.507	0.183
		Other Person	41.733	27.112	-0.066	0.932	0.147	0.472	0.653
		Mirror	25.667	17.947	-0.056	1.888	0.197	0.691	0.516
		Toy or Book	64.400	27.307	0.325	7.284	1.155	2.917	0.027*
		Object	38.667	30.165	0.326	4.725	0.827	2.129	0.077
		Cannot See	13.733	6.829	.556*	12.726	0.504	1.940	0.100
		Eyes Closed	1.200	1.971	0.112	-14.929	-0.171	-0.444	0.673
		Not Directed	39.800	23.785	0.095	2.144	0.296	0.556	0.598
	Duration	Caregiver	131639.000	58310.741	0.171	0.000	0.159	0.391	0.709
		Other Person	162067.200	136122.085	-0.184	-0.001	-0.637	-1.467	0.193
		Mirror	103569.267	88049.544	-0.076	-0.001	-0.277	-0.743	0.485
		Toy or Book	555241.200	285450.728	-0.272	0.000	-0.543	-0.338	0.747
		Object	153579.333	129750.271	0.293	2.817E-05	0.021	0.017	0.987
		Cannot See	54905.800	42138.921	.536*	0.002	0.451	1.205	0.273
		Eyes Closed	2566.533	4492.855	-0.022	0.008	0.217	0.352	0.737
		Not Directed	97230.733	70134.637	0.010	0.000	-0.078	-0.117	0.911
12	Frequency	Caregiver	55.800	23.094	-0.205	-7.001	-0.938	-2.268	0.064
		Other Person	30.333	35.614	0.001	-4.078	-0.843	-1.903	0.106
		Mirror	12.867	8.839	-0.025	-5.004	-0.257	-0.758	0.477
		Toy or Book	61.800	16.001	-0.016	3.263	0.303	0.890	0.408
		Object	42.867	38.050	0.181	2.521	0.557	1.079	0.322
		Cannot See	14.600	7.633	-0.165	-19.783	-0.876	-2.109	0.079
		Eyes Closed	0.200	0.414	0.072	-224.694	-0.540	-1.340	0.229
		Not Directed	30.533	22.171	0.229	5.029	0.647	1.153	0.293
	Duration	Caregiver	128654.467	63100.982	-0.133	-0.015	-5.456	-1.062	0.329
		Other Person	98439.333	114382.842	0.082	-0.014	-8.980	-0.976	0.367
		Mirror	51353.000	42773.547	-0.065	-0.013	-3.317	-1.003	0.354
		Toy or Book	623245.133	273073.362	-0.097	-0.013	-20.284	-0.959	0.375
		Object	191170.600	145892.720	0.189	-0.012	-10.011	-0.901	0.402
		Cannot See	61954.867	34443.491	-0.038	-0.012	-2.446	-0.990	0.360
		Eyes Closed	264.867	801.282	-0.111	-0.105	-0.490	-1.119	0.306
		Not Directed	76497.400	44567.666	0.030	-0.015	-3.846	-1.029	0.343
16	Frequency	Caregiver	42.000	12.734	-0.143	-1.407	-0.104	-0.174	0.867
		Other Person	28.133	39.199	0.234	-1.256	-0.286	-0.303	0.772
		Mirror	11.067	7.226	-0.348	-6.357	-0.267	-0.677	0.524
		Toy or Book	72.333	19.245	0.217	5.118	0.572	0.592	0.576
		Object	31.733	24.341	-0.162	-4.124	-0.583	-0.590	0.577
		Cannot See	13.600	6.905	0.073	2.391	0.096	0.189	0.856
		Eyes Closed	0.467	0.915	0.006	62.370	0.331	0.615	0.561
		Not Directed	34.933	14.719	-0.028	2.288	0.195	0.223	0.831
	Duration	Caregiver	92845.067	46701.809	-0.354	-0.001	-0.326	-0.673	0.526
		Other Person	71501.200	98099.156	0.138	6.372E-05	0.036	0.104	0.921
		Mirror	42954.333	48157.103	-0.209	0.000	-0.043	-0.119	0.909
		Toy or Book	649768.133	276989.025	-0.004	0.000	-0.320	-0.759	0.477
		Object	139136.467	137771.227	-0.253	-0.001	-0.468	-0.921	0.393
		Cannot See	62769.800	33081.094	0.107	0.001	0.249	0.379	0.717
		Eyes Closed	806.133	1746.345	0.058	0.024	0.246	0.401	0.703
		Not Directed	98642.000	52343.284	-0.268	-0.001	-0.293	-0.489	0.642

*p < .05, **p < .01, ***p < .001

Table 6 Summary Statistics, Correlations, and Results from the Regression Analysis (Dependent Variable = Expressive Vocabulary at 3 years)

Predictor Variables			*M*	*SD*	*r* (Pearson Correlation)	Multiple Regression Weights		*t*	*p* (sig)
Infant Age in Months	Frequency /Duration	Gaze Direction				*B*	*β*		
8	Frequency	Caregiver	49.733	23.091	-0.500	-0.878	-0.705	-1.857	0.113
		Other Person	41.733	27.112	-0.135	-0.061	-0.058	-0.170	0.871
		Mirror	25.667	17.947	-0.304	-0.919	-0.574	-1.839	0.116
		Toy or Book	64.400	27.307	-0.162	0.149	0.141	0.326	0.756
		Object	38.667	30.165	-0.104	-0.515	-0.541	-1.270	0.251
		Cannot See	13.733	6.829	0.056	0.897	0.213	0.747	0.483
		Eyes Closed	1.200	1.971	0.246	-2.017	-0.138	-0.328	0.754
		Not Directed	39.800	23.785	0.141	1.533	1.268	2.173	0.073
	Duration	Caregiver	131639.000	58310.741	-0.240	0.000	-0.369	-0.869	0.418
		Other Person	162067.200	136122.085	0.035	6.966E-05	0.330	0.728	0.494
		Mirror	103569.267	88049.544	-0.205	0.000	-0.500	-1.285	0.246
		Toy or Book	555241.200	285450.728	0.167	-2.002E-06	-0.020	-0.012	0.991
		Object	153579.333	129750.271	-0.167	0.000	-0.679	-0.518	0.623
		Cannot See	54905.800	42138.921	0.020	0.000	0.393	1.008	0.352
		Eyes Closed	2566.533	4492.855	0.201	0.001	0.114	0.178	0.865
		Not Directed	97230.733	70134.637	0.238	0.000	0.734	1.060	0.330
12	Frequency	Caregiver	55.800	23.094	-0.302	0.171	0.137	0.326	0.756
		Other Person	30.333	35.614	0.072	0.322	0.398	0.882	0.412
		Mirror	12.867	8.839	-0.173	-1.107	-0.340	-0.985	0.362
		Toy or Book	61.800	16.001	-0.207	-0.679	-0.378	-1.089	0.318
		Object	42.867	38.050	-.515*	-0.655	-0.867	-1.648	0.150
		Cannot See	14.600	7.633	-0.111	0.450	0.119	0.282	0.788
		Eyes Closed	0.200	0.414	-0.086	-8.317	-0.120	-0.291	0.781
		Not Directed	30.533	22.171	-0.368	0.129	0.100	0.174	0.867
	Duration	Caregiver	128654.467	63100.982	-0.444	-0.001	-1.499	-0.326	0.755
		Other Person	98439.333	114382.842	0.090	0.000	-1.802	-0.219	0.834
		Mirror	51353.000	42773.547	0.106	0.000	-0.702	-0.237	0.820
		Toy or Book	623245.133	273073.362	0.388	-0.001	-5.095	-0.269	0.797
		Object	191170.600	145892.720	-0.505	-0.001	-3.032	-0.305	0.771
		Cannot See	61954.867	34443.491	-0.096	0.000	-0.370	-0.167	0.873
		Eyes Closed	264.867	801.282	0.083	-0.004	-0.099	-0.252	0.809
		Not Directed	76497.400	44567.666	-0.357	-0.001	-1.258	-0.376	0.720
16	Frequency	Caregiver	42.000	12.734	0.239	0.071	0.031	0.075	0.942
		Other Person	28.133	39.199	-0.362	0.091	0.124	0.188	0.857
		Mirror	11.067	7.226	-0.141	-0.890	-0.224	-0.812	0.448
		Toy or Book	72.333	19.245	-0.418	-0.862	-0.577	-0.855	0.426
		Object	31.733	24.341	-0.137	0.888	0.752	1.090	0.318
		Cannot See	13.600	6.905	0.081	2.533	0.608	1.717	0.137
		Eyes Closed	0.467	0.915	0.156	-8.575	-0.273	-0.725	0.496
		Not Directed	34.933	14.719	-0.438	-2.237	-1.145	-1.868	0.111
	Duration	Caregiver	92845.067	46701.809	0.165	0.000	0.741	1.797	0.123
		Other Person	71501.200	98099.156	-0.288	0.000	-0.488	-1.639	0.152
		Mirror	42954.333	48157.103	-0.080	0.000	-0.257	-0.839	0.433
		Toy or Book	649768.133	276989.025	-0.024	-2.743E-05	-0.264	-0.734	0.490
		Object	139136.467	137771.227	0.108	7.735E-05	0.371	0.855	0.425
		Cannot See	62769.800	33081.094	0.075	0.001	1.131	2.022	0.090
		Eyes Closed	806.133	1746.345	0.135	-0.012	-0.758	-1.452	0.197
		Not Directed	98642.000	52343.284	-0.204	-0.001	-1.120	-2.195	0.071

*p < .05, **p < .01, ***p < .001

Table 7 Effect Sizes (Cohen's d) between Criterion and Predictor Variables

Predictor Variables			Expressive Vocabulary at 1 Year	Receptive Vocabulary at 1 Year	Expressive Vocabulary at 2 Years	Expressive Vocabulary at 3 Years
Infant Age in Months	Frequency/ Duration	Gaze Direction				
8	Frequency	Caregiver	0.490	3.100	2.457	23.047
		Other Person	0.615	3.186	2.604	21.792
		Mirror	0.903	3.522	2.753	26.078
		Toy or Book	0.243	2.833	2.150	20.910
		Object	0.657	3.200	2.621	20.770
		Cannot See	1.127	3.778	2.864	30.478
		Eyes Closed	1.347	3.991	2.968	31.867
		Not Directed	0.654	3.249	2.627	23.152
	Duration	Caregiver	3.191	3.187	3.184	3.177
		Other Person	1.683	1.681	1.680	1.677
		Mirror	1.662	1.660	1.658	1.653
		Toy or Book	2.750	2.750	2.749	2.748
		Object	1.673	1.671	1.670	1.667
		Cannot See	1.840	1.834	1.830	1.821
		Eyes Closed	0.783	0.730	0.693	0.603
		Not Directed	1.959	1.956	1.953	1.947
12	Frequency	Caregiver	0.390	3.004	2.498	22.813
		Other Person	0.774	3.260	2.673	19.168
		Mirror	1.139	3.784	2.869	29.984
		Toy or Book	0.296	2.961	2.461	25.309
		Object	0.570	3.041	2.565	18.025
		Cannot See	0.111	3.761	2.856	30.236
		Eyes Closed	1.364	4.008	2.977	31.987
		Not Directed	0.812	3.409	2.706	24.155
	Duration	Caregiver	2.882	2.878	2.875	2.869
		Other Person	1.216	1.214	1.213	1.209
		Mirror	1.695	1.690	1.686	1.676
		Toy or Book	3.227	3.226	3.226	3.224
		Object	1.852	1.851	1.850	1.847
		Cannot See	2.541	2.534	2.529	2.517
		Eyes Closed	0.326	0.031	0.169	0.681
		Not Directed	2.425	2.420	2.416	2.407
16	Frequency	Caregiver	0.635	3.296	2.627	27.373
		Other Person	0.796	3.244	2.679	18.112
		Mirror	1.172	3.189	2.885	30.508
		Toy or Book	0.116	2.773	2.370	23.640
		Object	0.786	3.369	2.691	23.236
		Cannot See	1.129	3.779	2.865	30.466
		Eyes Closed	1.360	4.004	2.974	31.961
		Not Directed	0.753	3.398	2.682	26.958
	Duration	Caregiver	2.809	2.804	2.801	2.792
		Other Person	0.130	1.027	1.026	1.021
		Mirror	1.260	1.254	1.251	1.242
		Toy or Book	3.317	3.316	3.316	3.314
		Object	1.427	1.426	1.425	1.422
		Cannot See	2.680	2.673	2.668	2.656
		Eyes Closed	0.588	0.452	0.357	0.126
		Not Directed	2.663	2.658	2.656	2.648

A *Cohen's d* of 0.2 is interpreted as a small effect size, of 0.5 as medium, and of 0.8 as large.

Appendix A

Prior Findings in the Infant Vocal Development Laboratory Pertinent to the Present Study

Edwards & Ramsdell-Hudock, 2016	The purpose of this study, *Infant Gaze Direction during Early Vocalizations as an Indicator of Vocabulary Development,* 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 complete generalized linear model, gaze direction was not an indicator vocabulary development. However, more research should be conducted on infant gaze behaviors between 11 and 14 months of age in relation to vocabulary development (based on significant *t*-test findings). In addition, the results did indicate that gaze direction was correlated to itself and that age was a reliable indicator of vocabulary development. 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.

Andreasen & Ramsdell-Hudock, 2018	The purpose of this project, *Infant Gaze Direction, Early Vocalizations, and Vocabulary Development*, was to determine if there was a relationship between gaze direction and later development of expressive and receptive vocabulary. We hypothesized that there would be a relationship between gaze (before, during, and after infant vocalization) and later vocabulary development. Data was extracted from a longitudinal study comparing gaze direction in 15 infants at 8, 10, 12, 14, and 16 months of age and how that related to expressive and receptive vocabulary development in the same children at 1.5, 2, and 3 years of age. Gaze direction was coded with an observer-based classification system, while vocabulary was documented through standardized parent report. The results indicated a clinically relevant relationship between 8, 10, 12, 14, and 16-month-old infants' gaze direction before, during, and after spontaneous vocalizations and their later expressive and receptive vocabulary development from 1.5 to 3 years. If studied further, these results could be used in establishing additional factors that impact later development, therefore aiding in early identification and intervention. Strategies to facilitate vocabulary development through early gaze direction could also be established in future work. Clinical implications, study limitations, and future directions will be discussed.

This material has been disseminated at American Speech-Language-Hearing Association Conventions.