ABSTRACT

SARAH ANNE HUTCHESON

The Development of Directedness and Canonical Babbling in Prelinguistic Vocalizations and Their Relationship to Later Language Measures

(Under the Direction of DR. SUNEETI NATHANI IYER)

The purpose of the present study was to examine the development of gaze directedness of vocalizations and canonical babbling in infancy and their possible relationships with later expressive language measures in toddlerhood. As part of an ongoing longitudinal study, ten typically developing infants were recorded in a laboratory setting from 5 to 30 months at weekly to monthly intervals. The directedness of vocalizations, i.e., whether the vocalizations were undirected or directed toward a person or object, was ascertained at 6 and 9 months using muted video recordings. The age of onset of canonical babbling, or the production of well-formed consonant vowel sequences, was also determined. These results will be compared to scores obtained at 18 and 30 months of age on standardized expressive language and vocabulary measures. It was expected that vocalizations directed toward a person or object would increase from 6 to 9 months of age as the infants' communication became more intentional. Furthermore, based on results of previous research, a positive correlation between person-directed vocalizations and expressive language scores and vocabulary size was expected. However, the prediction was neutral regarding the correlation between earlier canonical babbling onset and those same measures as previous research had obtained contradictory results.

INDEX WORDS: Gaze, Directedness, Canonical Babbling, Expressive Language, Infancy

THE DEVELOPMENT OF DIRECTEDNESS AND CANONICAL BABBLING IN PRELINGUISTIC VOCALIZATIONS AND THEIR RELATIONSHIP TO LATER LANGUAGE MEASURES

by

SARAH ANNE HUTCHESON

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SARAH ANNE HUTCHESON

Approved:

Dr. Suneeti Nathani Iyer
Dr. Suneeti Nathani Iyer — April 28, 2010
Faculty Research Mentor — Date

Approved:

Dr. Hui-Chin Hsu
Dr. Hui-Chin Hsu — April 28, 2010
Reader — Date

Approved:

Dr. David S. Williams
Dr. David S. Williams — May 7, 2010
Director, Honors Program, Foundation Fellows and Center for Undergraduate Research Opportunities — Date

Approved:

Dr. Pamela B. Kleiber
Dr. Pamela B. Kleiber — May 7, 2010
Associate Director, Honors Program and Center for Undergraduate Research Opportunities — Date

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TABLE OF CONTENTS

Page

LIST OF TABLES

Page

LIST OF FIGURES

Page

CHAPTER 1
INTRODUCTION

Although early studies on language development claimed that there was no connection between prelinguistic vocalizations and later speech and language (Jackobson, 1941), more recent research has favored the existence of such a link (Camp, Burgess, Morgan & Zerbe, 1987; McCathren, Yoder & Warren1999; Vihman & Greenlee, 1987; McCune & Vihman, 2001; Whitehurst, Smith, Fishel, Arnold, & Lonigan, 1991; see review by Locke, 1993). Studying the relationships between features of prelinguistic vocalizations and later language outcomes may help establish a basis for the identification of children at risk for language disorders and delays. This information, in turn, could lay the groundwork for developing effective assessment and therapy strategies at the prelinguistic level. This study examines the relationships between two features of prelinguistic vocalizations at 6 and 9 months - directedness of vocalizations and the onset of canonical babbling - and expressive language outcomes at 18, 29, and 30 months in typically developing children.

Directedness

The primary factor of interest in the present study is the directedness of infant vocalizations. Directedness refers to "the tendency to produce displays with the intention of having them be observed, and by implication of having them produce social effects" (Oller, 2000). It is plausible then that an infant who often directs his or her vocalizations towards people may have a great desire for social communication and thus may perhaps have an increased incentive to develop more mature language and thereby achieve even greater social effects. Few

researchers have examined the social aspects of prelinguistic vocalizations, in general, and even fewer have examined the relationships between directedness of infant vocalizations and later language development. An early study by Delack and Fowlow (1978) looked at the contexts in which infants vocalize the most and thereby provided indirect evidence regarding the directedness of infant vocalizations. They recorded 19 typically developing infants in their homes at biweekly intervals from one month to one year of age. Their results showed that infants vocalized most when alone, less when with their mothers, and the least when in the presence of a stranger. By breaking down the frequency of vocalizations in specific contexts by age, they also discovered that, the frequency of vocalization occurring in the presence of visual toys peaked at 3-4 months and again at 9 months. They postulated that the first peak at 3-4 months was due to the child's interest in mobiles while in the crib. More notably, they attributed the second peak at 9 months of age to the child's increased interest in their surroundings and added that, often, the mother would comment on the object at which the child was vocalizing thereby suggesting that by 9 months of age, infants are perhaps aware of the social effects of vocalizations.

A study by Legerstee (1991) investigated the social context of infant vocalizations during the first 6 months of life. Recordings of 8 infants were made biweekly in a laboratory setting from 3 weeks (with the exception of one participant who began at 7 weeks) to 25 weeks, i.e., 0-6 months of age. The infant was recorded with his or her mother, a stranger, and a doll. There was an active condition in which each of the partners actively interacted with the infant and a passive condition in which the partners did not respond to the infant for a total of 6 unique conditions (active mother, passive mother, active stranger, passive stranger, active doll, passive doll). The infants' vocalizations were classified as melodic (speech-like), vocalic (non-speech-like) or emotional (fixed signals). Legerstee's results indicated that the infants produced the most

melodic or speech-like sounds while in the presence of the active mothers and the second most speech-like sounds in the presence of the active stranger. The increased frequency of speech-like sounds in the presence of an active communication partner (rather than a passive partner or object) provides further indirect evidence for the concept that the use of advanced prelinguistic forms is fostered by social interactions.

Research by Hsu and Fogel (2001) also conducted research similar to that of Legerstee (2001). 13 typical infant-mother dyads were recorded from 4 weeks to 24 weeks of age and the type of interactions that occurred between mother and child as well as the quality of vocalizations were observed. The quality of vocalizations was determined by classifying utterances as syllabic (speech-like) or vocalic (non speech-like). Speech-like utterances were defined as vocalizations produced towards the front of the mouth with greater oral resonance whereas non speech-like utterances were produced towards the back of the mouth with greater nasal resonance. They found that infants produced more speech-like sounds than non speech-like sounds only during symmetrical communication (well-coordinated, mutual interactions between mother and infant) and fewer during unilateral communication (when the infant was disengaged from the mother). These results suggest that social interactions may indeed foster the production of more advanced vocalizations.

A follow up study by Hsu, Fogel, and Messinger (2001), using the same set of recordings as the previous study, examined the impact of infant smiling and gaze on the quality of vocalizations. They found that infant smiling and infant gaze directed towards the mother were more likely to occur before speech-like vocalizations than non speech-like vocalizations. This finding further supports the idea that social interactions between mother and infant encourage the use of more sophisticated utterances.

The only study, to our knowledge, that has directly examined the relationship between directedness of vocalizations and later language was conducted by Paavola, Kunnari, & Moilanen (2005). However, these researchers chose to group vocalizations together with gestures, making it difficult to specifically determine the role of vocalizations in facilitating language. Gestures and vocalizations produced by 27 typically developing Finnish-speaking mother infant dyads were observed during a 20 minute unstructured play session at 10 months of age. Paavola et al. (2005) used the term "intentional communicative acts" to describe gestures or vocalizations that were directed toward the mother. Infants' use of intentional communicative acts at 10 months positively predicted their communication scores on a standardized language test at 12 months of age.

Other researchers, who have looked at directedness, have examined atypical populations and obtained contradictory results (McCathren et al., 1999; Whitehurst et al., 1991). McCathren et al. (1999) longitudinally followed 58 toddlers (34 boys and 24 girls), who ranged from 17-34 months of age at the beginning of the study and had mild to moderate developmental delays, for one year. These children had no associated sensory impairments but had fewer than 3 words in their productive vocabulary. McCathren et al. correlated the rate of vocalization, rate of consonant use, and rate of vocalizations used interactively with an adult, at the beginning of the study with their expressive language abilities measured 12 months later using a standardized test and a 15-minute unstructured interaction. They found that the rate of vocalizations directed towards the adult (the feature of most interest to the present study) had a positive correlation with later expressive vocabulary.

Whitehurst et al. (1991) looked at 37 two-year-olds with severe specific expressive language delay with normal intelligence and receptive language. At the first assessment,

standardized language and cognitive tests were administered and the infants were recorded in a semi-structured session with their mothers. The second assessment occurred five months later and consisted of the administration of standardized language and cognitive tests. Unlike McCathren et al, results of Whitehurst et al. (1991) did not show a significant correlation between the rate of babble used interactively with their mothers in the first session and expressive language scores at the second assessment.

The focus of the present study is to further elaborate upon the development of directedness and the relationship between socially directed vocalizations and expressive language. Speech-like vocalizations will be identified in the present study using more contemporary and well-accepted criteria (e.g., Oller, 2000; Nathani, Ertmer, & Stark, 2006) than in previous investigations (e.g., Hsu et al., 2001; Legerstee, 1991). The present study will also exclude other communicative efforts, such as gestures as used in Paavola et al. (2005), from consideration thereby allowing for more precise conclusions to be drawn about the relationship of vocalizations with later language. Infants' directedness will be examined at both six and nine months of age to capture the transition to intentionality, as noted by Bates, Camaioni & Volterra (1975). Bates et al. noted that, in the perlocutionary stage prior to 8-9 months of age, infants tend to exhibit interactions in which they simply attend to stimuli in their environment. In contrast, upon entering the illocutionary stage at around 8-9 months, infants begin to use gestures and vocalizations to communicate their intentions to their caregiver. Correlations between these directedness measures with language outcomes at ages (18, 29, and 30 months of age) farther from the ages at the start of the study than in the Whitehurst et al. (1999) and Paavola et al. (2005) studies will be obtained.

Onset of Canonical Babbling (CB)

A secondary predictor variable of interest in the present study is canonical babbling (CB). Canonical babbling refers to the production of canonical syllables, either alone or in sequence; canonical syllables consist of a fully resonant nucleus and a consonant-like element connected by an adult-like formant transition (Oller, 2000). The advent into the canonical babbling stage occurs around 5-10 months and is considered a milestone in infant language development.

Researchers have examined the link between canonical babbling onset and expressive vocabulary in typically developing populations (Oller, Eilers, Neal, & Schwartz, 1999; Oller, Levine, Cobo-Lewis, Eilers, & Pearson, 1998). Oller et al. (1999) examined canonical babbling onset in 3,400 at-risk infants using a five-minute parent interview when the child had reached 10 months of age. When the children, who had a late onset of canonical babbling (after 10 months), were compared to a control group, who had an onset of CB before 10 months, they found that the majority of the late babblers had a lower level of expressive vocabulary development at 18 months as measured by the MacArthur Communicative Development Inventory (MCDI, Fenson et al., 1993) when compared to the control group. Oller et al. (1998), on the other hand, failed to find a significant correlation among the onset of CB and age of first word, age of first five words, and mean length of utterance. This study included 15 full-term infants from low socioeconomic status (SES) homes, 12 full-term infants from middle SES homes, 7 preterm infants from low SES homes, and 8 preterm infants from middle SES homes. These negative results may be attributed to the fact that there are more factors than just the capacity for the production of speech like sounds involved in a child's transition to actual speech. The child must also have the ability to consistently use phonetic forms in reference to an object or event and possess other intact cognitive and perceptual skills.

Indirect evidence of the relationship between canonical babbling and later expressive language can also be found from results of studies that examined the onset of CB in atypical populations. Eilers and Oller's study (1994), which examined canonical babbling in infants with hearing loss, was an expansion of a previous study by Oller and Eilers (1988) and determined that children with hearing loss enter the canonical babbling stage later than children with normal hearing. All of the children with normal hearing reached the canonical babbling stage before 11 months, whereas all of the children with hearing loss entered at 11 months or later despite the stricter requirements for the normally hearing children In another study, Chapman, Hardin-Jones, Schulte, & Halter (2001) studied the differences in babbling between 30 infants with unrepaired cleft palates and 15 age-matched peers. They determined that only 57% of the babies with cleft palates had reached the canonical babbling stage at 9 months, while 93% of the peer group had reached it. Because the atypical groups showed delays in canonical babbling and are also known to have delays in subsequent language development, it may be the case that typically developing children who enter the canonical babbling stage later will also have delays in language development.

Because a common conclusion has not been drawn on the role of canonical babbling in later language development, there is a need for more research to reconcile these differing results By examining the onset of canonical babbling in typically developing children, the current study looks to expand on Oller et al.'s (1998, 1999) results.

Focus of the Present Study

The present study will examine relationships between directedness of vocalizations and onset of canonical babbling in the first year of life and expressive language scores and vocabulary size in the second and third years. Based on the majority of results from previous

research, it is expected that there will be a positive correlation between vocalizations directed towards people and later expressive language scores and vocabulary size. The expectation about correlations between earlier onset of canonical babbling and expressive language scores and vocabulary size is neutral given contradictory results from previous research.

CHAPTER 2
METHOD

Participants

Ten typically developing infants, five females and five males, were followed longitudinally from five months to 30 months of age. They were all participants in a larger longitudinal study by Iyer. For this study, the recordings from these infants at 6 and 9 months of age and scores from language measures administered at 18, 29, and 30 months, were used.

All of the participants had normal cognitive abilities, as evidenced by their scores within the normal range on the Bayley Scales of Infant Development (Bayley, 1993) at one year of age. Additionally, all infants passed annual hearing screenings. All but two of the children came from English-speaking homes. One child came from a home where only Chinese was spoken and another child came from a home where both English and Hindi were spoken. However, this second child was also in full-time daycare for the majority of the day from seven months of age, where only English was spoken.

Socioeconomic status (SES) of the participants were designated using procedures established by Eilers, Oller, Levine, Basinger, Lynch, & Urbano (1993) ranging from 1 (high) to 5 (low). Seven of the infants had Level 1 SES designations and three of the infants had Level 2 SES designations. Level 1 and 2 designations meant that all of the participants came from two-parent homes and had at least one parent who had graduated from college. Individual demographic data can be found in Table 1.

Session Description

Sessions for each infant typically lasted between 30 and 60 minutes and involved three or four different segments including: the child playing alone with age-appropriate toys and books, the parent interacting with the child using age-appropriate toys and books, the experimenter interviewing the parent with the child present, and/or a feeding episode. For F2, a segment that involved the experimenter interacting with the infant was also included. The order of these segments was randomized for each recording. Parents were permitted to bring in toys from home that the child may be more familiar with. Care was taken to ensure that noisy toys were not included in order to not obscure the child's voice during recordings.

Three sessions from 5-7 months of age and two sessions from 8-10 months of age respectively were analyzed for directedness. The sessions that were selected did not have any standardized testing administered during the sessions and were deemed to have acceptable video and audio quality for coding. Given known tremendous variability in infant behaviors, scores across the three 5-7 months of age sessions were averaged to yield the 6 month directedness data. Similarly, scores from the two 8-10 months of age sessions were averaged to yield the 9 month directedness data.

Recording Equipment

Participants were recorded in a sound treated booth using three digital cameras (Canon VC-C4) as well as wireless microphones on both the parent (Samson T32) and the child (Samson AL1). The child's microphone was secured to a customized cloth vest that housed the battery pack. The three cameras were remotely controlled from outside the booth to obtain the best possible view of the infants as they moved around the room. However, for one infant, F5, the recordings were completed prior to the addition of remote control cameras and so these

recordings featured stationary cameras which were mounted high to obtain the largest viewing area possible. Input from the cameras and microphones were recorded outside the booth to mini DV tapes via a Eurorack UB802 Ultra Low Noise Design 8-input 2-bus audio mixer and a Videonics Digital video mixer.

Digitization Procedures and Analysis Software Description

The video portion of the sessions recorded as uncompressed video files on mini DV tapes were converted to compressed video files (mpeg2 or mpeg4) using commercially available software to allow for analysis within a customized version of the AACT system (Action Analysis Coding and Training System, Oller et al., 2003). The audio wave files used in the analysis were not subjected to compression and were directly obtained from the uncompressed audio recordings.

The AACT software was ideal for this study because it allowed for simultaneous playing of the digital video and audio recordings. AACT presented the audio as both a waveform and a spectrogram using acoustic analysis software within it, namely TF32 (Milenkovic, 2001). The video was displayed within AACT using Windows Media Player. Judges could select a specific category to analyze based on the objective of the analysis (e.g., gaze direction, facial affect, or vocal quality). Using cursors within the TF32 program, judges were able to select specific segments of the recording to show the beginning and end times of utterances or to select a section of the recording to play.

Ensuring that the video and audio were synchronized was vital for accurate coding. For some of the files, the process of encoding files into the mpeg2 format caused the video to lag behind the audio in AACT. These files were therefore, re-digitized as larger mpeg4 files to

maintain higher video quality. The new files were then synchronized with the original audio files using the TF32 software.

Identification of Utterances

The utterance identification process began by a judge scanning each session within AACT to determine the segment of the session during which the baby was vocalizing the most. Utterances within these segments were then identified until a total of 75-100 utterances was obtained. Utterances were defined as vocalizations perceived as belonging together in a single breath group, i.e., when no audible breath sounds could be heard, or when linked together by a unified intonation contour as is the case with sequences of ingresses and egresses. Utterances had to be intentional vocalizations rather than reflexive (e.g., cries or laughter) or vegetative (e.g., sneezes, coughs, etc.) and could not be so excessively soft or brief in duration that they could not be detected.

An experienced judge (SNI) checked 20% of each session to verify the utterances identified by the primary judge. If agreement between primary judge and SNI was 80% or higher, the file was noted as "certified". If agreement was lower than 80%, the file was recoded until the 80% criterion was reached. If, on recoding, the 80% criterion could not be reached, two possible courses of action occurred: i) a notation was made as such if the session was particularly difficult to code, e.g., infant was very fussy, and the session was cautiously accepted for analysis, or ii) consensus judgments between the original coder and the more experienced judge were made for the entire session (if the session did not have any anomalies as noted in i).

Of the 50 sessions used for the 10 participants in the current study, only 7 required recoding. Of these 7 sessions, 5 sessions reached 80% agreement on the 1st recoding, 1 required yet another pass to achieve 80% agreement between the primary judge and SNI, and the

remaining 1 session was noted as difficult to code because the infant was fussy. Utterances from this session were cautiously accepted for analysis, as described in (i) above.

Interjudge reliability for utterance determination was achieved by having a second judge code 20% of the sessions in their entirety. Additionally, the primary judge coded 20% of their sessions a second time to provide intrajudge reliability. The overall interjudge agreement was 85.62% and the intrajudge agreement was 90.46%, which was deemed to be acceptable for the present study.

Directedness Categorization

Identification of directedness categories utilized the "video loop" feature of AACT. This feature allows the judge to select an utterance and then play only the section of video that corresponds to this utterance. The primary judge for this analysis (SH) was different from the primary judge for utterance identification. SH watched the video for each utterance (with the sound muted in order to avoid influence from the quality of the utterances produced) no more than three times and then determined what the infant was directing his or her vocalization towards (e.g., towards person, towards object, not directed – Please see Appendix for the various categories used for directedness). The video segment was only viewed three times because it was assumed that if a judgment could not be confidently made within the first three viewings, the judge was probably guessing and additional views would not be helpful. Body position as well as eye gaze was used in determining directedness. Although judges were not permitted to watch the video loop more than three times, it was permissible to apriori scan the video surrounding the utterance to determine the overall context of the utterance, e.g. to help determine location of toys and people around the room.

An experienced coder (SNI) then recoded 20% of the utterances for each session, following the same procedures for certification as identifying utterances. Of the 50 sessions checked by SNI, only 4 sessions required recoding. Of the 4 that required recoding, 3 achieved 80% on the second pass and 1 used consensus judgments between the original coder and the more experienced judge for the entire session

Once directedness categorization was completed for all files, interjudge and intrajudge reliability procedures were conducted. A second judge coded 20% of the files to obtain interjudge reliability for directedness categorization and the primary coder (SH) also recoded 20% of the files to obtain intrajudge reliability. One session was analyzed for reliability per infant. These sessions were split evenly across all infants between 6 and 9 months. Intrajudge agreement was 84% and interjudge agreement was 76%.

Identification of Onset of Canonical Babbling (CB)

In order to determine the onset of CB, a judge analyzed the sessions around the parent report of CB onset. The judge listened to each utterance and then determined if it contained any canonical syllables. If the utterance contained one or more canonical syllables, it was designated as a canonical utterance. Once the child achieved a ratio of 0.1 canonical utterances, i.e., number of canonical utterances divided by total number of utterances, that session was designated as the laboratory onset of CB. The experienced judge (SNI) confirmed the onset of CB by verifying all utterances containing a potential canonical syllable, as identified by the primary judge.

Expressive Language Measures at 18, 29, and 30 months

Three standardized measures were used to determine the participants' language abilities. The MacArthur-Bates Communicative Development Inventory (MCDI, Fenson et al., 1993) was administered at 18 months and again at 29 months. At these ages, the MCDI is a parent checklist

that measures expressive vocabulary size. It should be noted that because F3 was exclusively Mandarin Chinese speaking, a Mandarin Chinese version of the MCDI was used for her. F1 and F4 were not available for testing at 29 months of age and therefore, MCDI scores from only 8 participants are available at that age.

The Preschool Language Scale (PLS-4, Zimmerman et al., 2002) was administered to 7 of the 10 participants at 30 months. F1 and F4 were not available for testing at 30 months, and F3, who lives in a Mandarin Chinese-speaking home, could not complete the assessment as a Mandarin Chinese version of the PLS-4 was not available. While the PLS-4 tests both expressive and receptive language, only the expressive portion was used in analysis because correlations between gaze directedness categories and receptive language scores were not expected. For all three tests, raw scores were converted to standard percentile ranks.

CHAPTER 3
RESULTS

Development of Directedness

A total of 5,080 utterances were analyzed for directedness. Because the majority of sessions had equal numbers of utterances, approximately 100 utterances each (mean=101.6; range=58-117), the frequency of utterances in each category of gaze directedness was used in the analysis, rather than the proportion. The results were averaged across the three sessions analyzed for 6 months and the two sessions analyzed at 9 months because infants are known to be highly variable in their behaviors at these young ages. Individual data for gaze directedness appear in Table 2 and group data are provided in Figure 1. As is evident from Figure 1, infants consistently vocalized towards objects more than any other category at both ages. No apparent differences between the relative frequencies of categories of directedness were observed from 6 months to 9 months. However, it was interesting to note that even at 6 months of age, the infants were already directing their vocalizations towards something nearly 80% of the time.

A two-way repeated measures analysis of variance was used to analyze the data. The two within-subjects variables used in this analysis were category of directedness (person, object, mirror or not directed) and age (6 months and 9 months). For the purposes of analysis, similar categories were combined. “DrPerson” and “DrFace” were combined under “Person” and “ToOther”, “ToBook”, and “ToToy” became “Object.” “EyesClos” and “CantSee” were combined under “CantTell”; however, this category was not included in analysis as it compromised less than 5% of all the utterances. Normality was determined using the

Kolmogorov-Smirnov test of normality and only the category of mirror at 9 months of age approached significance. This was to be expected as some infants never vocalized towards the mirrors and others looked at it much more often. Given these results, no transformation of the data was conducted.

The ANOVA values for main and interaction effects of category of directedness and age can be found in Table 3 in the appendix. There were no interaction effects between age and category of directedness. There was also no main effect of age, which indicates that there was not a change in use of the various directedness categories from 6 months to 9 months. However, there was a main effect of directedness category. This means that there were significant differences between the frequencies of utterances in each gaze directedness category. A post-hoc paired t test analysis was conducted to determine which of the categories differed significantly from the others (see Table 4). The significance values which appear in table 4 were divided by the number of possible pairs (6). Of the six possible pairs of directedness categories, four differed significantly from each other. Person and object, object and mirror, object and not directed and mirror and not directed all differed significantly from each other. There was not a significant difference between person and mirror, or person and not directed.

Directedness and Later Expressive Language

Scatterplots were created to examine the associations between the frequencies of each category of directedness and the scores from each assessment. Frequencies of directedness categories were averaged across the two age points of 6 and 9 months because the ANOVA determined that the two ages did not differ significantly from each other. R^2 values were also computed for each possible comparison, e.g., Person directedness category with MCDI scores at 18 months of age, Object directedness category with MCDI scores at 29 months of age. Figure 2

is an example of one such comparison. It shows the correlations between the frequency of undirected vocalizations and the PLS scores at 30 months of age. The R^2 value for the correlation of this pair, 0.445, was the highest correlation that was obtained for the entire data set. R^2 values for the entire data set ranged from 0.0035 to 0.445 indicating that none of these relationships had strong correlations. When significance testing was conducted, none of these correlations approached significance.

Onset of Canonical Babbling and Later Expressive Language

The age of onset of CB for each participant can be found in Table 5. The average age of onset of CB was 8.22 months, and ranged from 7.45 to 9.22 months. The language scores from the MCDI and expressive scores from PLS-4 were used to analyze relationships between age at onset of CB and later expressive language. Scatterplots were used for this analysis as well, plotting the age at onset of CB against the scores from each assessment and R^2 values were calculated. R^2 values ranged from 0.03 to 0.15 indicating no more than weak correlations between the two variables.

CHAPTER 4
DISCUSSION

Directedness

The primary objective of this study was to analyze the development of directedness in infancy and to determine what relationships may exist between directedness and later expressive language abilities. A secondary purpose was to examine a possible link between earlier onset of CB and those same expressive language abilities.

Development of Directedness

It was found that, on average, 77% of the utterances produced by the infants were directed towards people, objects, or mirrors. Given the young ages investigated, it is impressive that the infants are able to attend to people and objects while vocalizing with this degree and consistency. Additionally, the target of these directed vocalizations was most frequently objects. In fact, vocalizations directed towards objects accounted for nearly half of all utterances. This may be because the infants are exploring their environment or because they are vocalizing towards objects in an attempt to initiate joint attention with their caregiver or comment on an object.

No changes in directedness with age were, however, observed. The ages analyzed, 6 months (bin of 5-7 months) and 9 months (bin of 8-10 months) were chosen because they occurred just before and just after the point at which infants' vocalizations are expected to become intentional (Bates et al., 1975). It was therefore, expected that during this transitional period, changes in the directedness of infant vocalizations may similarly occur. The lack of any

significant changes in directedness suggests that either the two constructs or not related or perhaps the development of directedness lags that of intentionality. Furthermore, because data were averaged from sessions at 5-7 months to obtain the 6-month data and 8-10 month sessions were averaged to obtain the 9-month data, the 6- and 9-month sessions might have even been closer in time than necessarily three months apart and would not be sufficient to reveal changes in directedness. Perhaps, if the two age ranges for the sessions had been father apart and beyond 9 months of age, a more distinctive change in gaze directedness might have been observed. Alternatively, using only the data from the first and last session (rather than using all sessions within the age ranges) for analysis may reveal significant changes with age.

Another possibility is that the categories of directedness as defined in this study may need to be adjusted or refined. While infants consistently vocalized the most towards objects, their motivations for vocalization towards objects may have changed with age, which was not captured with the directedness categorization procedures. For instance, it could be that younger infants vocalize towards objects because they are exploring their environment, while older infants vocalize towards objects in response to an adult's comments on the object or as a way to direct the adult's attention to the object. The latter would reflect more intentional communication, so it may be necessary to differentiate the categories in order to get a more accurate picture. In the present study, the audio was muted to avoid any bias from the sound recordings thereby making this distinction between object exploration and intentional communication even more difficult. Perhaps if instances of joint attention had also been coded to make this distinction, a change would have appeared. This could easily be added in future research by examining the utterances directed towards objects and people to see if the infant looked at a person or object respectively just before or after the utterance.

A third obvious possibility is that only 10 infants were included in the study. Had more infants been included at each age, a developmental trend, if it existed, might have been more apparent. Finally, perhaps while infants may not change in their tendencies towards particular categories of directedness with age, the variability between infants may decrease with age. This was not observed, as the standard deviations for each category did not decrease noticeably and consistently from 6 to 9 months.

Directedness and Later Expressive Language

The hypothesis that infants who directed more of their vocalizations towards people and were therefore considered to be more interactive would have better expressive language outcomes was not supported by the data. The results also did not show any correlations between any of the other categories of directedness and expressive language scores. One promising trend in the results was that greater frequencies of undirected vocalizations were associated with lower language scores. This trend suggests that directedness of any sort, whether toward people or objects, may be more critical than directedness towards people specifically. However, the absence of statistical significance does not allow us to make any conclusions regarding directedness in infancy and later language scores. The absence of correlations could be a genuine finding, or it may be that some aspect of the study design confounded the results.

As with the development of directedness, the small sample size was even more of a concern here. The CDI scores at 29 months were available only for eight infants and the PLS-4 scores at 30 months were available only for seven infants. Thus, the subset of infants analyzed for these correlations was even smaller than the original sample size of 10 infants. It is possible that the tendency toward a negative correlation between undirected vocalizations and later language scores might be more evident with larger sample sizes.

Another concern was that all infants did not spend equal proportions of time with adults present in the recording booth. Because only the most voluble portion of the session was analyzed until 75-100 utterances were obtained, the segment of the session that was analyzed varied across infants, such that some segments included infants playing alone, whereas other segments included the infant interacting with the caregiver, and/or included the infant when the experimenter was interviewing the caregiver. This may have affected the results of the correlations between person-directed utterances and expressive language measures because perhaps the infants who spent less time with adults present had fewer opportunities to vocalize towards people. This, however, did not appear to be the case as for the majority of the infants, 70% of the sessions analyzed included a segment in which the infant was in the presence of adults and thereby had ample opportunity to vocalize towards people. The three infants who spent less than 80% of the time in the presence of adults (F1, F3, F4) all had average to low expressive language scores. Therefore, even if they had vocalized more towards people as the result of an increased opportunity, the correlation between person-directed vocalizations and expressive language would have shifted even farther away from the expected result. Having more time spent alone could have also caused these infants to have more undirected vocalizations than the other infants. Since the frequencies of undirected vocalizations for F1, F3, and F4 were in the middle of the range of frequencies for all babies, this did not appear to be the case.

Additionally, the portions of sessions selected for judgment were chosen because the infant was most vocal during that time. Therefore, the infants with lower proportions of time spent with adults vocalized less when in the presence of adults and more when alone, further supporting the results regarding weak correlations between increased frequency of person-

directed utterances and increased expressive language scores. Another issue may be that the assessments used to measure expressive language may not have measured what they were intended to measure. It may be the case that frequency of person-directed vocalizations could correlate with assessments that measure different, perhaps more specific, aspects of expressive language. Because the frequency of person-directed vocalizations was intended to represent the infants' desires to be socially interactive, future research may want to include measures that specifically look at correlations with pragmatic language skills, rather than expressive vocabulary or overall expressive language scores.

Onset of Canonical Babbling and Later Expressive Language

The age of onset of CB varied from 7.45 to 9.22 to months of age across the 10 infants . These ages for onset are within typical age ranges, as previously reported by Oller (1995), thus providing confidence in our measurements of the onset of CB. The results comparing age at onset of CB to later MCDI and PLS-4 scores, however, failed to confirm the finding by Oller et al. (1999) that infants with later onsets of CB had lower MCDI scores at 18 months. The glaring difference between the two studies was the characteristics of the participants. The Oller et al. (1999) study used 12 late babblers and 13 control participants who were all considered "at risk" for language disorders and delays, while the current study included only typically developing infants. It may be that this relationship is significant only for children at risk for developing speech and language disorders.

Other investigations of the relationship between CB and expressive language have not found a positive correlation (Oller, 1998), so it is possible that these results are a genuine finding. It may be the case that onset of CB alone is not enough to predict vocabulary and expressive language development as there are many more factors, e.g., the knowledge that

consistent phonetic forms can be used to reference people, places, or events, that can influence language abilities, as hypothesized by Oller (1998). Perhaps age at onset of CB may have also been a more reliable indicator of speech skills and if a specific speech production measure had been included instead, e.g., articulation test scores, because canonical babbling examines the ability to rapidly sequence consonants and vowels in speech production.

Future Directions

Additional research obviously needs to be conducted before any conclusions can be drawn about directedness, canonical babbling, and later language. Larger sample sizes are required to increase statistical power and the inclusion of participants from more diverse backgrounds is necessary to allow results to be generalized to other populations, e.g., different SES levels. The modifications in ages analyzed, e.g., choosing ages that are father apart, and assessments administered, e.g., assessing pragmatic skills specifically, may help to obtain different results or further confirm the results from the present study. It may also be helpful to reduce the number of utterances included in analysis to only those that are produced above a given loudness threshold and that are clearly produced on purpose in order to eliminate utterances with less intention. By only investigating the utterances with obvious intention (those utterances which the infant appears to making purposefully and with some motivation or reason) different patterns of gaze directedness may be revealed. Another alteration to the analysis that may prove helpful is to use the bootstrapping scheme used by Yale et al. (2003). This procedure creates simulated sessions from the available data and determines whether the probability of a vocalization and a given behavior (e.g., directing gaze towards a person) occurring simultaneously is greater than that expected by chance. However, based on the results of this

study, it has been concluded that there is no relationship between directedness or onset of canonical babbling and later expressive language skills.

Table 1

Participant Demographic Information

Participant	SES	Parent Language	Bayley Scores (MDI)
F1	1	English	111
F2	1	English and Hindi	99
F3	1	Mandarin	102
F4	1	English	107
F5	2	English	113
M1	1	English	111
M2	1	English	102
M3	2	English	96
M4	2	English	96
M6	1	English	105

Note. F = Female, M = Male. SES 1: both parents have completed college, professional or high level management employment, stable two-parent homes and SES 2: at least one parent has completed college, white collar, middle management, two-parent homes. Bayley scores were obtained at 12 months of age, MDI = Mental Development Index.

Table 2

Frequencies of Utterances in Various Categories of Directedness for Individual Participants at 6 and 9 Months of Age

Participant	Person	Object	Mirror	NotDir	Person	Object	Mirror	NotDir
	6 months				9 months			
F1	0.33	61.67	16.00	21.33	7.00	47.00	41.00	12.00
F2	22.00	59.33	0.00	19.33	37.00	48.50	0.00	14.00
F3	14.00	39.33	4.33	33.33	15.00	51.00	3.50	20.00
F4	21.67	60.33	0.00	16.00	15.00	56.50	3.00	23.00
F5	25.33	42.00	0.00	20.67	22.50	55.50	0.00	21.50
M1	3.00	60.33	12.67	23.33	8.00	56.00	30.50	5.00
M2	46.33	12.33	11.33	29.00	25.00	39.50	20.50	15.00
M3	28.67	37.33	0.00	38.00	17.00	72.00	0.00	17.50
M4	32.00	41.33	3.67	19.67	23.00	49.00	3.00	27.00
M6	16.00	42.67	16.33	27.00	28.00	46.50	12.00	14.00

Table 3

Analysis of Variance for Directedness Category and Age

Source	Sig.	Partial Eta Squared
Directedness	0.000	0.752
Age	0.128	0.238
Directedness * Age	0.104	0.201

Table 4

Paired Samples Test Comparing Various Categories of Directedness

		Paired Differences (95% Confidence Interval of the Difference)				
		Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	Person - Object	-41.34235	-15.78965	-5.058	9	0.000167
Pair 2	Person - Mirror	-1.52091	24.42091	1.997	9	0.012833
Pair 3	Person - NotDir	-7.21164	6.22864	-0.165	9	0.145333
Pair 4	Object - Mirror	29.40448	50.62752	8.531	9	0
Pair 5	Object - NotDir	19.54612	36.60288	7.447	9	0
Pair 6	Mirror - NotDir	-21.42043	-2.46257	-2.850	9	0.003167

Table 5

Age at Onset of CB and Expressive Language Scores

Participant	Onset of CB (months of age)	MCDI (percentile rank) 18 months	MCDI (percentile rank) 29 months	PLS (percentile rank) 30 months
F1	7.45	32	------	----------
F2	9.59	5	17	79
F3	7.98	53*	10*	----------
F4	7.68	30	------	----------
F5	8.77	65	30	70
M1	8.87	65	56	99
M2	7.19	45	33	55
M3	7.55	30	66	47
M4	7.91	80	41	96
M6	9.22	67+	47	79

Note. * Mandarin version of MCDI used, + signs and words included

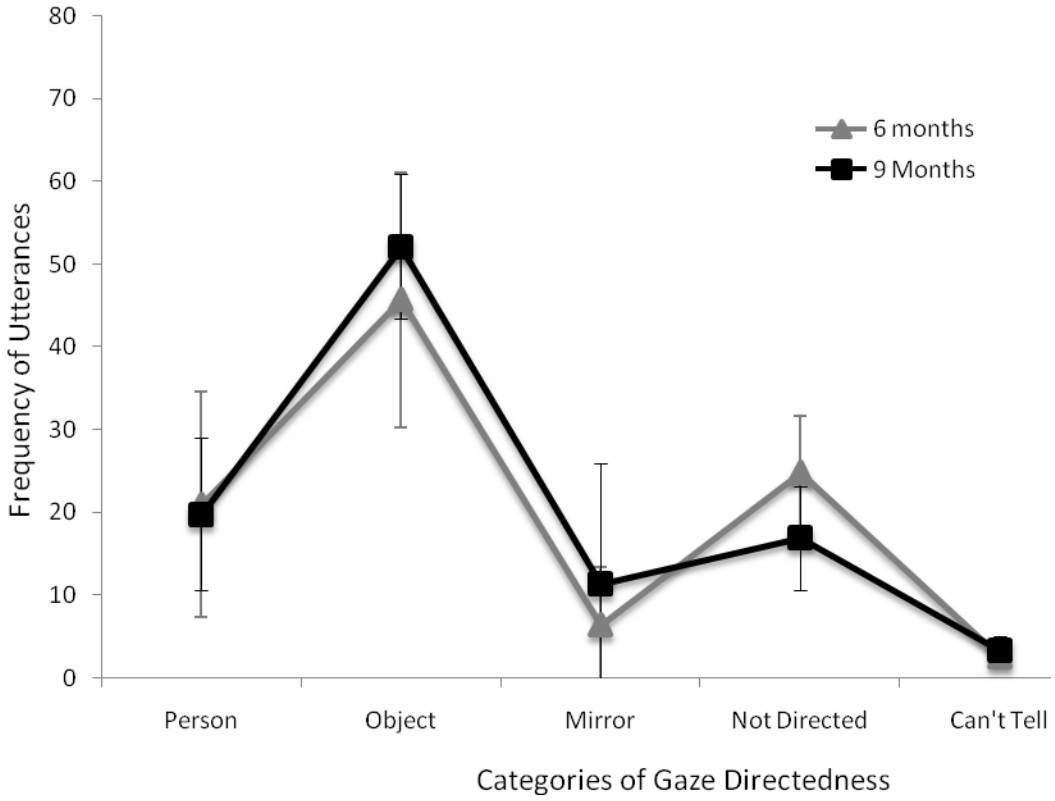

Figure 1. Mean frequencies (and standard deviations) of utterances in various gaze directedness categories at 6 and 9 months of age

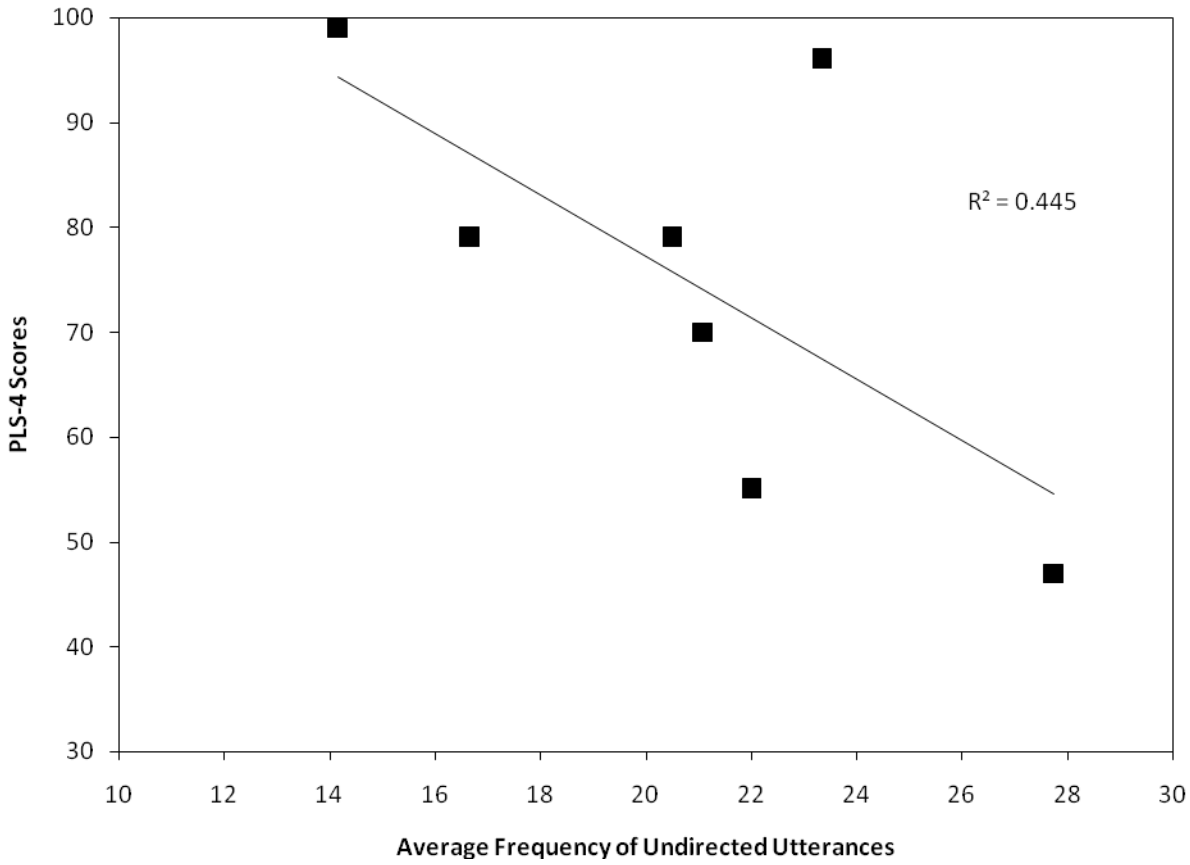

Figure 2. Scatterplot examining associations between frequency of undirected utterances (average of 6 and 9 months) and expressive PLS-4 scores at 30 months of age.

APPENDIX

Categories of Directedness

Directedness Category	Description
DrFace	the child is looking at another person's face
DrPerson	the child is looking at another person's body
ToToy	the child is primarily looking at a toy
ToMirror	the child is looking at a mirror
ToBook	the child is primarily looking at a book
ToOther	the child is primarily looking at an object other than a toy or book
NotDr	child is looking into space, with no visual target
EyesClos	the child's eyes are closed throughout the utterance
CantSee	you cannot see the child well enough to be able to make any judgment about gaze direction

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