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Quantity and Quality of Infant Vocalizations as they relate to Later Vocabulary Development

by

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Quantity and Quality of Infant Vocalizations as they relate to Later Vocabulary Development

Thesis Abstract–Idaho State University (2018)

This study attempted to characterize the relationship between the quality and quantity of infant vocalizations and expressive/receptive vocabulary development in early childhood. Archived data from 15 parent/infant dyads was explored. Infant vocalizations from 8, 12, and 16 months of age were tallied (quantity) and coded as vegetative, reflexive, non-canonical, canonical, or linguistic (quality). Expressive/receptive vocabulary was obtained from the *MacArthur-Bates Communicative Development Inventories* (CDI) at 1, 2, and 3 years. Correlation and multiple regression analyses were conducted to examine the relationship between criterion and predictor variables. As the number of infant vocalizations increased, the size of expressive/receptive vocabularies increased at later ages. The more complex the infant vocalizations, the larger expressive/receptive vocabulary was at later ages. As expected, higher quantity and quality of infant vocalizations at 8, 12, and 16 months resulted in increased expressive/receptive vocabulary at 1, 2, and 3 years.

Key Words: quantity and quality of infant vocalizations, infants, vocal development, phonological development, vocabulary development, expressive vocabulary, receptive vocabulary, infant vocalizations, speech language pathology

Quantity and Quality of Infant Vocalizations as they relate to Later Vocabulary Development

Vocabulary development is intricately linked with language acquisition and academic success[1], as a well-developed vocabulary is necessary for literacy comprehension and communication as a whole (Moghadam, Zainal, & Ghaderpour, 2012). The rate of growth and size of vocabulary varies dramatically for toddlers (Cartmill et al., 2013; Mayor & Plunkett 2011; Rowe, Özçalişkan, & Goldin-Meadow, 2008). According to normative data, children in the 10th percentile for vocabulary have developed an average of 560.2 words by 30 months of age, while children in the 90th percentile display a drastically larger vocabulary of 2032.9 words by 30 months (Mayor & Plunkett, 2011). Many aspects of an infant's development are responsible for this variability in vocabulary development and can be indicators of vocabulary size in childhood, including: parental interaction, gender, mobility during the first year of life, and non-verbal communication (Mayor & Plunkett, 2011; Rowe et al., 2008). For speech-language pathologists, increasing the evidence-based knowledge available regarding factors that

[1] Vocabulary and language development are associated with social success, as young people with a history of language difficulties are likely to enter adolescence with less social confidence as compared to their peers (Durkin, Toseeb, Botting, Pickles, & Conti-Ramsden, 2017). Language is the principal tool used for learning and interacting with peers, so those lacking in language and communicative skills miss out on opportunities to connect with others and often learn at a different pace than their peers who are typically developing. Persisting difficulties may include "social withdrawal, reticence, and difficulty joining groups of peers," (Brownlie, Bao, & Beitchman, 2016, p. 1061). Social and emotional problems and differences can be seen as early as preschool age (Vissers & Koolen, 2016). Studies have shown that those with a history of language difficulties and disorders are more likely to have emotional health problems in adulthood when compared to age matched peers (Botting, Durkin, Toseeb, Pickles, & Conti-Ramsden, 2016). Other studies have found that students with expressive-receptive language disorders had significantly poorer academic achievement and concomitant learning disabilities than students without language disorders (Benner, Mattison, Nelson, & Ralston, 2009).

contribute to vocabulary size could lead to earlier identification of language delay/disorder as well as more comprehensive early intervention approaches.

Prelinguistic behaviors (vocalizations and non-verbal gestures that occur prior to the production of first words) have been shown to be predictors of later language abilities (Fasolo, Majorano, & D'Odorico, 2008; Oller, Eilers, Neal, & Schwartz, 1999; Sotto, Redle, Bandaranayake, Neils-Strunjas, & Creaghead, 2014; Watt, Wetherby, & Shumway, 2006), but this knowledge has not been leveraged to the full extent possible for clinical use. The clinical challenge lies in identifying infants and toddlers who may be at risk of future speech and language difficulties (Määttä, Laakso, Tovanen, Ahonen, & Aro, 2012). Identification is difficult because normal vocal development is variable and unstable both within and across children (Fenson et al., 2000). Adding further complication, the methodology used to study prelinguistic infant vocalizations has been cumbersome and tedious. Implementing more efficient procedures for documenting infant vocalizations has the potential to enhance the clinical utility of infant babbling as an important clinical marker.

While early fricative and other consonant use is a predictor of earlier expressive language production (Sotto, Redle, Bandaranayake, Neils-Strunjas, & Creaghead, 2014), late onset babbling is a red flag for speech and language disorders and smaller productive vocabularies (Oller et al., 1999). Few studies cover both quantity and quality of infant vocalizations and their relationship with later vocabulary development. For the purposes of this project, quantity is defined as the total number of utterances produced, while quality is defined as the type of utterances produced (e.g., vegetative, reflexive, non-canonical, canonical, or linguistic). Previous research has shown that delayed babbling and other prelinguistic skills result in delayed expressive language development (Oller et al., 1999; Watt, Wetherby, & Shumway, 2006), but

continued research in this area is critical because it may lend perspective into speech and language development. This perspective may provide early diagnostic information for identifying infants at risk for later speech and/or language delay/disorder.

Quantity and Quality of Phonological Development

As vocalizations and phonology emerge, it is difficult to distinguish between developmental milestones of quality and quantity as they are often intertwined and related. The quality of vocalizations refers to the form or type of the vocalization (such as whether the vocalization is vegetative, babbling, linguistic, etc.), while the quantity of vocalizations can refer to the number of vocalizations produced.

During assessment of infant vocal development, speech-language pathologists and other trained professionals classify infant sounds in a variety of ways, such as using the Stark Assessment of Early Vocal Development-Revised (SAEVD-R). The SAEVD-R outlines 23 different vocalization types placed within five developmental levels according to the average age of predicted emergence in typically developing children (Nathani, Ertmer, & Stark, 2006; Yeni-Komshian, Kavanagh, & Ferguson, 1980; see Appendix A for SAEVD-R Table). The SAEVD-R was evaluated for validity/reliability in a cohort of 30 infants that were normed for socioeconomic status (SES) and gender. Infants with hearing loss and atypical developmental histories were not included in the normative data (Nathani et al., 2006), given that these populations can experience atypical speech and/or language development.

The first developmental level presented in the SAEVD-R is the *Reflexive Level* which primarily includes crying, fussing, and vegetative sounds (cough, sneeze, burps, and sounds of discomfort). These sounds are typically produced from birth to 2 months of age. Reflexive sounds are produced as a response to a physical state or stimuli (Nathani et al., 2006). Quasi-

resonant nuclei are also produced during this time. Quasi-resonant nuclei are "faint, low-pitched grunt-like sounds with muffled resonance" that cannot be classified as adult vowel productions (Nathani et al., 2006, p. 17).

The second level, between 1 to 4 months of age, is the *Control of Phonation Level*. Fully resonant nuclei are present during this stage, which are longer and vary more across frequencies than quasi-resonant nuclei (Nathani et al., 2006). In this stage, vowel-like segments are combined with consonant-like segments resulting in marginal babbles. Raspberries, chuckles, and sustained laughter occur as well (Nathani et al., 2006).

The third level is *Expansion*, which takes place from 3 to 8 months of age. This level includes the production of isolated vowels, combinations of vowels, vowel glides, squeals, and marginal babbling. Vowels can be transcribed as adult sounds and are more resonant and longer than quasi-resonant nuclei and fully-resonant nuclei. Vowel-glides are vowel segments where a change in pitch or quality occurs in the sound with no audible gap between the vowel parts. Squeals are high-pitched sounds (Nathani et al., 2006). Marginal babbling includes vowel and consonant segments together or a series of segments with prolonged or slow transitions between the sounds.

Basic Canonical Syllables is the fourth level, occurring between 5 to 10 months of age. By this stage, a child will be able to produce single consonant-vowel syllables (CV), canonical babbling, whispers, CV combinations followed by an isolated consonant, and disyllables (Nathani et al., 2006). A single CV syllable is an isolated syllable starting with a consonant followed by a vowel. Canonical babbling can be reduplicated, repeated productions of the same CV, or non-reduplicated, different CV productions, or combinations in a series. Canonical babbling is made up of clearly articulated consonants, fully resonant vowels, and timely

transitions between the two. Whispers are produced with no voicing. Disyllables are a sequence of two CV syllables with an audible pause in between each CV syllable (Nathani et al., 2006).

The last level presented in the SAEVD-R developmental scheme is *Advanced Form* that ranges from 9 to 18 months of age. By this time, the following skills may be present: complex syllables, jargon, and diphthongs. Complex syllables are single syllables that have constant stress and intonation, and combinations other than CVs, such as "VC, CCV, CCVC, etc." (Nathani et al., 2006, p. 369). Jargon is defined as "a series of syllables with at least two different Cs and Vs with a changing stress and/or varied intonation pattern within the series" (Nathani et al., 2006, p. 369). Jargon often sounds like a child having a conversation with proper intonation and stress, but with non-words and syllables. Diphthongs are vowel pairs with rapid transitions between two vowel sounds, forming one sound.

Some terms from the SAEVD-R will be used to categorize infant vocalizations in terms of quality for the present project: reflexive, vegetative, non-canonical, and canonical. The term linguistic vocalization will also be used to define any utterance that is perceived as a word by an unfamiliar listener. The purpose of doing so is to explore how such vocal variety impacts later vocabulary development.

Vocabulary Development

By the time children begin to acquire a vocabulary, they have already been exposed to copious language and have had a wide range of individual experiences. Early expressive and productive vocabularies are fairly similar across children, despite different backgrounds and ambient language environments. However, vocabulary acquisition in children is dependent on many different factors such as: phonological development, cognitive development, and language input (Gleason, 1989). Children are more likely to produce vocabulary words that include

favored sounds and sound patterns that are easier to produce (Ferguson & Farwell, 1975; Owens, 2012). Children develop expressive and receptive vocabulary at differing rates, with perception preceding production (Owens, 2012).

Receptive vocabulary. Signs of comprehension, or receptive language, can be seen as early as 4 or 5 months of age, but a considerable amount of comprehension is usually observed at 10 to 11 months of age. A child shows comprehension by reacting differently to certain words or phrases. This shows that the child can differentiate between sound patterns and has placed meaning according to those patterns (Bernthal & Bankson, 2004). Owens (2012) states that discriminating between phonological, or sound patterns can be seen around 8 months of age. Comprehension of words is holistic at first, with infants able to understand phonotactically different words like "book" and "cracker". Eventually infants attain the skills needed to discriminate between single syllables and words that differ minimally, such as by one phoneme, like "lid" versus "lip". Furthermore, infants are responsive to word boundaries and phonological patterns by 11 months of age (Owens, 2012).

Infants begin to comprehend familiar words, or words that are heard more often, before comprehending rare words, or words used infrequently (Benthal & Bankson, 2004). In the beginning stages, comprehension is highly contextual. For example, an infant may repeatedly respond to, "time for a bath," while being undressed and placed in a bathtub filled with water. Repeatedly contextual and concrete utterances, words, and routine scripts are understood first. Symbolic word understanding expands and develops through the second year of life (Owens, 2012). During this time, children learn words or phrases that belong to a specific referent. For example, the word "kitty" may refer to all "cats", where the "cat" is the referent. The word "kitty" is arbitrary, meaning there is nothing about a "cat" that relates to the sound combinations

that make up the word "kitty". This arbitrary relationship between word and referent is symbolic and children increase their capacity to learn new words for referents as they hear and understand more vocabulary (like a snowball growing larger and larger as it continues to roll down a snowy hill - Gleason, 1989; Owens, 2012).

Expressive vocabulary. Following the above SAEVD-R stages of vocal development through advanced forms, protowords and true words begin to emerge after a child's receptive vocabulary has begun to form. Protowords are "productions with some phonetic and semantic consistency", which differ from babbling, as babbling is not produced with a consistent referent (Yavas, 1998). Protowords differ from true words in that they do not resemble the adult target words (Yavas, 1998). A child's first word may emerge between 11 and 13 months (Shulman & Capone, 2012), with overlap between babbling, protoword, and real word productions common at the end of the first year. During this transition period between babbling and talking, a child is learning to link sound patterns with meaning, first in comprehension, then in production (Bernthal & Bankson, 2004). The transition between babbling and first words typically ends when the child can produce 50 spontaneous words; most often occurring between 9 to 18 months of age and occasionally up to 2 years (Bernthal & Bankson, 2004; Owens, 2012). The initial 50-word lexicon predominately consists of general nouns at nearly 51% of the child's vocabulary (Shulman & Capone, 2012).

Children continue to absorb language and develop their expressive abilities through the models of those around them. As children transition from single word productions to multiple word productions, they often exhibit "selective imitation" in which a child will only repeat part of an utterance. Although it seems unexpected, selective imitation actually facilitates vocabulary growth because it scaffolds by simplifying longer and more difficult utterances to utterances and

vocabulary that are more age and developmentally appropriate (Owens, 2012). Early words are used to make various requests, comment on the location of items, ask basic questions (such as "what" and "where"), apply an attribution to an object (e.g., "cold" or "big"), use greetings (like "hi" and "bye"), and affirm or negate ("yes" or "no" - Tomasello, 2006). Typically, two-word utterances emerge when a child has at least 50 words in their repertoire, which occurs around 18 months of age (Owens, 2012; Shulman & Capone, 2012).

Between 12 to 24 months of age, an infant's expressive vocabulary learning is primarily influenced by event-based knowledge and routines (Owens, 2012). For example, reading a book or getting fed involves certain roles, scripts, and repetitive utterances in a contextualized setting. A child will use "hypothesis-testing" to form hypotheses to entities that are labeled by adult speakers. The child will then use the label as the adult oversees the child's accuracy and provides reinforcement or feedback (Owens, 2012). Hypothesis-testing facilitates comprehension as well. Children also use "interrogative utterances" (e.g., "what" or "what's that") to gain further knowledge on an entity by asking what the entity is, pointing, or vocalizing (Owens, 2012).

The more vocabulary a child acquires and produces, the higher their mean length of utterance (MLU) will most likely be. Nelson (1973) found a correlation between vocabulary size at 2 years of age and MLU at 30 months of age. Not only does more vocabulary and word knowledge mean longer sentences, but a child's vocabulary and utterance length expands upon learning new function words and semantic categories. For example, when a person learns new function words, like conjunctions and prepositions, they are able to join new phrases and sentences together and expand topics further. Furthermore, learning new adjectives and adverbs allows for expansion of noun and verb phrases. A positive correlation has been found between

MLU and the number of different words a child can produce (a measure of vocabulary quality and diversity; Miller, 1991; Dethorne, Johnson, & Loeb, 2005; Ukrainetz & Blomquist, 2002).

Purpose

Our interest in receptive and expressive vocabulary development derives from its previously stated link with language acquisition and academic success. The *long-term goal* of the present work is to determine predictors of language development and how clinicians can meaningfully intervene earlier, in the prelinguistic stage, to promote language development and aid in future social and academic success. Given the strong connection between vocabulary development and later language ability, we look to predictors of vocabulary growth. The present proposal aims to evaluate the relationship between the quantity and quality of early infant vocalizations and later vocabulary development. The *objective* is to determine how infant vocalizations relate to expressive and receptive vocabulary development in a cohort of infants who are typically developing. The *central hypothesis* is that greater quality and quantity of infant vocalizations from 7 to 18 months of age will be related to larger expressive and receptive vocabularies in the same children at 1, 2, and 3 years of age. The hypothesis has been formulated from documentation that canonical babbling and early infant vocalizations are precursors to later speech and language development (Oller et al., 1999; Watt et al., 2006), and that the earlier an infant makes well-formed utterances, the earlier he/she develops speech and language (Sotto, Redle, Bandaranayake, Neils-Strunjas, & Creaghead, 2014). The *rationale* for the proposed research is that if the quantity and quality of early infant vocalizations are a predictor of later vocabulary development, we can incorporate this knowledge into clinical practice and potentially facilitate earlier intervention of children at risk for later speech and/or language delay/disorder.

The central hypothesis will be tested through the following *aims.* With 15 children who are typically developing, we will determine the impact of the quality and quantity of prelinguistic vocalizations at 8, 12, and 16 months of age on: *Aim 1*. Expressive vocabulary at 1, 2, and 3 years of age, and *Aim 2*. Receptive vocabulary at 1 year of age. Based on previous findings supporting the positive relationship between the quality of infant vocalizations and expressive and receptive vocabulary development, the working hypothesis for Aims 1 and 2 is that greater diversity of quality and quantity in infant vocalizations at 8, 12, and 16 months will result in larger expressive and receptive vocabularies, respectively, at 1, 2, and 3 years of age.

We expect outcomes for the aims to demonstrate that quality and quantity of infant vocalizations directly impacts expressive and receptive vocabulary development. If the central hypothesis is correct, it could mean that intervention to increase the quantity and quality of infant vocalizations in children who are at risk will help facilitate receptive and expressive vocabulary development. These results would have an important positive impact by informing researchers and clinicians about factors that are impacting later development. Strategies to facilitate vocabulary development based on increasing quantity and quality of early infant vocalizations can then be established.

Methods

Participants

Participants came from a cohort of 15 parent/infant dyads, who participated in a longitudinal research study (at East Carolina University) from 7 to 18 months of infant age under the direction of Dr. Heather L. Ramsdell-Hudock. Research advertisements were sent to addresses (obtained from publicly available Register of Deeds records at the Pitt County Court House in Greenville, NC) of families with infants born between November, 2010 and March,

2011. Interested families were interviewed, and details of the study, along with informed consent, were discussed. Inclusion criteria for the study consisted of caregivers who experienced normal pregnancies and no significant history of prenatal or perinatal problems; infants not at risk for developmental disorders; families where English was the primary language spoken in the home; families who were able to travel to the laboratory monthly; and families who did not expect to move away from the surrounding area within 2 years of beginning participation in the study. Families received $98.00 in the form of mercantile gift cards as incentive for every 2 months of participation in the study.

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

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

incomplete. Two of the infants received bilateral myringotomy and pressure equalization tubes during enrollment in the study.

Materials and Procedure

The University and Medical Center Institutional Review Board at East Carolina University approved the study prior to data collection. All caregivers gave voluntary informed consent for participation in the study. Exemption was also obtained from the Human Subjects Committee at Idaho State University, as the purpose of the present study was covered in the original consent. Parent/infant dyads were followed over a 12-month longitudinal period through weekly interviews and monthly recordings.

Laboratory setting. Infants and caregivers came to the lab at East Carolina University once a month for hour-long recordings for 12 months. During recordings, caregivers were instructed to play with their infants, and interact as they would typically do in a home setting. 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, an infant vest housed 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. During 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.

Infant vocalizations. For the current project, we analyzed data from the middle 20 minutes of each 60-minute recording at 8, 12, and 16 months of age. This yielded a total of 45 twenty-minute recordings. Infant vocalizations were coded by trained laboratory staff (graduate and undergraduate students in the Department of Communication Sciences and Disorders) under the direction of Dr. Heather L. Ramsdell-Hudock in the Infant Vocal Development Laboratory at Idaho State University. Consensus coding was utilized, with at least 2 of 10 coders working together at all times in case there were questionable boundary placements or code assignments that needed discussion. Further, all boundaries and codes were checked by a third coder prior to inclusion for data analysis.

Utterance location and coding of audio/video recordings was conducted within Action Analysis Coding and Training (AACT, 1996) software that coordinates frame accurate video and audio presentation with real-time acoustic displays in TF32 (Milenkovic, 2001). Utterance location boundaries were used to determine video playback (via Windows Media Player) for coding of infant utterance types. Utterances were located using a breath-group criterion (i.e., each vocalization occurred on a single egressive breath; Oller & Lynch, 1992). Vocalizations containing significant vocal or noise overlay (e.g., toy-related sounds) were not included.

Once utterances were located, they were coded for utterance type. Coding across infants and infant ages was conducted randomly, such that no single coder would sequentially code the same infant or infant age. Generally, laboratory staff were instructed to use as few listening/viewing opportunities as possible before assigning codes (no more than three). The

reason for this instruction was for the researchers to assign codes intuitively based on salient characteristics; the most prominent impression of each utterance was used to determine judgment. Utterance type codes were tallied for each infant age to determine the quantity and quality of vocalizations produced.

To determine the quality of infant vocalizations, utterances were coded as either *vegetative*, *reflexive*, *non-canonical*, *canonical*, or *linguistic*. In line with SAEVD-R classifications, vegetative was coded when an infant utterance contained sounds with no real semantic value, such as coughing, burping, and hiccups. Reflexive was coded when infants were crying or laughing. Non-canonical utterances were those representing marginal babbling: fuzzy sounding consonant and vowel productions with imprecise articulation, slow transitions, and an overall immature sounding (mushy) quality. Canonical utterances, conversely, were coded when well-formed babbling occurred, with fully-resonant nuclei and clearly articulated consonants, timely transitions between the two, and an overall mature sound. Linguistic was coded for any utterance that was interpreted as a word by an unfamiliar listener.

Vocabulary. Parent report has been recognized as both a reliable and valid means of determining speech language development in infants and toddlers (Feldman *et al.*, 2005; Fenson *et al.*, 1994; Heilmann, Ellis Weismer, Evans, & Hollar, 2005; Korkman, Jaakkola, Ahlroth, Pesonen, & Turunen, 2004; Oller, Eilers, & Bassinger, 2001; Rescorla & Alley, 2001). *The MacArthur-Bates Communicative Development Inventory* (CDI) was the parent report measure of vocabulary for the present study (Fenson et al., 1991). The CDI in particular has several studies to back up its concurrent and predictive validity as a measure of vocabulary (Feldman *et al.*, 2005; Heilmann *et. al.,* 2005). In a study by Feldman and colleagues (2005), the CDI was shown to have positive and statistically significant concurrent validity when compared

to three standardized accepted measures of infant language and cognition (e.g., *McCarthy General Cognitive Index*, the *McCarthy Verbal Scale*, and the *Peabody Picture Vocabulary Test-Revised*). A study by Heilmann and colleagues (2005) found the CDI to be positively correlated with the *Preschool Language Scales* III, the number of different words produced by the child according to the *Systematic Language Transcription Analysis* (SALT), and the child's MLU. Results of these studies indicate that the CDI is a valid measure of receptive and expressive vocabulary in toddlers.

Caregivers completed the CDI *Words and Gestures* bi-monthly from 10 to 18 months of infant age, and *Words and Sentences* in follow-up studies at 2 and 3 years of age. The CDI *Words and Sentences* does not provide a measure of receptive vocabulary. Accordingly, we tallied expressive and receptive vocabulary at one year (15 to 18 months), and expressive vocabulary only at two (23 to 27 months) and three (37 to 40 months) years of infant/child age.

Design

Correlation and multiple regression analyses were conducted to examine the relationship between all criterion and predictor variables. Variables of interest are presented in Figure 1. The criterion variables were expressive and receptive vocabulary at 1 ½ years of age, and expressive vocabulary at 2 and 3 years of age. The predictor variables were the quantity of infant vocalizations, the quality of infant vocalizations (e.g., vegetative, reflexive, non-canonical, canonical, or linguistic), and infant age at 8, 12, and 16 months.

Results

The 15 participants produced a total of 4,972 utterances in the middle 20 minutes of 60-minute recordings at 8, 12, and 16 months of age. Further, the raw number of predictor variables (quantity and quality of infant vocalizations across 8, 12, and 16 months of age) are shown in

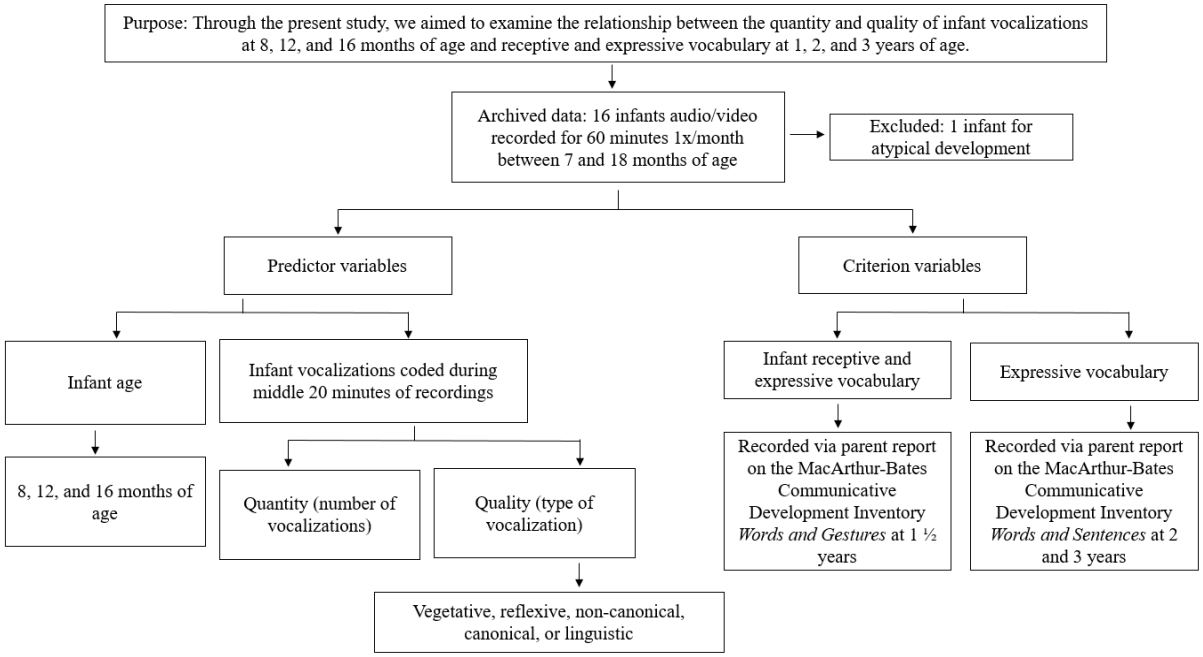

Figure 1. Purpose, participants, and variables of interest.

Table 1. The number of utterances produced, while variable both within and across infants, increased with infant age. With respect to vocal type, approximately 77% of utterances were non-canonical across infant ages. Canonical and reflexive were the next highest produced at 11% and 6%, respectively. Remaining utterances were vegetative and linguistic at 3% and 2% respectively. While the total number of vegetative utterances decreased with increasing infant age, the total number of canonical and linguistic utterances increased with increasing age. Reflexive and non-canonical utterances did not show consistent patterns across age.

Table 1
Number of Utterances per Predictor Variable across Infants

	Age in Months			
Predictor Variables	8	12	16	Total
Quantity of Vocalizations	1437	1752	1783	4972
Quality of Vocalizations				
Vegetative	61	57	36	154
Reflexive	158	72	86	316
Non-canonical	1166	1384	1287	3837
Canonical	46	198	305	549
Linguistic	6	41	69	116

Expressive Vocabulary at 1 ½ Years

Table 2 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.

The multiple regression model with all predictors (excluding non-canonical utterances) at 8 months of age produced $R^2 = 0.169$, $F(5, 9) = 0.366$, $p = 0.859$, at 12 months of age produced $R^2 = 0.223$, $F(5, 9) = 0.516$, $p = 0.759$, and at 16 months of age produced $R^2 = 0.498$, $F(5, 9) = 1.785$, $p = 0.212$. Quantity of infant vocalizations, quality of infant vocalizations (e.g., vegetative, reflexive, non-canonical, canonical, or linguistic), and infant age (8, 12, and 16 months) did not significantly contribute to the multiple regression model for expressive vocabulary at 1 ½ years.

Table 2
Summary Statistics, Correlations, and Results from the Regression Analysis (Dependent Variable = Expressive Vocabulary at 1 ½ years)

Predictor Variables		M	SD	r	Multiple Regression Weights		t	p
Age	Utterances				B	β		
8 Months	Total	95.800	36.261	0.118	0.670	0.296	0.850	0.417
	Linguistic	0.400	1.298	-0.088	-5.394	-0.085	-0.252	0.807
	Canonical	3.067	4.935	-0.302	-6.082	-0.366	-0.873	0.405
	Non-canonical	77.733	32.740	-0.180				
	Reflexive	10.533	10.162	0.243	-0.690	-0.086	-0.231	0.822
	Vegetative	4.067	4.431	-0.123	-0.555	-0.030	-0.078	0.940
12 Months	Total	116.800	56.850	-0.052	0.580	0.402	0.787	0.452
	Linguistic	2.733	4.788	-0.053	-0.239	-0.014	-0.046	0.964
	Canonical	13.200	14.011	-0.048	-0.477	-0.082	-0.257	0.803
	Non-canonical	92.267	50.687	0.268				
	Reflexive	4.800	4.632	-0.050	-10.870	-0.614	-1.250	0.243
	Vegetative	3.800	6.668	-0.269	3.383	0.275	0.914	0.384
16 Months	Total	118.867	47.086	0.199	-0.350	-0.201	-0.498	0.630
	Linguistic	4.600	5.877	0.074	10.673	0.765	2.008	0.076
	Canonical	20.333	13.568	0.085	1.284	0.213	0.575	0.579
	Non-canonical	85.800	37.676	-0.247				
	Reflexive	5.733	5.599	0.289	-11.030	-0.753	-2.551	0.031
	Vegetative	2.400	2.501	-0.444	-17.085	-0.521	-1.723	0.119

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

Receptive Vocabulary at 1 ½ Years

Table 3 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, vegetative utterances at 16 months of infant age were negatively and significantly correlated with receptive vocabulary at 1 ½ years of age, indicating that higher values in this category were related to lower receptive vocabulary. Receptive vocabulary at 1 ½ years of age was not significantly correlated with any of the other predictor variables.

The multiple regression model with all predictors (excluding non-canonical utterances) at 8 months of age produced $R^2 = 0.224$, $F(5, 9) = 0.520$, $p = 0.756$, at 12 months of age produced $R^2 = 0.141$, $F(5, 9) = 0.294$, $p = 0.904$, and at 16 months of age produced $R^2 = 0.777$, $F(5, 9) = 6.278$, $p = 0.009$. As can be seen in Table 2, linguistic utterances at 16 months had significant positive regression weights, indicating that infants who produced more linguistic utterances at 16 months were expected to have higher receptive vocabulary at 1 ½ years, after controlling for other variables in the model. Reflexive utterances at 16 months had significant negative regression weights, indicating that after accounting for linguistic utterances at 16 months, those infants who produced more reflexive utterances at 16 months, were expected to have lower receptive vocabulary at 1 ½ years of age (a suppressor effect). All other predictor variables at 8, 12, and 16 months of age did not significantly contribute to the multiple regression model for receptive vocabulary at 1 ½ years.

Table 3

Summary Statistics, Correlations, and Results from the Regression Analysis (Dependent Variable = Receptive Vocabulary at 1 ½ years)

Predictor Variables		M	SD	r	Multiple Regression Weights		t	p
Age	Utterances				B	β		
	Total	95.800	36.261	0.037	0.408	0.170	0.503	0.627
	Linguistic	0.400	1.298	0.067	8.540	0.127	0.387	0.708
8 Months	Canonical	3.067	4.935	-0.365	-8.957	-0.506	-1.249	0.243
	Non-canonical	77.733	32.740	-0.274				
	Reflexive	10.533	10.162	0.125	2.065	0.240	0.672	0.518
	Vegetative	4.067	4.431	0.018	-1.466	-0.074	-0.199	0.847
	Total	116.800	56.850	-0.330	-0.379	-0.246	-0.458	0.657
	Linguistic	2.733	4.788	-0.173	-2.717	-0.149	-0.466	0.652
12 Months	Canonical	13.200	14.011	-0.166	-0.321	-0.052	-0.154	0.881
	Non-canonical	92.267	50.687	-0.060				
	Reflexive	4.800	4.632	-0.273	-1.614	-0.086	-0.166	0.872
	Vegetative	3.800	6.668	-0.297	0.140	0.011	0.034	0.974
	Total	118.867	47.086	-0.084	-1.222	-0.659	-2.449	0.037
	Linguistic	4.600	5.877	0.035	14.259	0.960	3.780	0.004**
16 Months	Canonical	20.333	13.568	-0.069	2.260	0.351	1.426	0.188
	Non-canonical	85.800	37.676	-0.060				
	Reflexive	5.733	5.599	0.012	-16.885	-1.083	-5.503	0.000***

	Vegetative	2.400	2.501	-.637*	-12.796	-0.367	-1.819	0.102

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

Expressive Vocabulary at 2 Years

Table 4 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, non-canonical utterances at 8 months of infant age were negatively and significantly correlated with expressive vocabulary at 2 years of age, indicating that higher values in this category were related to lower expressive vocabulary. Also, the total number of utterances produced and reflexive utterances at 16 months were positively and significantly correlated with expressive vocabulary at 2 years, indicating that higher values in these categories were related to higher expressive vocabulary. Expressive vocabulary at 2 years of age was not significantly correlated with any of the other predictor variables.

The multiple regression model with all predictors (excluding non-canonical utterances) at 8 months of age produced $R^2 = 0.353$, $F(5, 9) = 0.984$, $p = 0.477$, at 12 months of age produced $R^2 = 0.296$, $F(5, 9) = 0.758$, $p = 0.602$, and at 16 months of age produced $R^2 = 0.562$, $F(5, 9) = 2.313$, $p = 0.130$. Quantity of infant vocalizations, quality of infant vocalizations (e.g., vegetative, reflexive, non-canonical, canonical, or linguistic), and infant age (8, 12, and 16 months) did not significantly contribute to the multiple regression model for expressive vocabulary at 2 years.

Table 4

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

Predictor Variables		M	SD	r	Multiple Regression Weights		t	p
Age	Utterances				B	β		
	Total	95.800	36.261	0.107	1.131	0.238	0.773	0.460
	Linguistic	0.400	1.298	0.239	22.880	0.172	0.575	0.579
8 Months	Canonical	3.067	4.935	-0.313	-8.717	-0.249	-0.674	0.517
	Non-canonical	77.733	32.740	-.523*				
	Reflexive	10.533	10.162	0.250	2.164	0.127	0.391	0.705
	Vegetative	4.067	4.431	-0.075	-16.266	-0.418	-1.225	0.252
	Total	116.800	56.850	-0.115	1.082	0.357	0.733	0.482
12 Months	Linguistic	2.733	4.788	-0.019	-1.397	-0.039	-0.134	0.896
	Canonical	13.200	14.011	0.194	2.447	0.199	0.658	0.527
	Non-canonical	92.267	50.687	0.181				

	Reflexive	4.800	4.632	-0.170	-26.404	-0.709	-1.515	0.164
	Vegetative	3.800	6.668	-0.371	4.968	0.192	0.670	0.519
16 Months	Total	118.867	47.086	.544*	0.805	0.220	0.582	0.575
	Linguistic	4.600	5.877	0.227	18.027	0.614	1.726	0.118
	Canonical	20.333	13.568	0.349	2.221	0.175	0.506	0.625
	Non-canonical	85.800	37.676	-0.259				
	Reflexive	5.733	5.599	.569*	-14.363	-0.466	-1.690	0.125
	Vegetative	2.400	2.501	-0.224	-36.730	-0.533	-1.885	0.092

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

Expressive Vocabulary at 3 Years

Table 5 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, expressive vocabulary at 3 years of age was not significantly correlated with any of the predictor variables.

The multiple regression model with all predictors (excluding non-canonical utterances) at 8 months of age produced $R^2 = 0.368$, $F(5, 9) = 1.049$, $p = 0.446$, at 12 months of age produced $R^2 = 0.097$, $F(5, 9) = 0.193$, $p = 0.958$, and at 16 months of age produced $R^2 = 0.459$, $F(5, 9) = 1.528$, $p = 0.273$. Quantity of infant vocalizations, quality of infant vocalizations (e.g., vegetative, reflexive, non-canonical, canonical, or linguistic), and infant age (8, 12, and 16 months) did not significantly contribute to the multiple regression model for expressive vocabulary at 3 years.

Table 5
Summary Statistics, Correlations, and Results from the Regression Analysis (Dependent Variable = Expressive Vocabulary at 3 years)

Predictor Variables		M	SD	r	Multiple Regression Weights		t	p
Age	Utterances				B	β		
8 Months	Total	95.800	36.261	0.270	0.292	0.368	1.211	0.257
	Linguistic	0.400	1.298	-0.101	3.864	0.174	0.589	0.570
	Canonical	3.067	4.935	-0.090	-3.774	-0.648	-1.770	0.110
	Non-canonical	77.733	32.740	0.305				
	Reflexive	10.533	10.162	0.203	0.685	0.242	0.750	0.472
	Vegetative	4.067	4.431	0.234	3.648	0.562	1.667	0.130
12 Months	Total	116.800	56.850	0.231	0.063	0.125	0.227	0.825
	Linguistic	2.733	4.788	0.152	0.948	0.158	0.481	0.642
	Canonical	13.200	14.011	0.017	-0.155	-0.075	-0.220	0.830
	Non-canonical	92.267	50.687	-0.017				
	Reflexive	4.800	4.632	0.219	1.058	0.170	0.322	0.755
	Vegetative	3.800	6.668	0.259	-0.278	-0.064	-0.198	0.847
16 Months	Total	118.867	47.086	-0.097	-0.112	-0.184	-0.438	0.671
	Linguistic	4.600	5.877	0.267	3.396	0.694	1.755	0.113
	Canonical	20.333	13.568	-0.228	-0.497	-0.235	-0.612	0.556
	Non-canonical	85.800	37.676	0.269				
	Reflexive	5.733	5.599	-0.057	-3.210	-0.625	-2.039	0.072

	Vegetative	2.400	2.501	-0.283	1.081	0.094	0.299	0.771

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

Effect Size

While many of the analyses conducted resulted in statistically nonsignificant findings, large effect sizes were found between most criterion and predictor variables, as can be seen in Table 6 (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, while effect sizes were substantial across all criterion variables, effect sizes were profoundly large between all quantity and quality predictor variables and expressive vocabulary at 3 years of age. The clinical importance of these results is that the volubility and nature of infant/child productions contributes to future vocabulary ability in this group of children who are typically developing. The only exceptions observed to this fact would be differences between means for non-canonical utterances and expressive vocabulary at 1 year of age.

Table 6
Effect Sizes (Cohen's d) between Criterion and Predictor Variables

Age	Utterances	Expressive Vocabulary at 1 Year of Age	Receptive Vocabulary at 1 Year of Age	Expressive Vocabulary at 2 Years of Age	Expressive Vocabulary at 3 Years of Age
8 Months	Total	0.261	2.272	2.114	16.959
	Linguistic	1.361	4.005	2.943	31.949
	Canonical	1.312	3.956	2.920	31.392
	Non-canonical	0.025	2.577	2.268	18.597
	Reflexive	1.177	3.815	2.855	29.685
	Vegetative	1.296	3.941	2.912	31.430
12 Months	Total	0.532	1.776	1.889	11.853
	Linguistic	1.318	3.931	2.922	31.434
	Canonical	1.124	3.750	2.828	28.185
	Non-canonical	0.191	2.177	2.101	13.554
	Reflexive	1.283	3.928	2.906	31.361
	Vegetative	1.298	3.939	2.913	30.992
16 Months	Total	0.592	1.836	1.902	13.634
	Linguistic	1.285	3.928	2.907	31.132
	Canonical	1.003	3.639	2.771	28.038
	Non-canonical	0.102	2.407	2.191	16.858
	Reflexive	1.266	3.911	2.897	31.135
	Vegetative	1.326	3.971	2.926	31.763

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.

Discussion

Through the present study, we aimed to examine the relationship between the quantity and quality of infant vocalizations at 8, 12, and 16 months of age and receptive and expressive vocabulary at 1, 2, and 3 years of age. The quantity of infant vocalizations was tallied from the total number of vocalizations produced, whereas the quality was tallied from the type of vocalizations produced (vegetative, reflexive, non-canonical, canonical, and linguistic).

As expected, the quantity of vocalizations produced varied across recording sessions from day to day depending on individual differences, background, and typical growth and development (Huttenlocher et al., 2010). Given that speech and language is unstable and variable across children in development, the same would be expected during recording sessions of typically developing infants (Fenson et al., 2000). The results of this longitudinal study demonstrate this variability, despite significant findings between variables of interest. Further, in spite of variability, all predictor variables (total number of infant vocalizations and type of infant vocalization) were represented at all infant ages (8, 12, and 16 months).

There was evidence that greater quantity and more developmentally advanced quality of infant vocalizations at 8, 12, and 16 months resulted in increased expressive and receptive vocabulary at 1, 2, and 3 years of age. Specifically, as the number of infant vocalizations increased, the size of expressive and receptive vocabularies also increased at later ages. Furthermore, the more complex and diverse the infants' vocalizations were, the larger later expressive and receptive vocabulary was. Although there were not as many statistically significant results between predictor and outcome variables as expected, results observed were meaningful. The majority of the statistically significant findings were related to receptive vocabulary at 1 ½ years of age, rather than for expressive vocabulary at 1 ½, 2, and 3 years of

age. This may be due to the fact that receptive vocabulary develops faster than expressive vocabulary (Owens, 2012).

The first aim for the study was to determine the impact of the quality and quantity of infant vocalizations on *expressive vocabulary* at 1, 2, and 3 years of age. The results indicated that the more non-canonical vocalizations produced at 8 months of age, the smaller expressive vocabularies were at 2 years of age. This may be because non-canonical vocalizations are immature, where more mature vocalizations appear to contribute to larger vocabularies. Interestingly enough, the more reflexive utterances produced 16 months of age, the larger later expressive vocabulary. Reflexive utterances were categorized in this study as laughing or crying. Although reflexive utterances are earlier developing vocalizations, they are often made in response to their environment, which is most often in response to a communication partner or caregiver, in an engaging manner. Perhaps the more interactions such as these with caregivers or communicative partners, the larger an infant's expressive vocabulary will be later on.

Aim 2 was to determine the impact of quality and quantity of prelinguistic/early linguistic vocalizations on receptive vocabulary at 1 year of age. We saw that more well-formed vocalizations (linguistic utterances) produced at younger ages were indicative of larger receptive vocabularies at older ages. Conversely, more reflexive utterances produced at younger ages were indicative of smaller receptive vocabularies at older ages.

Observed effect sizes show that the majority of relationships between predictor variables (quantity and quality of infant vocalizations) and outcome variables (expressive and receptive vocabulary) were clinically meaningful. Clinical significance translates to the ability of a treatment to make a difference or be effective in practice. For this study, it strengthens the notion that prelinguistic vocalizations are strongly indicative and systematic precursors to

vocabulary development. Effect size can reflect the magnitude of change between variables; the larger the effect size, the larger the change or difference (Page, 2014). 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 quantity and quality of prelinguistic and early linguistic vocalizations are exhibiting a strong influence over later vocabulary outcomes.

Our results were consistent with past studies, indicating that prelinguistic vocal behaviors predict and lay the foundation for later vocabulary development (Fasolo, Majorano, & D'Odorico, 2008; Oller, Eilers, Neal, & Schwartz, 1999; Sotto, Redle, Bandaranayake, Neils-Strunjas, & Creaghead, 2014; Watt, Wetherby, & Shumway, 2006). Individual variability and personality are acknowledged as contributing factors to later vocabulary development as well.

Clinical Implications

Results supported the central hypothesis, that greater quality and quantity of infant vocalizations at 8, 12, and 16 months of age are related to larger expressive and receptive vocabularies in the same children at 1, 2, and 3 years of age. Accordingly, it is possible that intervention to increase the quantity and quality of infant vocalizations in children who are at risk for speech and language difficulties will help facilitate receptive and expressive vocabulary development. More research in this area would need to be completed to confirm or refute this possibility. The results are meaningful and beneficial to clients and clinicians as they could enable intervention to start earlier in language development for infants at risk. Said differently, if infants are presenting with limited vocalizations in terms of quantity and quality, there may be

cause for concern. These results can aid in making intervention possible at earlier stages of language development in children.

Overall this study helps identify red flags or developmental milestones to watch for that relate to later vocabulary development. Specifically, infants under 18 months of age who are presenting with limited and more immature vocalizations may be at risk for later speech and/or language delay/disorder (as indicated by reduced expressive and receptive vocabulary size). Clinicians should attend to the quantity and the quality of vocalizations produced when working with children under 18 months of age. Specifically, clinicians who work with infants would benefit from knowing the stages of babbling and prelinguistic language development, and that infants who are more voluble and producing more variable/mature vocalizations in the prelinguistic/early linguistic stage are likely to have a larger vocabulary size throughout early development.

Study Limitations

While the longitudinal research design is optimal for conducting research on developmental trends, several challenges are inherent to the nature of such studies. First of all, this study had a relatively small sample size. As statistical findings can often be confounded by sample size and the effect sizes of this study were very large, it would be valuable to repeat a similar study with a larger number of participants to ensure reliability and increase the potential for generalization. Second, through this study, we specifically looked at infant vocalizations and how they relate to later vocabulary development in a sample of infants who are typically developing. Accordingly, the results do not generalize to infants who are at risk, disordered, or delayed. Further, given the nature of retrospective research, and the reality that this data was gathered for alternative aims, we are presented with a third study limitation; there was only one

measurement of receptive vocabulary at 1 ½ years of age. We did not have a measure of receptive vocabulary at 2 or 3 years of age to include in the present study. Since many of the statistically significant findings were related to receptive vocabulary at 1 ½ years of age, more information on receptive vocabulary at later ages may have been informative.

Future Directions

More research is necessary in order for the prelinguistic vocalizations of infants to be of optimal prognostic value. In line with study limitations, one specific focus may be to look at the same data in a cohort of infants/young children who are at risk for speech and/or language delay/disorder (e.g., those who experience one or more of the following conditions prior to 6 months of age: pre- and/or perinatal problems; ear, nose, and throat problems; swallowing/sucking problems; and/or a family history of speech and/or language problems - Brady, Marquis, Fleming, & McLean, 2004; Girolametto, Weitzman, Wiigs, & Pearce, 1999; Goldstein & Schwade, 2008; McDuffie & Yoder, 2010). Doing so would provide a potentially contrasting sample with different or no relation between quantity and quality of early vocalizations and later receptive and expressive vocabulary, indicating that the patterns observed (or the lack thereof) may provide early diagnostic information for identifying typically versus atypically developing infants. Larger sample sizes would be beneficial, along with measures of receptive vocabulary at older ages.

Beyond study limitations, there are additional directions for future research. In some instances, non-verbal indicators of vocabulary have been used to develop screeners for earlier identification of infants at risk for speech and/or language delays (Bayley, 2005). Future research could look to developing a similar screener for earlier identification, a screener for verbal (e.g., quantity and quality of vocalizations produced prior to 18 months of age) indicators of

vocabulary. Such development would increase the clinical applicability of the current findings. Further, it would be beneficial to look at ways to increase the quantity and quality of vocalizations produced if they appear to be lacking (in terms of quantity, diversity of vocal types, and maturity of vocal types). Clinical trials could be implemented to determine the effectiveness of possible intervention strategies. Intervention could include educating parents and caregivers on how to increase the quality and quantity of their child's prelinguistic and early linguistic vocalizations to build future vocabulary. It is imperative that future research continue to focus on prelinguistic verbal and nonverbal predictors of language development or disorder to make it possible for clinicians to intervene earlier and facilitate future academic and social opportunities and skills in children who may struggle otherwise.

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Appendix A

The Stark Assessment of Early Vocal Development-Revised (SAEVD-R)

The SAEVD-R involves 23 vocalization types to describe and organize the vocalizations of infants and toddlers from 0 months to 18 months. The vocalizations are categorized into five groups of developmental levels by ascending order. The table includes operational definitions provided by Nathani, Ertmer and Stark (2006).

Level 1. Reflexive (0–2 months)	
VEG	Vegetative sounds, e.g., burp, cough, sneeze, etc.
CR	Sustained crying/fussing or series of brief discomfort sounds. Ingressive sounds, squeals, and vegetative sounds in cry are not classified as separate items. Cries that contain syllables (e.g., mamama) are classified as CR and the term 'Fussy Syllables' is noted as a comment. Conversely, utterances that are fussy (not full-blown cries) or utterances that contain non-fussy elements + cry are assigned applicable vocalization types (e.g., CVCV, V) and 'fussiness' and/or 'cry' are noted.
Q	Quasi-Resonant Nuclei. Faint, low-pitched grunt-like sounds with muffled resonance. Characterized by a lack of energy above 2000Hz. If there is energy across mid and higher frequencies, the vocalization may be classified as Q if the sound is brief (<100 ms). Q sounds cannot be transcribed as an adult vowel.
Q2	Two or more Qs in a series or row.
Level 2. Control of Phonation (1–4 months)	
F	Fully-Resonant Nuclei. Vowel-like sounds that are longer than Qs but cannot be readily transcribed as adult vowels. These vocalizations have energy across a wide range of frequencies (i.e., not restricted to low frequencies like Q). They may have poor vocal quality (harshness, high pitch, etc.). If glottal stops or [h] interrupt a Q or F, they are counted as a single syllable and glottal stops are noted.
F2	Two or more Fs in a series or row.
	Vocalization in which a vocant (vowel-like segment) or an F are combined with a superimposed closant (consonant-like segment). Also includes an isolated closant (e.g., 'raspberry', trill, click) or an isolated consonant (e.g. m, n, sh). Glottal stops and [h] are not considered closants.
	Two closant-vocant combinations, or two or more closants in a series.
CH	At least two brief chuckles or sustained laughter. Frequently, a [h]-like closant is perceived before the vowel. Ingressive sounds during laughter are not classified separately.

Level 3: Expansion (3–8 months)	
V	An isolated vowel. Vowels can be distinguished from Q/F because Vs are longer and more fully resonant than Qs and are of better quality and more easily recognized as vowels than Fs. They may contain some harshness, high pitch, etc. but are transcribable as adult vowels. Note any aberrant voice quality features.
V2	Two or more vowels in a series or row.
Vg	Vowel Glide. Vocant in which a change in vowel quality is present. No audible gap is present between the two segments. No closure can be identified, (e.g., [pa], [da]). The formant transition is characteristically slow: greater than 200 ms. If formant transition duration is less than or equal to 200 ms, classify as CV if closure perceived (e.g., w, j), or judge as diphthong if no closure is perceived (e.g. oɪ, aɪ).
IN	Ingressive Sound. Single long (>200 ms) ingressive sound or series of short ingressive sounds.
SQ	Squeal. High-pitched sound or series of squeals.
MB	Marginal babbling. Series of closant and vocant segments or series of Vgs. Irrespective of the nature of the closant/vocant, the key characteristic of MB is that formant transitions between the closant and vocant are prolonged. Therefore, even sequences of real consonants and vowels would be considered MB if they had long (> 120 ms) formant transitions. Elements in the sequence need not always contain a closant and vocant; occasional isolated vocants and closants might also be present. Well-formed, rapid glide and other semivowel sequences (e.g., wa, ja) would not be included under MB; they would be included under CV.
Level 4: Basic Canonical Syllables (5–10 months)	
CV	Single consonant-vowel syllable. Does not include syllables with /h/ or a glottal stop as a consonant.
CB	Repeated canonical syllable production. More than two CV syllables in sequence are required for this category. Because the consonants and vowels in the sequence can be same or different, this category includes reduplicated babbling (repeated productions of the same consonant-vowel sequence) and nonreduplicated babbling (sequence of different consonant-vowel combinations). If squeals, ingressive sounds, etc. occur during CB, corresponding vocalization types are merely noted.
WH	Whispered productions. V1, V2, Vg, MB, CB, or CV vocalizations produced without voice
CV-C	A consonant-vowel combination followed by an isolated consonant. A silent gap between CV and C should be observed.
CVCV	Disyllables. Two adjacent CV syllables or series of two CV syllables with an audible gap separating the CVs.
Level 5: Advanced Forms (9–18 months)	
CMPX	Complex syllables. 1) Single syllable types other than CV (e.g., VC, CCV, CCVC, etc.), or 2) Complex Disyllables (e.g., VCV, VCVC), or 3) Multisyllabic strings with

	complex syllables and without variable stress or intonation patterns (e.g., VCVCV, VCVCCVCV), or 4) Multisyllabic utterances with varied stress and/or intonation patterns in which the consonants and vowels remains unchanging. The latter are designated as Canonical Jargon (CBJN).
JN	Jargon. A series of syllables with at least two different Cs and Vs with a changing stress and/or varied intonation pattern within the series. The series must contain more than 2 syllables.
DIP	Diphthongs, e.g. /oɪ/, /aɪ/, /au/, or other forms with rapid formant transitions. Diphthong is characterized by formant transition that is less than 200 ms and overall syllable duration of less than 500 ms.