THE PHONETIC CHARACTERISTICS OF BABBLING IN KANNADA:

A LONGITUDINAL STUDY

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CHAPTER I

INTRODUCTION

"The interaction between infants and their caregivers lays so many foundations for later learning" (McLaughlin, 1998)

Crying and laughter are the earliest rhythmic vocal expressions of infants, and they are highly expressive. One of the most impressive accomplishments is the childôs ability to produce speech sounds and the ability to combine those sounds to form words. Even newborn babies make simple cooing vocalizations which may be precisely coordinated with similar sounds made by an adult imitating sensitively (Malloch, 1999). The child language development is commonly divided into pre-linguistic behavior, vocalizations prior to the first true words and linguistic development, which starts with the appearance of first words. The acquisition of speech and the phonological skills that allow a child to verbalize his or her first words is a complex motor and linguistic process that begins in infancy and proceeds through the early school years. Speech sound development refers primarily to the gradual articulatory mastery of speech sound forms within a given language. Phonological development refers to the acquisition of a functional sound system intricately connected to the childôs overall growth in language.

The production of the ñfirst wordò was viewed as the childôs initial step towards the acquisition of adult like speech. Therefore, most of the pioneering articulation developmental studies included children between 2 and 8 years of age in their investigations. The study of the speech skills that an infant acquires before his or her first words began in the late 1970s and early 1980s (e.g., Oller, 1980 & Stark, 1978, 1980). Research since then has done away with the notion that vocal behaviors prior to the one-word stage are unimportant productions bearing no relationship to the development of meaningful speech. But over the last decades more research has been made on this topic.

Infant Production of Vocal Sounds

Infant babbling in humans is considered to be an important step in early language acquisition. The infantôs learning of production of speech sounds can be considered as an increasingly complex task, ranging from vocal production to communicative use, in context, of adult-based sound patterns, or words (Menyuk, Menn, & Silber, 1986).

Babbling begins at approximately 6-7 months of age and extends until the childôs first words appear at age 10-13 months. The initial portion of babbling known as reduplicated babbling (Ollerôs stage 4, Oller, 1980) progresses from 7 months to 9 months of age. This form of babbling is characterized by the reduplication of similar consonant-vowel (CV) syllable strings. A variation in the vowel sounds may occur from syllable to syllable; however the consonant tends to remain constant (e.g., [mamu]). The CV syllable production in this stage are reduplicated resulting in syllable sequences such as [baba], [kaka], and [tata]. Non reduplicated or variegated babbling (Ollerôs stage 5, Oller, 1980) is marked as the second portion of babbling, which begins at approximately 9-10 months of age and progresses to about the first year. This form of babbling is characterized by varying consonant and vowel productions from one syllable string to another. The CV syllable sequences continue, but the infant combines a variety of CV sequences resulting in productions like [madaga], [putika], and [tikadi]. The infantôs vowel and consonant repertoire increases significantly at this point. Reduplicated and variegated babbling has frequently been included in a single stage of development called canonical babbling because of the difficulty that often arises in distinguishing the two (Smith, Brown-Sweeny & Stoel-Gammon, 1989; Mitchell & Kent, 1990). Jackobsonôs (1941/1968) ñdiscontinuity hypothesisò stating that a child typically undergoes a period of silence between the end of the babbling period and development of the first real words is no longer accepted as a fact. Recent research focusing on infant speech development, has repeatedly documented that babbling is not a random behavior, all possible sounds are not produced during the babbling stage, and the transition between the babbling and the first words is not abrupt but continuous (Bauman-Waengler, 2000).

A number of studies have looked at the sound repertoire and syllable shapes used by infants in the babbling stage. Most of the studies on the early phonological development have adopted a cross-sectional method of investigation and few have used the longitudinal method to assess the phonological development of individual children. With the growing concern that the infant population must be evaluated and served and that important communication milestones indeed occur in infancy, an increased knowledge base of early speech development has emerged in recent years especially in the western languages. However, in the Indian scenario, such reports on children as young as that are rare.

Need for the study

Babbling is an important milestone of early communication which can serve as a predictor of later language ability. Hence crucial importance for understanding speech development is assigned to the babbling period. A number of studies have looked at the sound repertoire and syllable shapes used by infants in the babbling stage. Many researchers have suggested that the quantity and the diversity of vocalizations do indeed play a role in later language development.

Though the history of infant speech development is long, most of the literature basically refers to Western studies. The issues related to babbling have not been explored extensively in the Indian context. Hence the need for the study is amplified. Most of the studies on the early phonological development have adopted a cross-sectional method of investigation and few have used the longitudinal method to assess the phonological development of individual children. Although age related changes can be based on cross-sectional data, it cannot be assumed that individual children pass through each of these stages. Longitudinal studies can provide more specific information regarding the developmental stages of an individual child or a group of children. There are no reported longitudinal studies in the Indian context focusing particularly on the babbling period. With the growing concern that the infant population must be evaluated and served, an increased knowledge base of early speech development has emerged in recent years especially in the western languages. However, in the Indian scenario, such reports on young infants are rare. In this regard, the present study aimed at investigating the development of babbling longitudinally in infants from Kannada speaking homes in the age range of 3 months to 12 months.

An intensive study of this acquisition process is extremely important for the Speech-language pathologist since one of the primary responsibilities of the Speech-language pathologist is to distinguish normal and disordered phonological development in a particular child and to base treatment on that distinction. Speech-language pathologists, especially those in early intervention services, are often confronted with children who are still within the babbling stages of development. Therefore, knowledge of the babbling stages, which includes characteristics and approximate ages of occurrence, can be helpful in our assessment and early intervention process.

Aim of the study

To understand the longitudinal development of babbling and to establish qualitative and quantitative database on the development of babbling in infants from native Kannada speaking homes in the age range of 3 months to 12 months with the following objectives:

- To establish the phonetic repertoire, including
    a) The characteristics and frequency of occurrence of vowels based on tongue height and tongue advancement.
    b) The frequency of occurrence of vowels across gender.
    c) The characteristics and frequency of occurrence of diphthongs.
    d) The characteristics and frequency of occurrence of consonants based on place and manner of articulation.

e) The frequency of occurrence of consonants across gender.

f) Contextual specificity of vowels with certain consonants

g) To identify the syllable shapes and to quantify their frequency of occurrence.

h) To calculate the percentage of reduplicated and variegated babbling.

CHAPTER II

REVIEW OF LITERATURE

Infant babbling in humans is considered to be an important step in early language acquisition. In infants, the ability to produce speech is limited by the immaturity of the vocal tract and the related musculature and babbling may provide vocal practice. Across all cultures, human infants will start to produce this form of speech at about 7 months of age, whereas the first words are usually uttered at about 14 months of age (Werker & Tees 1999; Doupe & Kuhl 1999). The importance of vocalization development for later speech and language development has been doubted in the past and so it has been somewhat neglected. But over the last decades more research has been done on this topic.

Why infants possibly vocalize?

Assuming that vocalizations are important for the later speech and language development it is interesting to speculate about reasons why infants possibly vocalize. Infants learn how to move and to position their speech organs and to combine this with the tactile feeling of the position of the speech organs. If infants lack the possibility to vocalize within the first year, it results in serious phonological delays at a later age as suggested by studies of tracheostomatized infants (Kamen & Watson, 1991; Kertoy, Guest, Quart & Lieh-Lai, 1999). These studies indicate the importance of the possibility to exercise the speech organs by vocalizing in order to develop a normal phonological and phonetic system later.

Vocalization as a precursor to language

Infant babbling was earlier believed to be random behavior bearing little or no relationship to the development of meaningful speech. Roman Jakobsonȇs discontinuity hypothesis (1941/1968) clearly emphasized a sharp separation between these two phases. Jakobson postulated that:

(1) Babbling and meaningful speech are distinct processes.

(2) Babbling has astonishing diversity, and

(3) Babbling has little or no regularity (i.e., it is random).

According to this theoretical notion, babbling is a random series of vocalizations in which many different sounds are produced with no apparent order or consistency. Such behavior is seen as clearly separated from the following systematic sound productions evidenced by the first words. The division between pre linguistic and linguistic phases of sound production, according to Jakobson is often so complete that the child might actually undergo a period of silence between the end of the babbling period and the first real words.

In support of the discontinuity theory, references have often been made to the studies of Lenneberg, Rebelsky and Nicols (1965) and Lenneberg (1967) who claimed that deaf infants vocalize exactly the same way as hearing infants do. It was concluded that hearing has no influence on vocalization development and that hearing (and the language environment) no sooner starts to influence speech and language development than after the first year. It was argued that vocalization development is influenced only by biological constraints such as anatomical and neurological development and is unrelated to the subsequent speech and language development after the first year.

In the past two decades, many researchers have studied babbling in infants and have found that some of Jakobson's ideas need to be reconsidered in light of the data. Research since time (e.g., Oller, 1980; Oller et al. (1976); Stark, 1980, 1986) has repeatedly documented that:

(1) Babbling behavior is not random but rather that the childós productions develop in a systematic manner.

(2) The consonant-like sounds that are babbled are restricted to a small set of segments.

(3) The transition between babbling and first words is not abrupt but continuous; late babbling behavior and the first words are very similar in respect to the sounds used and the way they are combined.In several recent studies a relationship between vocalizations and first words productions has been shown. Studies by De Boysson-Bardies and Vihman (1991) and Elbers (1989) show a clear relationship between the consonant- or vowel-like sounds produced in the babbling stage and the production of the first words. De Boysson-Bardies and Vihman studied the place and manner of the consonant-like segments produced by infants from several linguistic environments. They found that, during babbling, normal hearing infants produced more often the consonant-like segments specific to the input language as opposed to other segments, and these were also the segments produced more frequently by adults from the same environment.

During the first few months after birth, both quantitative and qualitative changes are detected in infant vocalizations. When the frequency of crying falls off sharply after the second month, speech like vocalizations become more frequent in infantŏs vocal repertoires (Oller, 1980; Stark, 1978; Stark, Rose, & McLagen, 1975). In this tradition, the view on infant vocal production has undergone several changes, from being viewed as a passive response to gravity, to a reflexive response to social simulation, to a product of exploratory discovery of vocal capacity, to a result of active learning (Oller, 1981).

The vocal repertoire during babbling is a small subset of that seen in adult language (as opposed to the common view that babbled sounds are a superset of adult productions). Infants acquire new productions (phonemes) only very slowly as the demands of word acquisition are imposed, and often make due with sounds from their babbling repertoire to create quasi-words, and imitate (as best they can) words from their target language. By the same token, the babbling literature also makes it clear that babbling and meaningful speech are not distinct processes. This is especially clear when considering studies of infants in the late babbling stage during which they are acquiring their first words. There is both phonological and phonetic continuity during this period, making it very difficult even to define separate stages of babbling and word acquisition.

Stages of vocal development

The development of the sound system leading up to the production of words has been well documented. Data exist concerning the order in which speech sounds and sequences emerge, the make-up of sound segments as well as the function of the speech mechanism when producing sounds (Davis & MacNeilage, 1995; MacNeilage, Davis, Kinney, & Matyear, 2000).

Many different classification schemes have been used to identify the stages of vocal development. While there is currently no universally recognized sequence of infant vocalization stages, most studies of babbling suggest a progression of developmental stages. Oller (1980) and Stark (1986) have provided descriptions of vocal production over the first year of life. Oller advanced specific stages that mark the acquisition of articulation and phonological skills during the first year of speech development. He divides the first six months into three sequential stages, which he terms the phonation stage, the cooing stage, and the expansion stage.

Table 1 represents the stages in speech development according to three authors: Stark (1986), Oller (1980), and Koopmans-van Beinum and Van der Stelt (1986). These three studies show considerable similarities in spite of some differences in onset and quality (content) of the stages.

<table>
<tr><th>Stark (1986)
(English)</th><th>Oller (1980)
(English)</th><th>Koopmans-van Beinum & Van der Stelt (1986)
(Dutch)</th></tr>
<tr><td>Reflexive
(0- 1 ½ months)</td><td>Phonation
(0-2 months)</td><td>Uninterrupted phonation
(0-1 ½ months)
Interrupted phonation
(1 ½ - 2 ½ months)</td></tr>
<tr><td>Cooing
(1 ½ ï 3 months)</td><td>Gooing
(2-4 months)</td><td>One articulatory movement
(2 ½ - 4 ½ months)</td></tr>
<tr><td>Vocal play
(4 ï 7 months)</td><td>Expansion
(4-6 months)</td><td>Variegated phonation
(4 ½ - 6 months)</td></tr>
<tr><td>Reduplicated babbling
(7-10 months)</td><td>Canonical babbling
(7-10 months)</td><td rowspan="2">Babbling
(7 ï 12 months)</td></tr>
<tr><td>Nonreduplicated babbling
(10-14 months)</td><td>Variegated babbling
(10-12 months)</td></tr>
<tr><td>First words</td><td>First words</td><td>First words</td></tr>
</table>

Table 1: Stages in speech development according to different authors.

Factors influencing early speech development

Vocalizations are of great importance for the development of a child hence it is important to know what factors might influence vocalization development. In the literature several of these aspects have been discussed. Some of these factors are as follows:

a) Development of auditory speech and language processing

During the first year of life an important development with respect to auditory speech processing takes place. In several studies it has been shown that infants recognize and prefer their native language within the first months of life, especially with respect to prosodic information. The perceptual development with respect to prosody influences the production of vocalizations already within the first months of life. For instance, Whalen, Levitt, and Wang (1991) found that the intonation contour of vocalizations of English and French learning infants between six and twelve months differed. The English learning infants more often produced a falling intonation, whereas the percentage of a falling and rising intonation was roughly equal for the French learning infants. Therefore it can be expected that the influence of auditory speech processing with respect to prosody on the production of vocalizations starts already within the first months of life.

b) Parent-infant interaction and spoken language input

Interaction between young infants and their parents and language input as a part of that interaction is seen by some researchers as a fundamental factor in early speech and language development. Both the quantity of language input during parent-child interaction and quality of parent-child interaction and their influence on the speech and language development of the child have been studied (e.g. Huttenlocher, Haight, Bryk, Seltzer & Lyons, 1991). According to Bloom (1988, 1998) syllabic sound productions of three-month-old infants are elicited by verbal communication with their parents. Around the same age imitation of the duration and pitch of maternal utterances was found in a three-month-old infant (Sandner, 1981). Therefore we can assume that from this age onwards the vocalization productions can be produced somewhat more intentionally and that the vocalization development is affected by parent-infant interaction.

c) Internal feedback

It has been argued by Fry (1966) that vocalizing is important, since it helps the infant to create a link between his auditory, tactile, kinesthetic and pro-prioceptive feedback via the speech-like sounds he produces. It is likely that there is influence from internal feedback on vocalization development, as shown in studies of children who have no possibility to train their internal feedback system and their speech productions.

d) Cognition

Only a few studies have been performed on the influence of cognition on vocalizations. According to Bloom (1998) growth in cognitive attention might serve vocalization development already at three months of age. Infants might respond to visual stimuli attracting their attention with movements of articulators such as the tongue and jaw. Also from that age on vocalizations can be elicited by verbal communication, suggesting a more intentional type of vocalizing at that early stage of development, possibly related to cognitive development (Bloom, 1998).

e) Development of anatomy and physiology of the speech organs

The anatomy (the structures) and physiology (the movements) of the newbornǿs speech apparatus is quite different from that of an adult or even of a child of two years of age as depicted in the figure 1. The vocal tract is short, with a relatively short pharyngeal cavity. During the reflexive/phonation/uninterrupted phonation stage the larynx is relatively high and the epiglottis and velum close to each other. The tongue is relatively big and fills the oral space almost completely and the velum (soft palate) hangs down passively, almost touching the tongue and epiglottis. The extrinsic (outer) velum muscles cannot actively lift up the velum yet, since the velum is still located in more upward position than these muscles (Fletcher, 1973). This results in actively lowering the velum instead of raising it, as we find in older infants and adults.

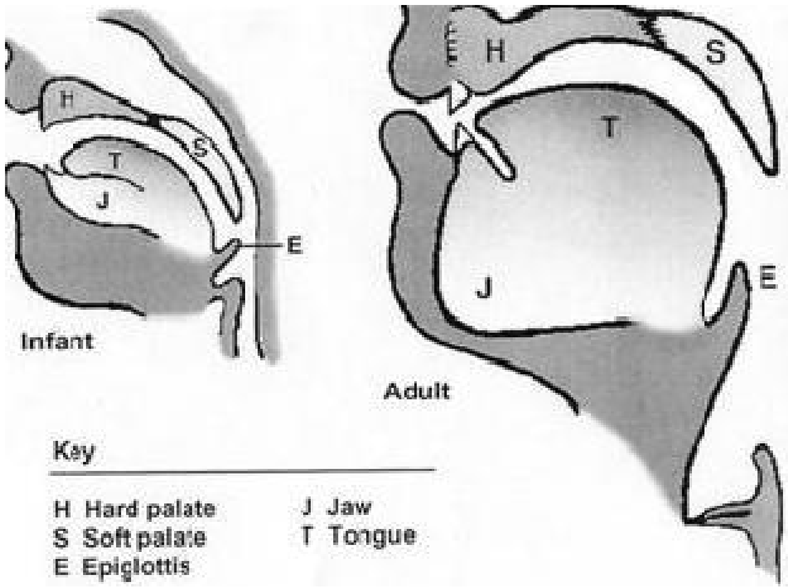


Figure 1: Vocal apparatus of an infant compared with that of an adult.

(From: Christina J C. 2004. *Development of vocalizations in deaf and normally hearing infants*. Utrecht: The Netherlands.)

In the first months many sounds are produced with the lips closed. For these reasons the air stream goes mainly via the nose and not via the mouth in newborns. This explains the nasality in this stage. At the age of four to six months the anatomy of the oral and pharyngeal areas changes again. The mandible grows more downward, giving the tongue more space to move and giving the air the possibility to go through the oral cavity, without causing the tongue or velum to vibrate. In the same period the human larynx descends gradually during infancy, possibly associated with developmental changes of the swallowing mechanism. The descending of the larynx contributes physically to an increased independence between the processes of phonation and articulation for vocalization (Nishimura, Mikami, Suzuki & Matsuzawa, 2003). These changes results in the onset of the vocal play/expansion/variegated phonation stage.

Around seven months it becomes anatomically and physiologically possible to move the jaw freely up and down. In this period infants starts to chew. If the up and down movement is repeated, the result might be babbling; a rhythmic up-and down movement of the jaw, normally during voicing and the reduplicated babbling/canonical babbling/babbling stage starts. If the infant opens the jaw after a closed position, the result can be heard as a consonant-like segment, such as a front plosive, a front glide or a front nasal. This movement is done with the jaw, while the lips and tongue are not actively involved yet (Munhall & Jones, 1998). Thus we can conclude that the enormous anatomical and physiological changes during the first year of life have an influence on the development of vocalizations in all vocalization stages.

f) Development of neurology of the speech organs

Neurological maturation and motor control of the speech organs most probably have an influence on the onset and duration of the developmental stages of speech (Netsell, 1981). The brain of a newborn infant and the neurological paths for the innervations of the speech organs undergo intensive development in the first years of life. It has been suggested that the pre-babbled vocalizations are related to an early maturing part of the sub-cortex involved in the vocalization subsystem common to most mammals).

g) Hearing as a factor influencing vocalization development

Contributions of auditory sensitivity to the emergence and organization of vocal patterns during the babbling period have not been thoroughly detailed in very young infants who have been identified with hearing loss in the first year of life. Lenneberg et al. (1965) and Lenneberg (1967) claimed that hearing impaired infants, like normally hearing infants, started cooing at two to three months and start babbling at six to seven months. Whereas Stark (1980) observed that the repertoire of phones produced by Hearing Impaired (HI) subjects were more limited than the repertoire of hearing subjects at the same stage of babbling development. Oller et.al, (1985) and Oller and Eilers (1988) calculated the ratio of the total number of canonical syllables to the total number of utterances, as a measure of whether the child had started to babble (ratio 0.2 or more). It was shown that seven deaf infants did not start babbling before eleven months of age, unlike all nine hearing subjects who produced canonical babbles before ten months of age. Hence it was concluded that the traditional belief that deaf infants produce the same kinds of babbling sounds as hearing infants is wrong and that audition plays an important role in infant vocal development.

Early vocal production

During the first two months of life, infant vocalizations are mainly expressions of discomfort (crying and fussing), along with sounds produced as a by-product of reflexive or vegetative actions such as coughing, sucking, swallowing and burping. There are some non-reflexive, non-distress sounds produced with a lowered velum and a closed or nearly closed mouth, giving the impression of a syllabic nasal or a nasalized vowel. During the period from about 2-4 months, infants begin making "comfort sounds", typically in response to pleasurable interaction with a caregiver. The vocal tract is held in a fixed position. Initially comfort sounds are brief and produced in isolation, but later appear in series separated by glottal stops. Laughter appears around 4 months. During the period from 4-7 months, infants typically engage in "vocal play", manipulating pitch (to produce "squeals" and "growls"), loudness (producing "yells"), and also manipulating tract closures to produce friction noises, nasal murmurs, "raspberries" and "snorts". The overall composition of pre-speech vocalizations changes dramatically during the first year of life. In the first six months, babies all over the world sound alike. During this period, vowels predominate and are supported by prolonged back consonants (e.g., \k\, \g\).

Onset of Babbling

Typically developing infants progress through a series of stages of vocal development during the first half year of life, culminating in the appearance of canonical babbling between 4 and 10 months of age, with a median at 6 to 7 months (Oller, 1978; Stark, 1980). Canonical babbling usually implies either reduplicated or variegated babbling. It is characterized by the production of repetitive, syllable-like output (i.e., [baba] or [daedae]). Perceptually, one of the most striking characteristics of canonical babbling is its sudden onset and rhythmicity as it sounds strikingly speech-like. Oller (1986) noted the following perceptual properties of canonical babbling: (a) at least one fully resonant nucleus (i.e., vowel with an identifiable quality, excluding highly nasalized vowels), (b) one non-glottal margin (consonant other than glottal consonant), (c) duration of syllable and formant transitions that are perceptually consistent with mature syllable production, and (d) normal phonation and pitch range. Virtually all normal infants begin canonical babbling by 10 months of age, but there is wide variability.

Eilers, Oller, Levine, Basinger, Lynch and Urbano (1993) suggested a more accurate method to obtain the age of onset of babbling. The parents are asked to be especially vigilant and call immediately when the first canonical babbles appear. The parents are trained to recognize canonical babbles. At this point, the staff calls the parents biweekly to ensure that the parents are monitoring the child's progress. When the parents call with the report that the child is producing canonical babbles, the child is brought into the laboratory on each of five consecutive days (excluding weekends) for confirmatory tests.

Despite controversies regarding the sequential nature of babbling (Holmgren, Lindblom, Aurelius, Jalling, & Zetterstrom, 1986;; Mitchell & Kent, 1990), babbling continues to be divided into two stages. The initial portion of babbling known as **reduplicated babbling** (Ollerĝs stage 4, Oller, 1980) progresses from 7 months to 9 months of age. This form of babbling is characterized by the reduplication of similar consonant-vowel (CV) syllable strings. The CV syllable production in this stage are reduplicated resulting in syllable sequences such as [baba], [kaka], and [tata]. A variation in the vowel sounds may occur from syllable to syllable; however the consonant tends to remain constant (e.g., [mamu]). The phonetic repertoire at this stage, although limited, may consist of stops, nasals, glides, and the lax vowels /e/, /I/, /^/. Stops present the sharpest possible contrast with vowels and provide the most prominent break in the acoustic stream of speech sounds.

On the other hand, stop production is also relatively undemanding: Syllables such as [ba], [da], and [na] may be articulated through mandibular action alone (Kent, 1992). It is likely that this production milestone represents an advance in: (a) Motoric control, which is maturational, or tied to natural physiological development in the first year; (b) the experience-based integration of visual and auditory perception of adult sequences of open-closed mouth and voice-silence alternation, and (c) the expression of the percept of adult vocalization through global imitation. That is, children see as well as hear stop consonants in adult speech, produce such sounds themselves, and engage in repetitive vocal production or sound play, re-creating their impression of adult speech..

Non-reduplicated or **variegated babbling** (Ollerôs stage 5, Oller, 1980) is marked as the second portion of babbling, which begins at approximately 9-10 months of age and progresses to about the first year. This form of babbling is characterized by continual use of adult-like syllables supplemented by the increasingly varied consonants and vowels within a single vocalization. The CV syllable sequences continue, but the infant combines a variety of CV sequences resulting in productions like [madaga], [putika], and [tikadi] (Smith et al. 1989; Mitchell & Kent, 1990).

Early studies of babbling held that reduplicated and variegated babbling was produced by the infant during different stages (Elbers, 1982; Oller, 1980, 1986). Recent studies have found that these two types of babbling co-occur from the onset of canonical babbling, although variegated sequences may not become a dominant category in the childôs production until some weeks or even months later. Thus, Roug, Landburg, and Lundburg

(1989) found that variegated utterances were present throughout their study, but increased dramatically towards the end of the first year of life or in the second year. Stoel-Gammon and Cooper (1984) studied 10 infants at four month intervals from 6-18 months of age. They analyzed consonant place changes as indices of variegation in multi syllables. A post-hoc analysis showed the following rank orderings: reduplication, place variegation, and manner variegation at 6-9 and 10-13 months; place variegation, manner variegation, and reduplication at 14-17 months. Their results show that the number of reduplicated babbles actually rises slightly until the age range 10-13 months when it begins to fall, finally dropping below the rate of variegated babbling at about 14 months of age. In contrast, the rate of production of variegated babbles falls slightly until 10-13 months of age, when it then starts to rise. By 14-17 months of age, the rate of production of variegated babbles is larger than the rate of reduplicated babble production, but at no time (before 17 months) does the production of reduplicated babbles cease. Similar results were obtained by Mitchell and Kent (1990).

Importance of Babbling and its relationship to later language development

Babbling in its canonical form is generally considered to be a crucial phase in the development towards the production of full-fledged speech. Longitudinal investigations of the transition from canonical babbling to speech have shown continuity between phonetic forms in infant pre-linguistic vocalizations and earliest speech forms (Stoel-Gammon & Cooper, 1984; Vihman, Ferguson & Elbert, 1986). This continuity supports the importance of considering canonical babbling as a crucial first step in the young childös journey toward mastery of ambient language phonology. The study of canonical babbling may also find application in the diagnosis of various kinds of speech disorders.

Canonical babbling is monumental to parents and specialists because of its assumed relationship to later speech and language development (Chapman, Hardin-Jones, Schulte & Halter, 2001). Recent studies indicate that late canonical babbling might be a predictor of disorders (Oller, Eilers, Neal, & Schwartz, 1999). Oller, Eilers, Neal & Schwart evaluated 3,469 infants who were at risk for delays. The researchers discovered that of the infants who demonstrated delayed onset of canonical babbling; fewer than half were diagnosed with a medical problem accounting for the delay. Westrmann and Miranda (2004) support these findings by indicating that there is growing evidence that the pre-linguistic stage influences the development of phonology. Research provides evidence of similarities between babbling and early speech (Cruttenden, 1970, Oller, Wieman, Doyle, & Ross, 1975; Vanvik, 1971). Studies revealed that infants who prefer certain syllables in babbling tend to carry these tendencies to early speech (Vihman, 1986).

Typical and Atypical Patterns of Vocal Development

The process of vocal development in typically developing infants and toddlers has been characterized as consisting of overlapping stages during which new vocalization types emerge and become common (Vihman, 1996). Advancements to higher levels of vocal development have been interpreted as signs of progress toward meaningful speech and phonological organization (Stoel-Gammon, 1998; Vihman, Ferguson, & Elbert, 1986). A relationship between the number of vocalizations and the later speech and language development has also been found. Kagan (1971) found a relationship between high number of vocalizations and larger vocabulary development at 27 months for girls. Also, Roe (1977) found a positive correlation between the number of vocalizations at three months of age and the amount of talking at three years, as well as the vocabulary development at five years in his study of 14 boys. Camp, Burgess, Morgan and Zerbe (1987) studied 141 normally developing infants and reported a correlation between the number of vocalizations at four to six months of age and word use at one year. Also, in studies of atypically developing children a relationship between number of vocalizations and later speech and language development is found. In the study of McCathren, Yoder and Warren (1999) a clear positive correlation was found between rate of vocalizations at 17-34 months of age and later expressive vocabulary of 58 children with a developmental delay.

If a relationship between vocalization development and the later speech and language development exists, it might be the case that an abnormal vocalization development might be related to an abnormal spoken language development. Jensen, Boggild-Andersen, Schmidt, Ankerhus and Hansen (1988) studied the development of infants who were at risk for a developmental delay (low birth weight, low Apgar score, neonatal cerebral symptoms) and compared them to infants not at risk. The infants at risk produced significantly fewer consonant-like segments and less reduplicated babbling than the children not at risk. A larger proportion of the children at risk also scored below age level on a language test. Moreover, Oller, Eilers, Neal and Cobo-Lewis (1998) argued that a late babbling onset might possibly function as an early marker of abnormal development. In a study by Chapman, Hardin-Jones and Halter, (2003) the relationship between vocalizations and later speech and language performance was shown for infants with a cleft lip and palate. It was suggested that the production of stop consonants in vocalizations at 9 months of age was related to phonological development at 21 months. Canonical babbling onset has also been studied extensively in a number of populations of infants who either had disorders of communication or were deemed to be at risk for such disorders (Smith & Oller, 1981; Eilers et al. 1993). Oller et al. (1985) has documented that the canonical babbling of children with severe to profound hearing losses differs significantly from that of normal hearing children, the variety of phonemes used is reduced, the volume of babbling is reduced and most importantly, the timing elements between the consonant and the vowel are significantly longer than those of normal hearing children. These studies clearly indicate a connection between vocalizations, babbling in particular, and later language development.

Approaches to the study of Babbling

All normal infants babble during the course of language acquisition. In recent years, the interest in babbling research has increased dramatically, and an interdisciplinary approach is often employed. Four basic forms of study of babbling are prevalent in the literature:

(1) Acoustic analysis: Vocal babbling gives rise to acoustic output which may be analyzed. Many regard babbling as a precursor to speech, and, therefore, babbling sounds are often analyzed with the intention of finding the similarities and differences between babbled sounds and similar speech sounds of adult speech

(2) Functional analysis: The functional role of babbling has been explored by many studies. Losik (1988) suggested that babbling serves to train the auditory system using repetitions to provide information on the variability likely to be encountered in speech.

(3) Developmental: The relationship between babbling and acquisition of various motor skills has been studied (Hay, 1984, Ramsay, 1984, Ramsay & Willis, 1984). One view is that babbling is simply the natural output of an immature production apparatus, with no link to perceptual mechanisms.

The first view can be referred to as the **‘independence hypotheses’**. It postulates that pre-linguistic productions are constrained by universal maturational (physiological, biological) processes (Lenneberg, 1967) and are thus universal. That is, they do not depend on the infant's linguistic environment. These constraints result in 'phonetic proclivities' (Locke 1985) or 'articulatory proclivities' (Lindblom, 1984) which make infants utter subsets of adult-like productions. According to the independence hypothesis, motor and perceptual components of a language are considered to develop separately (Studdert-Kennedy 1986). Perceptual discrimination skills, already present in neonates, change as a result of the infants' exposure to the phonetic, phonological and intonational characteristics of their future mother-tongue. This leads to some early language-specific discrimination ability (Werker & Tees 1984), not apparent in babbling and first language productions. Although this does not necessarily imply that the linguistic environment cannot affect babbling, such a conclusion is generally drawn.

The second view, **'interactional hypothesis'**, assumes that perceptual-motor mechanisms begin to operate at the babbling stage. According to this hypothesis articulatory procedures that are mastered step by step are oriented by auditory configurations. At 10 months, articulatory control (Buhr 1980, Lieberman 1980, Kent & Murray 1982), together with the restructuring of the auditory system that takes place at around the same age (Werker & Tees 1984), allows infants to specify some vocal tract positions and permits them to produce language-oriented sounds (De Boysson-Bardies, Sagart, Hallé & Durand 1986, McCune & Vihman 1987).

(4) Theoretical: Elbers (1982) provides a brief summary of the existing babbling theories. They are (i) learning theory, in which the infant is trying to acquire sounds resembling those of the caregiver, (ii) maturational theory, in which babbling is primarily the result of biological maturation, that it is only a "side effect", (iii) the continuity approach, an extension of learning theory, in which the sounds of babbling gradually merge into early speech, (iv) the discontinuity approach, an extension of maturational theory, in which speech may occur in the infant after maturation has completed, and (v) the cognitive approach, advanced by Elbers combines the best features of the other approaches.

A production-based theoretical explanation of babbling has been proposed by MacNeilage and Davis, the Frame/Content theory. According to the Frame-Content (F-C) theory (MacNeilage & Davis, 1990; MacNeilage, 1998), rhythmic mandibular cycles serve as a óóframeôô for the future syllable, by producing an alternation between resonant and non-resonant acoustic outputs producing the two basic syllabic components: vowel- and consonant-like percepts. In adult speech, the óócontentôô corresponds to controlled segments, generated by movements of the lower jaw, the lips, the tongue and the velum that are independently activated during verbal sequences. In contrast, at the onset of canonical babbling, the only active articulator is the lower jaw since the movements of the articulators it carries, that is, the lower lip and the tongue, as well as the velum and the upper lip, do not seem independent of the rhythmic jaw cycles. The predicted outcome, according to the F-C theory is the co-occurrence of following patterns: front vocalic sounds associated with coronal closants (e.g. /de/), central vocalic sounds with labial closants (e.g. /ba/), and backed vocalic sounds with palato-velar closants (e.g. /gu/). According to them these dominant co-occurrences in babbling occur because the tongue tends to stay relatively stationary while the jaw makes the movements that produce the closure for consonantal sounds and the opening for vocalic sounds. Later on, development from babbling onset to appearance of ýrst words and until a completely mature control of the vocal tract involves a number of steps that can extend over many years. These steps include the control of sequences of mandibular oscillation of the movements of the articulators carried by this cycle independently one of each other and of the full shape of the vocal tract to master sounds and sequential patterns of the ambient language.

Longitudinal and cross-sectional methods of investigation

Longitudinal studies trace the development of a given child or a group of children over a period of time. In most cases, data are collected at regular intervals ranging from daily observations of some dairy studies to semiannual or annual sessions. Longitudinal data allow the researcher to observe the patterns individual children follow in acquiring their phonological system.

Cross-sectional studies are based on data from a child or group of children at a single point in time. Data from a group of children at a given age are useful in that they provide information regarding the norms for that age. In some investigations researchers have used cross-sectional data from subject groups at specific ages as the basis for inferring longitudinal patterns of development (Templin, 1957; Wellman, Case, Mengert & Bradbury, 1931). Both types of investigation provide valuable information that leads to a better understanding of child phonology.

Coding infant vocalizations

It is traditional, in the study of speech, to transcribe an utterance according to the phonemes defined by the International Phonetic Alphabet (IPA). However, such a transcriptional approach assumes that the infant vocalizations correspond to adult speech. But this is not always the case. On the other hand, an acoustic analysis of an infantôs vocalizations yields quantitative and objective measures such as fundamental frequency, formant frequencies and transitions, durations, etc. however, it is difficult to relate such measures to adult speech, which is one of the goals of the study of infant babbling. Each approach has its advantages and disadvantages.

There are a number of enormously complex problems that arise when one attempts to achieve an appropriate and reliable system of coding of infant vocalizations, because vocal behaviors are remarkably complex, even in the first half year of life (Oller, 2000;

Oller & Lynch, 1992). By the early 1950s, the IPA transcription of infant sounds was under attack, and there were attempts to classify all infant vocalizations through acoustic analysis alone (Lynip, 1951). Still, the thrust toward early identification of disorders related to speech and language requires us to look beyond canonical sounds, which are not normally in place until 5 months of age or later in normally developing children and occur much later in children with hearing or linguistic handicaps (Oller & Eilers, 1988). Babies are being referred for speech and language services at ever-earlier ages primarily due to sophisticated diagnostic techniques, and, so, tools for handling pre-canonical sounds are sorely needed.

Phonetic transcription to study vocalizations

Phonetic transcription through the International Phonetic Alphabet (IPA) is widely utilized to study vocalizations in a variety of realms including linguistic fieldwork, child phonology, dialectology, evaluations of disordered speech, and infant vocalizations. In the study of infant vocalizations, phonetic transcription is often aimed at determining an inventory of adult like phonetic elements or syllables commanded by infants, and thus often provide the primary methodology to specify infant vocal capabilities and to predict likely emergent disorders of phonological capability. However, the reliability of phonetic transcription is often subject to serious question, especially when the speech or speech like materials to be transcribed are quite distinct from those found in mature well-formed speech.

Study of infant vocalizations through transcription is inherently complicated due to the immaturity of infant sounds. Researchers attempting to characterize immature sounds phonetically often óóshoehornôô them into an adult model through phonetic transcription (Oller, 2000). Clearly it is important to consider ways such transcription poses challenges to inter-observer agreement or reliability.

Prior stages of vocal development are termed pre-canonical, and often include many complex infant utterances composed of non-canonical syllables that have been reported anecdotally and in the preliminary evidence discussed in Oller (2000) as difficult to transcribe. Shriberg and Lof (1991) conducted both the most extensive review and the most extensive empirical study to our knowledge on transcription reliability across samples from typical speakers and individuals with disorders of speech. They found transcription reliability ranging from under 20% to nearly 100%, depending on the circumstances of sampling and reliability assessment. Louko and Edwards (2001) suggested that anything greater than 75% is acceptable reliability in phonology. Stoel-Gammonôs (2001) review concluded that acceptable reliability measures for transcription of childrenôs speech were between 60% and 80%. Irwin and colleagues (Irwin & Chen, 1941; Irwin & Curry, 1941) asserted that 85% reliability is needed among coders when transcribing vowel-like elements in the cry sounds of babies. The lack of consensus on acceptable levels of reliability exists in part because, as noted previously, there are large differences among samples of vocalizations in their degree of well-formedness and, consequently, large differences in what can be expected in the way of reliability across different sample types. There is much more to be said about acceptable levels of transcription reliability.

Phonetic Characteristics of Early Babbling

The pre-linguistic vocalizations of children display common trends across languages. Strong similarities in sound types (i.e. segments), sound combinations and utterance type preferences across different communities have been frequently documented, suggesting a universal basis for babbling. The fundamental questions for interventionists relate to what vocalization patterns occur at what age relative to typical developmental expectations, as well as what might be the cause if a child is not producing these vocalization patterns. These questions are addressed by identifying the type, number, and developmental sequence of vowels and consonants within a childôs repertoire. Independent research studies have described the content and framework of early speech and collectively offer a greater understanding of babbling and its developmental sequence.

Vowel Production in the First Year

In human speech, vowel is the sonority peak of a syllable and it is the most crucial element in human language (Maddieson & Ladefoged, 1995). Vowels are among the first óquasiresonantô sounds to be produced by an infant (Oller, 1986; Fernald, 1989, 1993; Trevarthen, 1999; Locke, 1993). The literature on vowel development suggests that the vowels of a language are acquired early, both in production and perception. Infants between 2 and 6 months old imitate vowel sounds in free vocal play with parents (Kugiumutzakis, 1993). Vowels exceed the number of consonants produced during babbling for most children. While no vowel pattern characterizes every child, certain tendencies exist universally. Vowels from the lower left quadrant of the vowel space (i.e. mid and low front and central vowels) are most often observed (Kent & Bauer, 1985; Lieberman, 1980; MacNeilage & Davis, 1990; Stoel-Gammon & Harrington, 1990). As illustrated in the Table 2 below, a vowelôs designation is derived from the manner (height) in which the jaw is open and the position of the tongue (front to back) when the vowel is produced. There is a tendency for children to begin producing front vowels and shift back in the mouth as maturation occurs. Low back vowels are not often produced until later in development (Oller, 1980). Although vowels represent a greater portion of an infantôs utterances, it is the consonant that is usually interpreted as carrying the speech message.

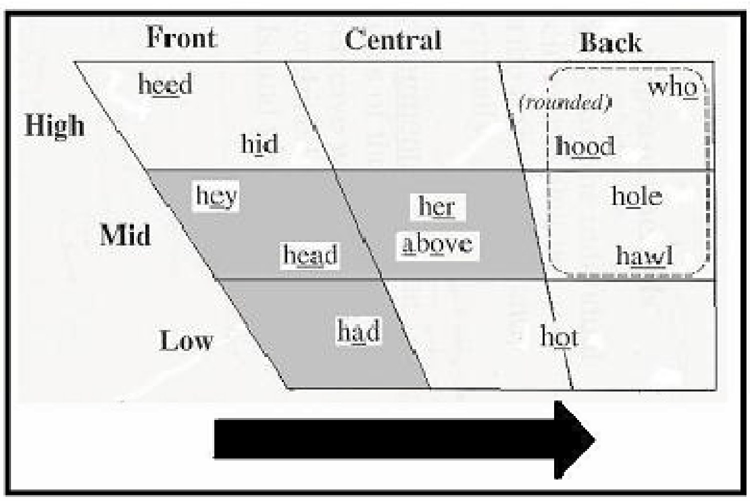


Fig 2: Vowel Chart indicating direction of acquisition over time.

(*Typical Development of Prelinguistic Vocalization Patterns Across Languages* (2007). Bilinguistics, Inc.)

Lieberman (1980) reported inter-transcriber reliability of 73 percent for the vowels produced by children aged about 3 to 14 months. He reported frequencies only for the vowels identified as belonging to the English repertoire. Lieberman used spectrographic analysis for a single child as a supplement to phonetic transcription and reported little change in average formant frequency values over the period investigated. However, the various vowels transcribed for four months showed considerable overlap in formant frequencies. A month later, spectrographic analysis yielded identification of a rudimentary vowel triangle. The gradual differentiation in the acoustic vowel space could be seen to continue until age 3. The vowels most often perceived during the entire period were lax [E,I,Θ,^, u] and were already present at the earliest session. Vowel [e] was heard most frequently (33 % of all the vowels transcribed), and the remaining lax vowels each accounted for 11% -17% of the data. The remaining (tense) vowels each accounted for no more than 5%, with the back-rounded [o] and [u] least frequent (1% each).

Buhr (1980) analyzed recordings of vocal production of an infant aged 16ï 64 weeks. The recordings were subjected to perceptual and acoustic analysis. Sounds resembling the vowel sounds of English were identified, and formant frequency measurements were made from spectrograms. Significant longitudinal trends for individual vowel sounds were not apparent during this period, although formant relationships for some vowels after 38 weeks were consistent with the notion of restructuring of the infant's vocal tract. However, analysis of F_1/F_2 plots over time revealed the emergence of a well-developed vowel triangle, resembling that of older children and adults.

Kent and Murray (1982) investigated the acoustic features of vocalic utterances at 3, 6, and 9 months (seven infants at each age). Their findings were reported similar to those reported by Lieberman. The range of F1 and F2 frequencies increased somewhat across each age interval, but the majority of the vowels used by the 9-month-old infants showed roughly the same formant pattern as did the vowels of the younger subjects. Roug, Landberg and Lundberg (1988) studied the vowels in the infants 1 to 20 months of age and found that the vast majority of the vowels were /a, æ, e, u and i/.

In a study of 10 month old infantsô vowel productions drawn from four linguistic communities-Arabic, Chinese, English, and French, De Boysson-Bardies et al. (1989) found that the categories of front-low and mid-central vowels accounted for the vast majority of vowels from all four groups. Acoustic analysis revealed characteristic patterns of vowel production for each group within those limits, however, with more high-front vowels for English, for example, and more low-back vowels for Chinese. The investigators interpreted these differences in vowel production to show that infants begin to position their lips and tongue in a manner specific to the language of their environment even before they produce word-forms modeled on adult speech.

Davis and Mac Neilage (1990) studied the course of acquisition of correct vowel production. The study suggests that there exists an illusory impression that vowels are acquired easily and are of little theoretical interest. Despite a relatively precocious rate of vocabulary acquisition over the period from 14 to 20 months, the subject studied produced less than 60% of vowels correctly according to evidence from phonetic transcriptions. They suggested that a complex pattern of vowel preferences and errors was only partially related to typical pre-speech babbling preferences, but was strongly related to word structure variables (monosyllabic vs. disyllabic) including stress patterns of disyllabic words, as reflected in patterns of relative frequencies of vowels in stressed and unstressed syllables. They also observed consonant-vowel interdependence in both the favoring of high front vowels in the environment of alveolar consonants, and a reciprocal relation between vowel reduplication and consonant reduplication in disyllabic words.

To determine the vowel-like sounds used most often by children at the end of variegated babbling stage, Bauman-Waengler (2000) compared Irwinǿs (1957) data with a study conducted by Kent and Bauer (1985). Some differences and similarities were noted in the data. The rank order of the six most prevalent vowels according to Irwinǿs study was /e/, /I/, /^/, /Y/, / A/, /u/. Kent and Bauer reported a different rank order: /^/, /E/, / Θ /, /A/, /Y/. Although the rank order varied slightly, at least four sounds remained constant across the two studies as the most prevalent: / E/, /^/, /A/ and /Y/.

Davis and Mac Neilageǿs (1995) longitudinal study with 6 infants (3 males, 3 females) from monolingual English-speaking homes revealed much individual variability in the use of vowels. The vowel data in the study was analyzed according to tongue height and tongue advancement dimensions. In relation to tongue height, the vowels were grouped into high, mid and low. For tongue advancement, the vowels were categorized as front, mid, and back. According to the tongue height dimension, mid vowels, particularly [^, Y and E], predominated in 3 subjects, while high vowels, particularly [u and I], predominated in the remaining 3 subjects. In relation to tongue advancement, front vowels, particularly [E,Θ and I] predominated in 4 subjects, and the mid vowels [a, ^, ᴅ], predominated in the remaining 2 subjects. Some common trends were identified in this study. The most commonly used vowels in the canonical babbling period were identified as [^, ᴅ, E, υ, Y, I and Θ], which were consistent with other studies (Irwin, 1957; Kent & Bauer, 1985).

Sussman, Duder, Dalston, and Caciatore (1999) analyzed stop consonant-vowel productions from babbling to meaningful speech in a single female child spanning the period from age 7 months to age 40 months. A total of 7,888 utterances were analyzed to obtain frequencies at F2 onset and F2 at vocalic center for each utterance. A linear regression line ("locus equation") was fit to the cluster of F2 coordinates per stop place category produced during each month. The slope of the regression lines provided a numerical index of vowel-induced co-articulation on consonant productions. Labial, alveolar, and velar CV productions followed distinct articulatory paths toward adult-like norms of co-articulation. Inferences about the gradual emergence of segmental independence of the consonant and vowel in the three stop place environments were made from locus equation scatter plots and mean F2 onset and F2 mid vowel frequencies obtained across babbling, early words, and natural speech.

According to the concept of 'frame dominance', most of the variance arises from a frame provided by open-close mandibular oscillation. In contrast, the tongue - the most versatile articulator in adults - plays only a minor role in inter segmental and even inter syllabic changes. The contribution of another articulator - the soft palate - to time-domain changes in babbling was evaluated by Matyear, MacNeilage, and Davis (1998) in an acoustic analysis of 433 consonant-vowel-consonant sequences produced by 3 infants. Strong nasal effects on vowels in symmetrical consonantal environment were observed in the form of a lower frequency first formant region in low vowels and a lower frequency second formant region in front vowels. These results, the first of which also occurs in adults, were complemented by perceptual tendencies for transcribers to transcribe more mid vowels relative to low vowels and more central vowels relative to front vowels in nasal environments. Thus the soft palate is like the tongue in making only minor contributions to time-domain changes in babbling, and this is considered to be additional evidence for the frame dominance conception.

During the first year, infant vowel production shows little change. Adult transcribers typically perceive the primitive vowels as mid-front or central. However, in many studies, identification of vowels by the researcher has been auditory, and in some studies, the listeners who identified the vowels seemed to be using information other than vowel formant heights for identification, since some vowels that were distinguished by ear remained indistinguishable on the formant charts. One must conclude that, despite the difficulties involved in learning to transcribe vowels (especially childrenœs vowels), the auditory identification of vowels is an irreplaceable tool in the analysis of vowel substitutions and development.

Consonant production in the first year

Consonants, as articulatory modifiers of vowels, play a part in marking tempo and creating perceptible and meaningful units in the speech stream. They define syllables, and they give 'infant directed speech' a clear rhythm that helps the infant to become familiar with the language environment into which they are born (Ramus, Nespor & Mehler, 1999). Consonants may also be extended like vowels in powerful non-verbal expressions. For example, 'contoid consonants', such as /p/, /f/, /h/, and 'fricative consonants', such as s, can be prolonged to act in the same way as vowel sounds (e.g. pssst). They can be used to sooth (e.g. shhhh) and to express complex emotions (e.g. mmm). 'Vocoid consonants' such as l, r, w, or j can also act in the same way (Crystal 1997). Like vowels, the first consonants that are produced are guided by the constraints of physical development. Stop consonants (/b, p, t, d, g, k/) and nasal consonants (/m, n, Ǽ) are the most common that are produced during babbling across languages (Vihman, 1985; Locke, 1983; Davis & MacNeilage, 1995). During the babbling period, children tend also to produce many coronal and labial consonants. Infants initially have a greater facility with front consonants such as the alveolars (/d, t/), and labials (/m, b, p/) (Locke, 1983) and few dorsals (Stoel-Gammon, 1985). Complex sounds such as liquids (/l, r/) and consonant clusters are infrequent or are not present (Vihman, Macken, Miller, Simmons, & Miller, 1985).

Locke (1983) has noted that /h/, /d/, /b/, /m/, /t/, /w/, and /j/ were reported as the most frequently occurring consonant-like sounds. Furthermore, 12 sounds were found to make up between 92 and 97% of the total sounds used by 11-to 12 month old infants across three studies. Roug et al. (1989) studied place of articulation, manner of articulation, and assigned babble sounds to phonotactic categories for infants from 1 to 20 months of age. They found that, of the 11 types of place of articulation recognized by the IPA, 92% of the babbles were one of four types: bilabial, dental-alveolar, velar, and glottal; while 4% were palatal, 3% were uvular, 1% was labio-dental, and 0% was all of the remaining 4 types of place of articulation. Of the four infants in the studied, three initially produced mostly glottal consonants. In addition, they observed variability among and within infants across the age range studied. The same study also looked at manner of articulation, 9 of which are recognized by the IPA. They found that the infants in the study produced predominantly stops, nasals, and fricatives (91 %); and few of the others: semi-vowel (4%), lateral (3%), trill (2%), the remaining three (0%). Davis and MacNeilageôs (1995) study also offered some information on the use of consonants during the canonical babbling period. Their study showed much individual variability, however some overall trends were identified. The most frequently produced consonants were labials /b/, /m/, /w/, alveolars /d/, /n/, and velars /g/, /ɖ/. They found that oral stops occurred with the highest frequency, followed by nasals and glides.

Studies of early-developing consonants (stops, nasals, and glides) in babbling have shown that most of the variance in consonants and their associated vowels, both within and between syllables. Neumann, Davis and Mac Neilage (2000) suggested that this is due to a ñframeò produced by mandibular oscillation, with very little active contribution from intra-syllabic or inter-syllabic tongue movements. In a study of four babbling infants, the prediction that this apparently basic ñframe dominanceò would also apply to late-developing consonants (fricatives, affricates, and liquids) was tested. With minor exceptions, confirming evidence for both the predicted intra-syllabic and inter-syllabic patterns was obtained. Results provided further evidence for the frame dominance conception, but suggest that the early rarity of late-developing consonants may be primarily a result of intra segmental production difficulty.

Syllable shapes in the first year

In a typical utterance, consonants and vowels never appear in isolation but are produced serially. This phenomenon of serial ordering is one of the most distinctive properties of speech production. The combination of consonant-and vowel-like sounds is said to begin during the Exploration Stage at about 4 to 6 months. During the later babbling period, open syllables or syllables ending in a vowel are the most frequently occurring syllable shapes (Bauman-Waengler, 2000). Kent and Bauerꞌs (1985) study revealed syllable shapes that were predominant during the babbling period. They found that V, CV, VCV and CVCV syllable structures accounted for approximately 94% of all the syllables produced at the end of babbling period. They also emphasized that while closed syllables occurred, they were found to be very limited in the repertoire of the infant at this stage of development. Children tend to favor open (CV) as opposed to close (CVC) syllable types (Oller & Eilers, 1982; Stoel-Gammon, 1985; Vihman, 1992).

Robb and Saxman (1990) examined the continuity in development of syllable duration patterns in 7 young children as they progressed from pre-word to multiword periods of vocalization development. Using a combination of lexical and chronological age points, monthly vocalization samples were analyzed for bi-syllable duration and final syllable lengthening. The results suggested that, the regularity in final syllable lengthening is consistent with a continuity theory of development.

Pre-linguistic babbling often seems remarkably speech-like, not because it has recognizable words but because it seems to have adult-like prosody. The prosodic correlates of stress in babbling were investigated by Davis, MacNeilage, Matyear, and Powell (2000). They compared disyllabic sequences from five infants and five adults in terms of the use of frequency, intensity, and duration to mark stress. Significantly larger values for the three acoustic variables were observed on stressed than on unstressed syllables independent of syllable position for both groups. Adults showed the correlates of utterance final syllables-lower fundamental frequency, lower intensity, and longer duration; infants showed only decrease in intensity. Ratios for stressed to unstressed syllables and participation of the three variables in stress production in individual disyllables were highly similar in both groups. No bias toward the English lexical trochaic stress pattern was observed. It can be concluded that infants in English environments produce adult-like stress patterns before they produce lexical items, which specify stress. Acoustic and perceptual analyses are used to explore stress marking by pre-linguistic infants in an English language environment. Results showed that infants employ the three acoustic correlates of stress in individual syllables in a manner largely similar to that of adult speakers, although they do not show second-syllable declination effects or an English language trochaic stress bias. The results of the study by Ducey, Abry and Vilain (2006) showed that between 6 and 9 months, there is very few CVCV (between 1% and 10 %) verses other productions in babbling. At 10 months, the proportions increase dramatically to reach a peak of 40 % of the babbling productions at 11 months. At the age of 13 and 14 months the figures decrease and there is less CVCV than other patterns in the production of the child. The very strong persistence of these patterns in languages as well as their presence at the onset of speech-like vocalizations in infants indicates that they reflect fundamental properties of the speech production system.

MacNeilage et al. (2000) analyzed dictionary data for the three predicted CV co-occurrence in ten languages: English, Estonian, French, German, Hebrew, Japanese, New Zealand Maori, Ecuadorian Quichua, Spanish and Swahili using chi square analysis. Observed frequencies exceeded expected frequencies for labial-central pairs in 7 languages, for coronal-front pairs in 7 languages, and for dorsal-back pairs in 8 languages. Mean values across the ten languages were labial-central, 1.10, coronal-front 1.18; and dorsal-back, 1.27. Japanese was the only language that did not show an overall average above 1.0 for the three categories combined. Rousset (2004) examined 14 languages from the ULSID database (Maddieson, 1984). The languages were Afar, Finnish, French, Kannada, Kanouri, Kwakwǒala, Navaho, Ngizm, Nyah Kur, Quechua, Sora, Swedish, Wa,Yupǒik, and !Xoo. In CV forms, very few exceptions to the predicted CV co-occurrences were found. The labial-central trend was not found in Navaho, Thai, and! Xoo and the coronal front co-occurrences were not found in Kwakwǒala.

The Transition Period: From Babbling to Meaningful Speech

The transition period is best defined by certain developmental events. It begins with the onset of comprehension of the adult language, and it closes when usage of words begins to dominate babble. The age range in which these developments occur is extremely variable. Some normally developing children fail to produce many recognizable words before the age of 2, although they will show evidence of good language comprehension long before this time. For many, and perhaps most children, the transition to speech will occur during the period from about 9 to 18 months. The transition from babbling to meaningful speech is a very important milestone in the development of articulation and phonological skills. It is at this point that the child moves from pre-linguistic to linguistic phonological development. There is typically an overlap of a few weeks to several months in the use of babbled and meaningful productions (Stoel-Gammon & Dunn, 1985). Children may even use a combination of babbling and meaningful speech in a single utterance (Branigan, 1977). A childôs first meaningful productions have been labeled protowords (Menn, 1983). Protowords are also known as vocables (Ferguson, 1978), phonetically consistent forms (Dore, Franklin, Miller, & Ramer, 1976), invented words (Locke, 1983), sensori-motor phonemes (Carter, 1979) and quasi-words (Stoel-Gammon & Cooper, 1984) are vocalizations absent of a recognizable adult model that are consistently by the infant. These sounds or sound combinations function as words for the infant, even though they are not based on the adult model. Because they are not based on the adult words, these vocalizations do not quantify as ñtrue wordsò. However, they cannot be considered babbling either because they have some phonetic consistency (Stoel-Gammon & Dunn, 1985). Ferguson (1978) described protowords as ñbabbling-like sounds used meaningfullyò. Protowords are frequently tied to a specific context and are often accompanied by a consistent gesture. These vocal productions have frequently been considered the link between babbling and adult-like speech. Researchers have reported four phonetic forms that are frequently used in protowords: (1) single or repeated consonant vowels, (2) syllabic nasals, (3) syllabic fricatives, and (4) single or repeated consonant vowel syllables in which the consonant is a nasal or a stop (Ferguson, 1978; Halliday, 1975; Lewis, 1951).

Phonetic characteristics of late babbling and early words

Vocalization at the end of the first year begins to be affected by the phonetic makeup of the specific language of the childõs environment and is not markedly different when an adult word is intended. Several detailed reports are available on the phonetic characteristics of the vocalizations during this period. Carter (1979) studied the progression from protowords to real words in a single subject. Carter termed the subjectõs productions ñsensori-motormorphemesò. She reported that between the ages of 1 year, 1 month, and 1 year 2 months, the subject produced vocalizations that differed from babbling in that it had some phonetic consistency and were frequently accompanied by a gesture.

Ferguson (1978) stated that children develop about 12 vocables as they undergo transition from babbling to the use of adult-based words, which was contradicted by Stoel-Gammon and Cooperõs (1984) study. Their study with 3 subjects showed greater variation among children. Stoel-Gammon and Cooper found that 1 subject used 13 vocables during the acquisition of 50 conventional words, while the other 2 subjects used only one vocable each during the same period.

Infants do not typically stop babbling when they begin producing words, and the words are highly idiosyncratic. Elbers and Ton (1985) suggests that the source of this idiosyncrasy "might be found in the child's speech-concurrent babbling". They also suggest that language acquisition may serve a dual role for the infant. To study these issues, Elbers and Ton (1985) recorded the play-pen monologues of a 1-year-old Dutch boy for 20-30 minutes each day while he played in his play-pen, for a period of six weeks. Prior to the study, the child had acquired two word-like forms and one word. The mother kept a diary and noted occurrence of new words. During the study, the infant acquired 4 new words, and it was found that prior babbling "prepared for" the selection and production of these words.

Stoel-Gammon and Cooper (1984) studied three infants from the beginning of the late babbling stage through the acquisition of the first 50 words. Their goal was to study the relationship between word acquisition and phonological development. They distinguished between (1) babbling (no consistent sound-meaning relationship), (2) acquisition of adult words (i.e., identifiable based on adult word), and (3) creation of child-based "quasi-words" (having consistent sound-meaning relationship, but not based on adult model). They noted that several of the phones produced by the infants during babbling are not phonemes of English, and therefore, they will never appear in real words. They conclude that an infant uses a limited number of "patterns" in the first words. These results directly challenged several of Jakobson's claims about the acquisition of language.

Locke (1985) notes that a number of investigators have reported that there is a tendency for words for 'father' to appear earlier than words for 'mother'. Such "gender" references are common across cultures. In English, 'dada' is produced before 'mama'. Locke summarizes a number of studies on the learning of words and concludes that "children aged 1.4 to 1.10 years were significantly more likely to it attempt the name of an object if it contained sounds the children were able to say". Many infants render 'papa' as 'baba' because they may, in fact, perceive [b] and [d] as voiceless, un-aspirated stops. Also, infants "are more likely to say a bilabial or an alveolar stop than they are to say a bilabial nasal". Only about 10% of infants have a preference for producing bilabial nasals.

Kent and Bauer (1985) described the syllable structures, vowel-consonant-like segments, and intonation contours used by five 13 month old children. They noted a difference in consonant use in vocalizations of different structures. Although stops dominated consonant use in CV vocalizations, they made up less than half of the consonants in VCV vocalizations and were greatly exceeded by fricatives and nasals in VC vocalizations. Bilabial and apical consonants were used most often and the consonant clusters were very rare. They found that the most common vowels used were central, mid-front, and low-front ([^, e, Θ]), while high vowels ([i, u]) were rare. Of the various intonation contours used, the fall and rise-fall accounted for over 75 percent of all vocalizations; a simple rising contour accounted for 10 percent more. Kent and Bauer stressed the fact that in all respects, the vocalizations of 13-month-olds were continuous with the vocalizations of younger children and children in the second year of life.

Davis and MacNeilage (1990) described vowel production for one child learning English (14 to 20 months). They found the high use of [i], especially in the second syllable of word productions. Their results also implied the interaction of consonant and vowel productions. High-front vowels were found to occur most frequently following alveolars, high-back vowels after velars, and central vowels after labials. In a replication of this analysis based on 23 subjects learning four languages-English, French, Japanese and Swedish, Vihman (1992) reported some of the same associations. Both velars and back vowels were rare, but they tended to be produced together when they did occur. Labials were typically followed by central vowels in the vocalizations of several children. Alveolars were not significantly associated with front vowels.

Sussman, Minifie, Duder and Stoel-Gammon (1996) studied Consonant-vowel productions at two distinct stages of language development in a single female child. At 12 months canonical babbling syllables identified by a panel of listeners as comprising of CV tokens which were acoustically analyzed by measuring F2 transition onset and F2 mid vowel frequencies and plotting their relationship as locus equations for each stop category. A regression analysis performed on these scatter plots revealed differential slopes and y-intercepts as a function of stop place. The same analysis was performed 9 months later on CV utterances produced as syllable-initial segments of real words by the same child. Whereas labial and velar locus equation parameters moved towards more adult-like values, alveolar slope and y-intercept moved away from adult values and more in the direction of decreased co-articulation between vowel and consonant. There was greater scatter of data points around the regression line for production of words compared to babbling. These results are compared to locus equations obtained from 3ï 5-year-olds and adults.

Social Interaction and Babbling

Social interaction certainly plays a role in the infant's acquisition of speech. A number of studies have examined this issue. Toda et al (1990) studied the interactions between a mother and her infant. Both Japanese and American mother/infant pairs were studied. They hypothesized that maternal speech serves two purposes: (1) as input for language acquisition, and (2) as socialization for culturally appropriate communication.

Siegel, Cooper, Morgan and Sarshad (1990) have studied if 9 to 12 month old infants spontaneously imitate either the average fundamental frequency or the fundamental frequency contour of their speaking partners. No tendency was found for infants to adjust vocal pitch, amplitude, or duration of either the father or the mother in a laboratory setting. However, infants are clearly able to control their fundamental frequency and have been observed using different registers.

Cross-Linguistic effects in Babbling

The importance of understanding babbling is increased by the fact that certain babbling preferences are also present in the worldôs languages. Some features of infant babbling are found to be the same across linguistic environments while others differ. The CV syllable, the most favored syllable type of babbling is considered to be the only universal syllable type in languages. Consonants favored in babbling ï simple stop consonants and nasals are highly frequent in the worldôs languages (Maddieson, 1984) and tend to dominate the repertoire of languages with small systems (less than 15 phonemes) containing a few segments characterized as articulatory ñsimpleò (Lindblom & Maddieson, 1988; Lindblom, Krull, & Stark, 1993).

In later studies, some effects due to linguistic context have been seen, especially in relation to vowel formant frequencies and variability. Boysson-Bardies, Halle, Sagart and Durand (1989) carried out a cross-cultural investigation of the influence of target-language in babbling. 1047 vowels produced by twenty 10-month- old infants from Parisian French, London English, Hong Kong Cantonese and Algiers Arabic language backgrounds were recorded in the cities of origin and spectrally analyzed. FI-F2 plots of these vowels were obtained for each subject and each language group. Statistical analyses provide evidence of differences between infants across language backgrounds.

Levitt and Utman, (1992) found that American and French infants produced vowels with different formant frequencies and variability from 5 months of age onward, suggesting that linguistic experience affects the earliest babbled vowels. They also found adjustments in duration of final and non-final syllables that reflect trends in the infant's target language.

De- Boysson-Bardies (1993) studied groups of five 10-12 month old infants from four different language communities (French, English, Swedish and Yoruba). She found predicted CV patterns in the infants to be influenced by the characteristics of the target language. Labial-central vowel association for initial syllables was found for French, Swedish, and Yoruba infants. American infants showed an association between labials and front vowels.

The drift in babbling towards features of native language environment is easier to demonstrate for vowels than for consonants, since infants in many language environments prefer the same consonants. Instead of consonantal preference, Patricia and Joanna (2006) compared the features of consonantality, consonantal repertoire, and consonant combinations across three different groups of infants: Italian-hearing, English-hearing, and Japanese-hearing. Italian-Canadian and Japanese infants were video recorded at home interacting with their mothers for 30 minutes. Six Italian-Canadian infants who heard mostly Italian from their mothers (more than 75%) were selected. Six Italian-Canadian infants who heard mostly English from their mothers (more than 70%) were selected. These infants had been visited twice between 9 and 10 months. Six Japanese infants were selected who had had two sessions at the same ages as the Italian-Canadian infants. In all groups there were 3 males and 3 females. All infant vocalized utterances were transcribed into phonetics, utterances being separated by more than 2 sec. Consonantal repertoire was the number of consonants used more than once .The 3 groups were compared on the consonantal features using ANOVA. The only group difference was in consonantal repertoire, the Japanese infants had a larger repertoire than English-hearing infants. The results indicated that between 9 and 10 months, these cultural groups are quite similar in their use of consonants in babbling. Japanese-hearing had a greater variety of consonants in their babbling but was not more consonantal or more complex. It may be that their larger repertoire is based on the fact that Japanese is basically a CV language and that initial consonants in a syllable are more salient.

Indian studies on babbling

With the growing concern that the infant population must be evaluated and served and that important communication milestones indeed occur in infancy, an increased knowledge base of early speech development has emerged in recent years especially in the western context. However, in the Indian scenario, such reports on children as young as that are rare. A study on the developmental milestones of language acquisition in Indian Languages (Kannada and Hindi), by Shyamala and Basanti (2003) revealed that the cardinal vowels /i/, /e/, /a/ /u/ and /o/ made their appearance by 6-12 months of age in Kannada. However, longer counterparts of vowels /i/, /e/ and /o/ were not present in all the subjects. Among the consonants, stops and nasals had higher frequency of occurrence and glides and glottal fricatives were among the less frequently occurring consonants. In Hindi, only four vowels (/i/, /e/, /a/ and /u/) including their longer counterparts were seen. Hindi group had a repertoire of 15 consonants whereas the Kannada group had 12 consonants and the additional sounds seen in Hindi group were /T/, /s/ and /r/.

A study of phonotactic development in Kannada by Rupela and Manjula (2006) with 30 Kannada speaking children in the age range of 0-5 years, divided into 9 age groups with 6-months interval revealed certain patterns of syllables and word shapes. The various syllable shapes, which were found in the samples analyzed, were V, C, CV, VC and CVC. CV syllables were found to be most commonly occurring syllables gradually increasing in frequency of occurrence between 0-18 months. VC syllables were found to occur occasionally at 12 months and gradually increased in frequency by 54-69 months. CVC syllables were reported to occur at 12 months increasing in frequency by 54-60 months.

A cross sectional study was conducted in Kannada by Anjana and Sreedevi (2008) on 30 typically developing infants in the age range of 6-12 months, divided into 6 age groups with an age interval of one month. The phonetic repertoire of vowels, consonants and syllable shapes were established. The vowel repertoire consisted of [I, e, æ, a, u, o], consonantal repertoire consisted of 14 consonants [p, b, m, n, t, d, ɩ̄̋, ˧, h, k, g, l, j, v] and the syllable shapes found were V, C, CV, CVC, VC, and VCV. Reduplicated babbling consisted of reduplication of simple CVCV productions. The variegated form of babbling began at 8-9 months and gradually increased with age. The most common form of variegation was place changes, followed by manner changes and a combination of place and manner variations. In comparison of reduplicated and variegated babbling, reduplicated babbling exceeded variegated babbling in all the age groups.

The continuity view of the babbling to speech relationship has gained much support over the past decade, considering research with the infants who were normally developing and those with developmental delays/disorders. Many researchers have demonstrated similarities in the syllable shapes and consonant types between late babbling and early speech, with those patterns produced in first spoken words. It is now widely agreed that the babbling of deaf and hearing infants differs substantially (Eilers & Oller, 1994), particularly in the onset of canonical syllables (those with adult-like acoustic features). In addition, it has been demonstrated that infants who have undergone tracheotomies do evidence delays and disorders in spoken language (Loke & Pearson, 1990), and that the severity of phonological delay is highly correlated with the length of time the infant remains without the ability to vocalize.

Also investigations have been conducted on the pre-speech vocal development of infants who have Down syndrome (Lynch, Oller, Eilers, & Basinger, 1991; Oller & Seibert, 1988; Smith & Oller, 1981; Steffens, Oller, Lynch, & Urbano, 1992). These studies have yielded conflicting findings regarding differences in the babbling of infants with Down syndrome compared with those who are developing normally, with further investigations required to resolve this issue. As research is illuminating what factors related to vocal development place an infant at risk for, or with pre-linguistic phonetic delay, the clinical identification of these infants has become a reality. Both formal and informal assessment instruments are available to evaluate the vocal development of infants prior to the emergence of spoken language. Given the growing body of research that suggests that babbling and speech are related, and that babbling can be delayed or different in populations with known developmental delays, it is important that speech/language pathologists conduct careful analyses of infant babbling development in order to determine the infantǿs developmental status related to pre-speech vocalizations, and to identify those children who are at potential risk in this developmental skill.

CHAPTER III

METHOD

The aim of the present study was to understand the longitudinal development of babbling and to establish qualitative and quantitative database on the development of babbling in infants from native Kannada speaking homes in the age range of 3 months to 12 months.

Participants: A total of 20 infants in the age range of 3-12 months from native Kannada speaking homes were recruited for the study. Among them only parents of 9 infants gave consent to participate in the study after the requirements of the study were fully explained. Nine typically developing infants [four males (M1, M2, M3 AND M4) and five females (F1, F2, F3, F4 and F5)], in the age range of 3-12 months from native Kannada speaking homes were selected as infants for the study. The infants were identified from hospitals, pediatric clinics, nursing homes and immunization centers in the city of Mysore. The purpose and relevance of the study was explained to the parents of infants and a written consent (Appendix 1) was obtained prior to the recording of the sample.

Infants selection criteria were as follows:

- It was ensured that infants had exposure to Kannada language primarily as participants from native Kannada spoken family were recruited, based on the research evidence that the characteristics of babbling can vary across languages.
- Parent case history reports, informal behavioral hearing screening and the Assessment Checklist for Communication skills (Developed by Department of Prevention of

Communication Disorders, AIISH) were utilized to establish normal development and chronological age-level performance of the infants.

- Infants with normal developmental milestones in all the domains of development were considered for the study.
- The selected infants belonged to middle socio-economic class and both of the parents were educated up to a minimum of 12th class.
- It was ensured that the parents were cooperative to participate in the study and also provided adequate speech stimulation to their infants.

Table 2 shows the recording details of each infant.

Infants	Commencement of Recording age (months)	Gender	Age in Months during which the recordings were carried out	No of recordings for each infant
M1	3.6	M	3.6, 4.6, 5.6, 6.6, 7.6, 8.6, 11.6	7
M2	3.6	M	3.6, 4.6, 5.6, 6.6, 7.6, 9.6, 10.6, 11.6	8
M3	4	M	4, 5, 6, 7, 8, 9, 10, 11	8
M4	5	M	5, 6, 8, 9, 10, 11	6
F1	3	F	3, 4, 5, 7, 8, 9, 11	7
F2	4	F	4, 5, 6, 7, 8, 9, 10, 11	8
F3	4	F	4, 5, 6, 7, 8, 11	6
F4	6	F	6, 7, 8, 9, 10, 11	6
F5	5.6	F	5.6, 6.6, 7.6, 9, 11	5

Table 2: Shows the recording details of each infant.

Three infants (M1, M2 & F1) were recruited at the age of 3 months. But recording for two infants (M1 & M2) began at the age 3.6 months since the infants were not keeping well at the time of recording i.e., at the age of 3 months. Infants M3, F2 and F4 were recruited at the age of 4 months. Infants M4, F4 and F5 were recruited at the age of 5 months but the onset of recording for F4 and F5 began at 6 and 5.6 months respectively because they were not in the city. Attempts were made to collect the data through audio cassettes and mobile phones but the quality of the data was not good enough for transcription and in some cases the data collected did not meet the criteria for considering the recording for the study (a minimum of 50 utterances of each recording were selected and subjected to further sound by sound analysis).

Data Recording: Data collection was initiated at the completion of 3 months of age by the infants. The details of recording for each infant are listed in the Table 2. For 3 infants (M1, M2 and F1) the recordings started form the age of 3 months. For M3, F2 and F3 the recordings were initiated form the age of 4 months onwards. With M4 and F5 the recordings started at 5 months and one infant (F4) was recorded from the age of 6 months onwards.

Data recording procedure: Each infant was visited at home, once in a month interval over a period of three months to 12 months of infantés age. Simultaneous audio and video recordings lasting about half an hour each were made every month until the infants were 12 months. That is, each infantés sample was recorded nine times, from 3 months of age until the infant completed 12 months of age. Recordings were carried out when the infant was fed and was in a comfort state using a digital video recorder (Sony Handy cam DCR DVD 908). The recordings were carried out in a quiet environment in a semi-structured manner, where one parent interacted with the infant and the experimenter was a passive observer. Parents were instructed to engage in play or other interaction with their infants as they normally would, allowing for natural pauses and breaks within the interaction sequence. The parent-child interaction and the use of toys were used to elicit verbal utterances.

Parents were inquired regarding the representativeness of the infantós vocalizations after recording the sample. In cases where the recorded sample was not typical of the infantós vocalizations, the recording was repeated and an alternative sample was utilized that was judged to be representative for that particular infant. And in some instances, a second recording was carried out, if the first recording was not representative due to, for instance, illness of the child and if a minimum of 50 utterances was not present in the collected sample. Number of recordings in each month varied as all the infants recruited were not available across the ages 3 -12 months.

Data reduction: A total of 60 recordings were subjected to editing to facilitate further analysis. The editing was accomplished using editing software Video Studio 11, Inter Video Digital Technology Corporation (2007). 30 hours of spontaneous data were edited to eliminate the parentós and siblingós verbalizations and the infantós vegetative vocalizations (such as cries, burps, coughs etc.) without affecting the infantós babbling like vocalizations. From the 60 minutes duration recording only the infantós speech-like utterances was retained for analysis. From this sample, a minimum of 50 utterances of each recording were selected and subjected to further sound by sound analysis.

Data analysis: The selected utterances were phonetically transcribed for each of the infant separately using the International Phonetic Alphabet (IPA) with broad phonetic transcription conventions. Interjudge-reliability of phonetic transcription was evaluated by point to point agreement for the two transcribers (researcher and a linguist) for 70 percent of the selected samples. A total of 7235 utterances including vowels, consonants and diphthongs were analyzed for several parameters under investigation after transcribing the required data. The selected utterances for each infant in the age range of 3 to 12 months were analyzed for their relative frequency of occurrence of sounds and the characteristics of the multisyllabic utterances were analyzed. Only typical verbal utterances were considered in the present study.

Vowels: Vowels were grouped according to tongue height, tongue advancement variations and also according to the duration of its production Tongue height variations included high [i, u], mid [e, o] and low [æ, Ö, a] categories. And tongue advancement variations included front [e, æ, i], central [a, Ö] and back [u, o] categories. Vowels classified according to the duration of its production included short [æ, Ö, a, e, i, u] and long [æ:, Ö:, a:, e:, i:, u:] categories. The vowels were quantitatively analyzed and their frequencies were established for each of the vowel group separately. This was calculated for each infantôs monthly recording in the age range of 3 to 12 months. Later the raw scores were converted to percentage scores for each of the infant separately. Percentages of occurrence of different categories of vowels were tabulated for all the infants using the following formula (Valleman, 1998).

$$\textbf{Percentage of vowel a/i/u/e/etc} = \frac{\textbf{No. of vowel a/i/u/e/etc}}{\textbf{Total No. of vowels}} \times 100$$

Consonants: The consonants were grouped based on manner and place of articulation dimensions and voicing dimensions. Manner of articulation variations included stops, nasals, continuants, laterals and fricatives (glottal). Place of articulation variations consisted of bilabial, dental, palatal, velar and glottal. The consonants were also qualitatively analyzed for the occurrence of voiced and unvoiced counterparts. The consonants were quantitatively analyzed and their frequencies were established for each of the consonant group separately. This was calculated for each infantós monthly recording in the age range of 3 to 12 months. The raw scores were converted to percentage scores for each of the infant separately. Percentages of occurrence of different categories of consonants were tabulated for all the infants using the following formula,

$$\textbf{Percentage of consonants k/g/t/d/etc} = \frac{\textbf{No. of consonant k/g/t/d/etc}}{\textbf{Total No. of consonants}} \times 100$$

Syllable shapes: The various syllable shapes that were found in the babbling samples of 9 infants were analyzed. Singleton consonants and vowels were also considered under syllable shapes. V, C, CV, VC, CVC and VCV syllable shapes were identified and transcribed from the recorded samples. Inventories of syllable shapes were established and tabulated for all the infants. The frequency of occurrence of each of these syllable shapes was determined for each infant separately. The percentage of occurrence of V, C, VC, CVC and VCV syllables were calculated using the formula,

$$\textbf{Percentage of CV syllables} = \frac{\textbf{No. of CV syllables}}{\textbf{Total No. of syllables}} \times 100$$

Multisyllabic utterances: Apart from these syllable shapes, multisyllabic utterances consisting of varied patterns such as CVCV, VCVCV were found in the samples analyzed. The multisyllabic utterances were characterized as belonging to either reduplicated or variegated utterances. Sequences in which the second CV consisted of the same phonemes that are present in the first CV were assigned to the category of reduplication, including a variation in the vowel such as [bababa], [pepepa] etc. All other multisyllabic utterances that had variations within the vowel and/or consonants were assigned to the category of variegation such as [putika], [matika] etc. Inventories of multisyllabic utterances were established and tabulated for all the infants. The raw scores were converted to percentage scores for multisyllabic utterances and for the reduplicated and variegated babbling utterances. The percentage of reduplicated and variegated babbling was calculated using the following formula:

$$\textbf{a) Percentage of Reduplicated babbling} = \frac{\textbf{No. of reduplicated utterances}}{\textbf{Total No. of multisyllabic utterances}} \times 100$$

$$\textbf{b) Percentage of Variegated babbling} = \frac{\textbf{No. of variegated utterances}}{\textbf{Total No. of multisyllabic utterances}} \times 100$$

Statistical analysis

Descriptive statistics was used to statistically analyze the data. Quantitative and qualitative analysis were used to describe the phonetic repertoire of each participant separately.

CHAPTER IV

RESULTS

The aim of the present study was to understand the longitudinal development of babbling and to establish qualitative and quantitative database on the development of babbling in infants from native Kannada speaking homes in the age range of 3 months to 12 months Since the data was on longitudinal development of babbling, certain criteria were considered in the present study. The criteria are as follows:

a) The data recorded every month was considered for analysis only if more than 50% of the infants recruited in the study (i.e. 5 out of 9 infants) in that particular month.
b) In an individual infant, a particular phoneme was considered to be present only if the occurrence was three or more times.

The results are discussed under the following sections:

1. Vowels
2. Diphthongs
3. Consonants
4. Contextual specificity of vowels with certain consonants
5. Syllable Shapes
6. Percentage of Reduplicated and Variegated babbling

1. VOWELS

In the present study, eight vowels were predominantly observed considering all nine infants. Less occurring vowels were six. All vowel like utterances which amounted to 14 in number in the sample were transcribed and analyzed for each of the nine infants separately in the age range of 3-12 months from the entire corpus of 7233 utterances. The vowel corpus alone amounted to 4454. The vowels were phonetically transcribed using Kannada Phonetic Alphabet (broad transcription method) and were classified into the following categories:

1. Vowels classified according to tongue height - high [i, u], mid [e, o] and low [æ, Ö, a]
2. Vowels classified according to tongue advancement - front [e, æ, i], central [a, Ö] and back [u, o]. The longer counter parts of these vowels were also seen

Vowel [Ö] is not represented in the Kannada vowel quadrilateral. However it is represented in the American English Vowel quadrilateral and was observed in the vowel repertoire of the present infants.

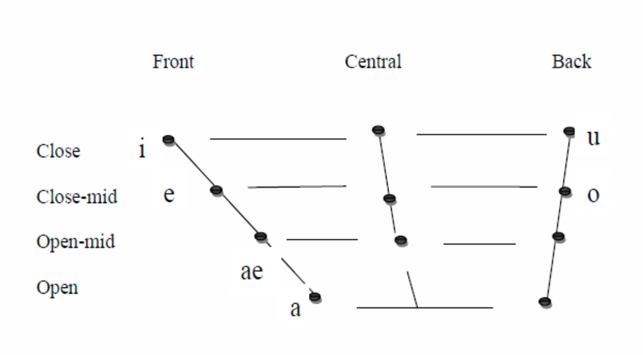


Fig 3: Shows the vowel quadrilateral of Kannada vowels

(From: Schiffman, H. 1983. *A Reference Grammar of Spoken Kannada.* Seattle: University of Washington Press.
Sridhar, S.N. 1990. *Kannada.* London: Routledge.)

Vowel data across age

Major vowels produced: The frequency of occurrence of each of the individual vowel for all infants in the age range of 3-12 months was established. Some of the vowels /i/, / i:/, /u/, /u:/ and /o:/ are not considered for statistical analysis as they occurred in less than 50 % of the subjects. Table 3shows the percentage of infants producing vowels considered in the age range of 3-12 months.

Age (in mts)	[æ]	[æ:]	[∂]	[∂:]	[a]	[a:]	[e]	[e:]
3-4	**Not considered as only 3 out of 9 subjects were present for recording**							
4-5	**(1)**	**83.3(5)**	**100(5)**	**100(6)**	**(2)**	**(2)**	**(1)**	**83.3(5)**
5-6	**62.5(3)**	**100(8)**	**75(6)**	**(2)**	**(1)**	**(4)**	**62.5(5)**	**75(6)**
6-7	**66.6(6)**	**100(8)**	**100(8)**	**87.5(8)**	**(2)**	**87.5(7)**	**(2)**	**75(6)**
7-8	**57.1(6)**	**87.5(7)**	**100(8)**	**87.5(7)**	**57.14(4)**	**87.5(7)**	**(2)**	**62.5(5)**
8-9	**71.4(4)**	**85.7(6)**	**85.7(6)**	**85.7(6)**	**(2)**	**85.7(6)**	**(2)**	**85.71(6)**
9-10	**(2)**	**85.7(6)**	**(2)**	**71.4(5)**	**(0)**	**71.4(5)**	**(2)**	**71.42(5)**
10-11	**60(4)**	**100(5)**	**60(4)**	**100(5)**	**(2)**	**80(4)**	**60(3)**	**100(5)**
11-12	**(2)**	**100(8)**	**75(6)**	**62.5(5)**	**50(4)**	**100(8)**	**50(4)**	**87.5(7)**

Table 3: Percentage of infants producing vowels in the age range 3-12 months. (The number of infants producing the particular vowel is given in parenthesis)

75 ï 100 %, 50-75%

The 8 vowels seen in more number of infants are **[æ], [æ:], [∂], [∂:], [a], [a:], [e] and [e:].** As per Table 3, the percentage of occurrence of vowels in the age range of 3-4 months was not considered as the number of recordings did not meet the criteria. In 4-5 months, the four vowels [æ:] [Ö] [Ö:] and [e:] made their appearance. Low front vowel [æ:] and mid front vowel [e:] were produced by 83.3 % of the infants. 100 % of the infants produced low central vowels [Ö] and [Ö:].

In 5-6 months, the five vowels [æ] [æ:] [Ö] [e] and [e:] occurred in more than 50% of the infants. Compared to the previous age range of 4-5 months, vowels [æ] and [e] continued to be present, however [Ö:] which was present earlier disappeared during this period. Low front vowels [æ] and [æ:] were produced by 62.5% and 100% of the infants respectively and low central vowel [Ö] was produced by 75% of the infants. Mid front vowels [e] and [e:] were produced by 62.5 % and 75% of the infants respectively.

In 6-7 months, low front vowels [æ] and [æ:] were produced by 65% and 100% of the infants respectively. 100% and 87.5 % of the infants produced low central vowels [Ö] and [Ö:] respectively. Low central vowel [a:] occurred in 87.5% of the infants and mid front vowel [e:] was present in 75% of the infants. Compared to the previous age range of 5-6 months, vowel [a:] made its appearance and vowel [Ö:] made its re-appearance from 4-5 months.

In 7-8 months, seven vowels [æ] [æ:] [Ö] [Ö:] [a] [a:] and [e:] out of the fourteen vowels were produced. Low front vowels [æ] and [æ:] were produced by 57.14 % and 87.5% of the infants respectively. 100% and 87.5 % of the infants produced low central vowels [Ö] and [Ö:] respectively. Low central vowels [a] and [a:] occurred in 57.14 % and 87.5% of the infants respectively and mid front vowel [e:] was present in 62.5% of the infants. Short vowel [e] made its reappearance from 5-6 months during this period.

During 8-9 months, vowels [æ] [æ:] [Ö] [Ö:] [a:] and [e:] continued their presence, however short vowel [a] was not present. Low front vowel [æ] was produced by 57.14% of the infants. While the remaining vowels [æ:] [Ö] [Ö:] [a:] and [e:] were produced by 87.5% of the infants.

In 9-10 months, vowels [æ:] [Ö:] [a:] and [e:] were produced. During this period, the number of vowels produced were reduced probably due to the occurrence of consonants. Low front vowel [æ:] was present in 85.71% of the infants. 71.42% of the infants produced low central vowels [Ö:], [a:] and mid front vowel [e:].

In 10-11 months, vowels [æ] [æ:] [Ö] [Ö:] [a:] [e] and [e:] were present. Short vowels [æ], [Ö] and [e] made their re-appearance from 7-8 months during this period. Low front vowels [æ] and [æ:] was produced by 60% and 100% of the infants respectively. 60% and 100 % of the infants produced low central vowels [Ö] and [Ö:] respectively. Low central vowel [a:] occurred in 80% of the infants and mid front vowels [e] and [e:] were present in 60% and 100% of the infants respectively. That is the long vowels were present in all infants.

In 11-12 months, seven vowels [æ:] [Ö] [Ö:] [a] [a:] [e] and [e:] were present. Compared to the previous age range of 10-11 months vowel [æ] disappeared and vowel [a] made its reappearance during this period. Low front vowel [æ:] was produced by 100% of the infants. 75% and 62.5 % of the infants produced low central vowels [Ö] and [Ö:] respectively. Low central vowel [a] and [a:] occurred in 50% and 100% of the infants respectively. Mid front vowel [e] and [e:] was present in 50% and 87.5% of the infants respectively. Table 4 depicts the mean and standard deviation of the frequency of vowels occurring in more than 50% of the infants.

As per Table 4, the mean and standard deviation of vowels in the age range 3-4 months was not considered as the number of recordings did not meet the criteria. In the age range of 4-5 months, the mean and standard deviation of vowel [e:] was higher. This was followed by the vowels [Ö:] and [Ö]. Whereas vowel [` :] had lower mean score of 9.8 and standard deviation of 9.64.

Age (months)	[æ]	[æ:]	[∂]	[∂:]	[a]	[a:]	[e]	[e:]
	Mean (SD)	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**
3-4	Not considered for analysis as the number of recordings did not meet the criteria							
4-5	-	9.8 (9.64)	10.33 (6.80)	15.5 (14.85)	-	-	-	20.66 (30.95)
5-6	6.37 (7.5)	11.87 (8.87)	6.25 (4.83)	-	-	-	3 (2.67)	10 (10.79)
6-7	7.37 (5.7)	19.87 (16.81)	10 (6.92)	18.75 (17.61)	-	7.62 (7.20)	-	9.37 (6.43)
7-8	4.62 (6.5)	22.75 (13.46)	14.12 (20.73)	13.12 (18.28)	2.12 (1.45)	6.87 (4.35)	-	9.87 (12.9)
8-9	4.57 (4.6)	16.57 (9.72)	4.57 (2.07)	22.14 (24.69)	-	8.14 (8.66)	-	14 (12.16)
9-10	-	21 (16.41)	-	11.85 (9.42)	-	11.28 (10.54)	-	17.42 (21.04)
10-11	2.8 (2.1)	14.6 (8.44)	8.6 (5.45)	13.4 (6.38)	-	8.8 (3.96)	7.6 (7.23)	15.2 (8.46)
11-12	-	19.87 (14.16)	4.12 (2.85)	9.25 (8.25)	7.5 (13.36)	20.37 (31.39	5.12 (6.44)	7.75 (5.17)
Total	5.14 (5.35)	17.04 (12.19)	8.28 (7.09)	14.86 (14.21)	4.81 (7.41)	10.51 (11.02)	5.24 (5.45)	13.03 (13.49)

Table 4: Mean and Standard deviation of frequency of vowels occurring in more than 50% of the infants.

- Indicates the absence of the vowel in this age range

In the age range of 5-6 months, vowels [` :] and [e:] had a higher mean and standard deviation values respectively. This was followed by vowel [`] and [Ö]. Vowel [e] had a lower mean and standard deviation value. In 6-7 months, vowels [` :] and [Ö:] had higher mean and standard deviation values followed by vowels [Ö] and [e:]. Vowels [a:] and [`] had a lower mean and standard deviation values.

In the age range of 7-8 months, the mean and standard deviation of vowel [` :] was higher. This was followed by the vowel [Ö] and vowel [Ö:]. Whereas vowels [a:], [`] and [a] had lower mean and standard deviation values.

In the age range of 8-9 months, vowel [Ö:] had a higher mean and standard deviation. This was followed by vowel [` :] and [e]. Vowels [`] and [Ö] had a lower mean and standard deviation values. In the age range of 9-10 months, the mean and standard deviation of vowels [` :] was higher followed by the vowels [Ö:] and [a:] respectively.

In the age range of 10-11 months, vowels [e:], [` :] and [Ö:] had a higher mean and standard deviation values followed by vowel [a:], [Ö] and [e] respectively. Vowel [`] has a lower mean and standard deviation value.

In 11-12 months, vowels [a:] and [` :] had higher mean and standard deviation values. Vowel [Ö] had a lower mean and standard deviation value.

Vowels seen in less number of infants*:* Table 5 shows the vowels occurring in less than 50% of the infants. High front short vowel [i] appeared at 5-6 month in infant F2 and disappeared later. And in remaining infants, the utterance of [i] were produced less than 3 times. High front long vowel [i:] was produced by only 3 infants out of 8 infants considered at 11-12 months. Only infant F4 produced it from 6-7 months to 8-9 months.

[i]	[i:]	[u]	[u:]	[o:]

Table 5: Vowels occurring in less number of infants.

High back vowel [u] appeared at 5-6 months in only one infant F2 and later it disappeared. Long vowel [u:] was produced by infant M2 at 4-5 months. Infant F5 produced it 12 times at 7-8 months and 4 times at 9-10 months during the recording sessions. And it was not present at other stages. Long vowel [o:] was produced by infant F5 at 6-7 months 34 times and 4 times at 9-10 months. Also another infant F2 produced it 3 times at 11-12 months.

Vowel characteristics of Male infants

All vowels occurring with a frequency of three times or more in each of the infants were calculated. A significant difference was observed in the frequency of occurrence of the vowels produced by male and female infants. Overall 4454 vowels including those occurring less than 3 times were transcribed for the entire group of 9 infants from 3 months to 12 months. Table 6 shows the percentage of the frequency of vowel categories (3 times/or more of occurrence) and their total number in each male infant.

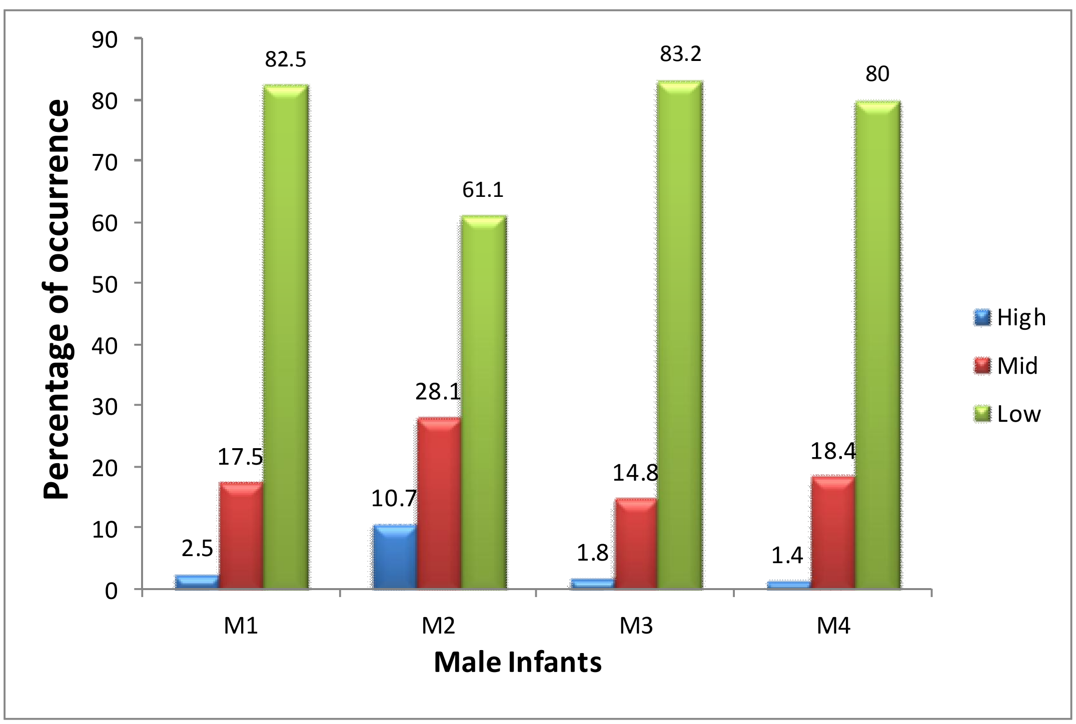
Infants							
M1		M2		M3		M4	
Vowels	%	Vowels	%	Vowels	%	Vowels	%
[` :]	23.6	[` :]	15.15	[` :]	22.73	[Ö:]	31.2
[Ö]	21.3	[e:]	14.6	[Ö:]	18.1	[` :]	26.75
[e:]	13.3	[e]	13.44	[Ö]	14.48	[e:]	13.05
[Ö:]	13.05	[Ö]	12.46	[a:]	14.48	[Ö]	7
[`]	10.8	[`]	12.2	[e:]	10.46	[a:]	6.52
[a:]	8.8	[a:]	9.53	[`]	9.85	[e]	3.98
[a]	4.7	[Ö:]	7.82	[e]	4.42	[`]	3.9
[e]	4.16	[i:]	7.82	[a]	3.62	[a]	1.75
[u:]	1.38	[a]	3.91	[u]	1.2	[i:]	0.63
[i]	0.8	[i]	0.97	[i]	0.6	[u:]	0.31
[u]	0.2	[u]	0.97	[i:]	0	[u]	0.15
[i:]	0	[u:]	0.97	[u:]	0	[i]	0.03
[o]	0	[o]	0	[o]	0	[o]	0
[o:]	0	[o:]	0	[o:]	0	[o:]	0
Total	360	409		497		628	

Table 6: Percentage of frequency of various vowels in males.

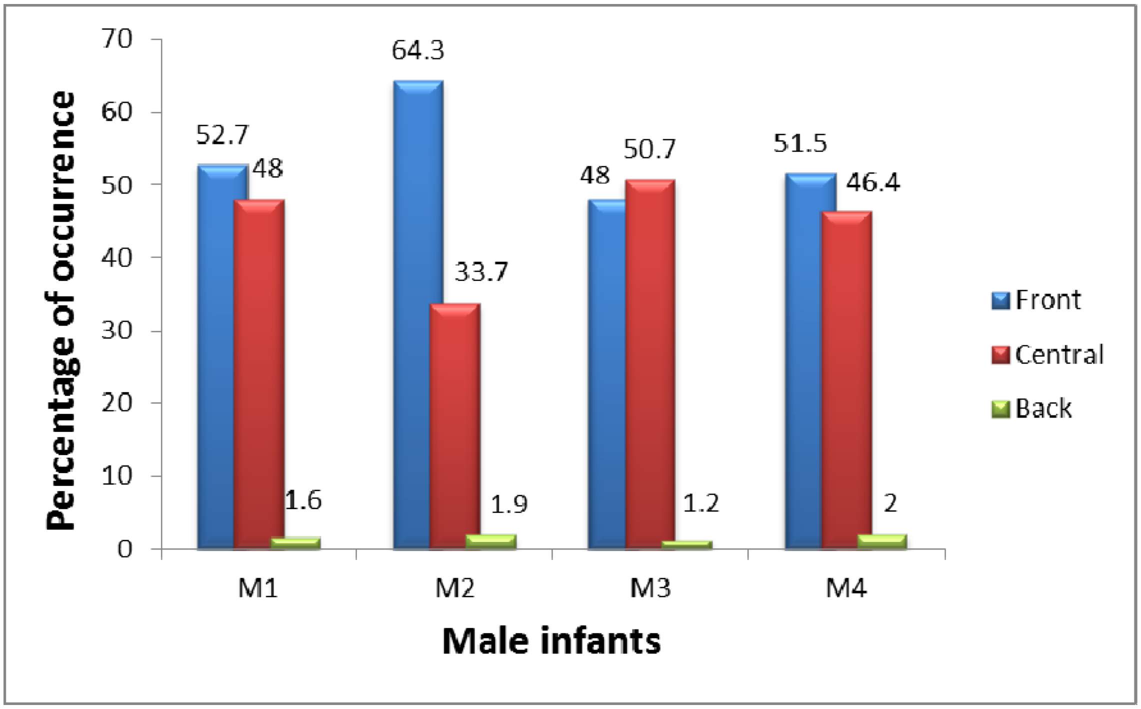
All vowels occurring with a frequency of 3 times or more in each of the four male infants are listed in Table 6. Overall 1894 vowels including those occurring less than 3 times were transcribed for the 4 male infants from 3 months to 12 months. Among the 4 male infants, the maximum number of vowels were produced by M4 (628) and the minimum by M1 (360). Vowel [æ:] strongly characterized all the male infants. This was followed by vowel [Ö] which dominated in 3 infants (M1, M3 & M4). High vowels [i] and [u] appeared with less frequency in all the infants. Vowel [o] did not make its appearance in any of the male infants.

Vowels according to tongue height and tongue advancement dimensions

Group and individual trends for vowels were apparent for vowel height and tongue advancement dimensions. Graph 1 displays each individual male infantõs percentages of vowels in the entire corpus characterized by height. Vowels were grouped into high (i, u), mid (e, o), and low (æ, Ö a) categories and their longer counter parts. Low vowels dominated the vowel types in each of the male infant. The order of frequency of occurrence is as follows: vowel [æ:] had a maximum number of frequency of utterance followed by vowel [Ö] and then vowel [a:]. Low vowels were followed by mid vowels. Among the two mid vowels (e, o), vowel [e] dominated in its frequency of occurrence in all the male infants whereas, vowel [o] did not make its appearance in the age range of 3 months to 12 months. High vowels were the least occurring vowel type. Among high vowels (i, u), infant M2 produced vowel [i:] with a relatively high occurrence (7%) followed by vowel [u]. Other infants M1, M3 and M4 produced high vowels with a very less percentage of occurrences. Vowels according to tongue height and tongue advancement dimensions in male infants are presented in Graphs 1 and 2 respectively.



Graph 1: Percentage of occurrence of vowels in males according to tongue height dimension.



Graph 2: Percentage of occurrence of vowels in males according to tongue advancement dimension.

In males, based on tongue advancement dimension, vowels were grouped into front [e, æ, i], central [a, Ö] and back [u, o] categories and their longer counter parts. Front and central vowels account for the largest occurrences in the data. Front vowels [æ:] was followed by [e:] were significantly produced by three male infants (M1, M2 & M4) followed by [i]. Long central vowels dominated in infant M3. Central vowel [Ö] predominated in the frequency of occurrence. Back vowel [u] was present in a meagre percent in the utterances whereas vowel [o] was not present in any of the male infants.

Vowel Characteristics of Female infants

Table 7 shows the percentage of frequency of various vowel categories (more than 3 times of occurrence) and total number of vowels produced by each female infant.

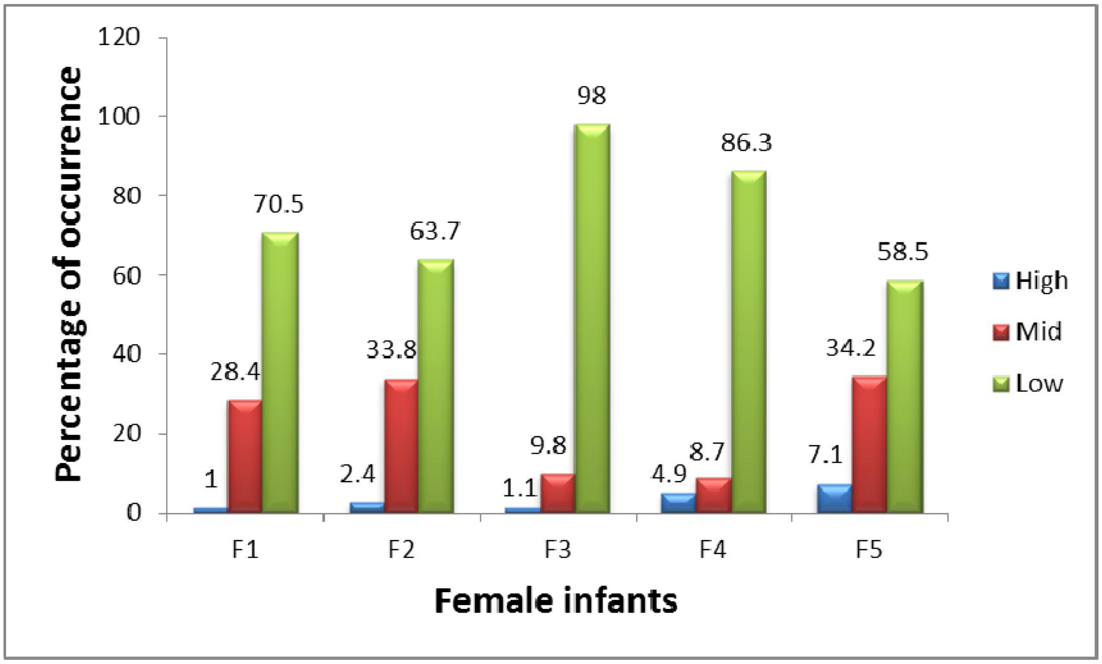
Infants									
F1		F2		F3		F4		F5	
Vowels	%	Vowels	%	Vowels	%	Vowels	%	Vowels	%
[Ö:]	34.15	[e:]	23.85	[` :]	34.08	[` :]	25.96	[` :]	26.24
[e:]	25.5	[a:]	22	[Ö:]	15.91	[a:]	25.96	[e:]	20.99
[` :]	17.86	[` :]	17	[Ö]	14.57	[Ö:]	18.59	[Ö:]	17.4
[Ö]	12.12	[e]	9.57	[a:]	11.88	[Ö]	7.71	[o]	10.49
[a:]	3.52	[a]	7.28	[`]	9.41	[e:]	5.96	[a:]	6.07
[e]	2.86	[Ö]	6.57	[e:]	6.72	[`]	4.91	[u:]	4.97
[`]	2.08	[Ö:]	6.42	[a]	3.13	[i:]	3.85	[Ö]	4.41
[a]	0.78	[`]	4.42	[e]	3.13	[a]	3.15	[`]	3.03
[i:]	0.78	[i:]	1.11	[u]	0.44	[e]	2.80	[e]	2.76
[i]	0.13	[i]	0.85	[u:]	0.44	[i]	0.7	[i:]	1.38
[u:]	0.13	[u]	0.42	[i]	0.22	[u]	0.35	[a]	1.38
[u]	0	[o]	0.42	[i:]	0	[u:]	0	[u]	0.82
[o]	0	[u:]	0	[o]	0	[o]	0	[i]	0
[o:]	0	[o:]	0	[o:]	0	[o:]	0	[o:]	0
Total	767		700		446		285		362

Table 7: Percentage of frequency of various vowels in females.

All vowels occurring with a frequency of three times or more in each of the five female infants are listed in Table 7. Overall 2560 vowels including those occurring less than 3 times were transcribed for the entire group of 5 infants from 3 months to 12 months. Among the 5 female infants, the maximum number of vowels were produced by F1 (767) and the minimum by F4 (285). Vowel [æ:] strongly characterized in all five female infants F3, F4 & F5. Vowel [Ö:] dominated in infant F1 and vowel [e:] was produced maximally by F2. Vowels [i] and [u] appeared with a low frequency in all the female infants. Vowel [o] was produced with 10.49% of occurrence in infant F5 and 0.42% in infant F2 whereas this vowel did not make its appearance in other female infants (F1, F3 & F4).

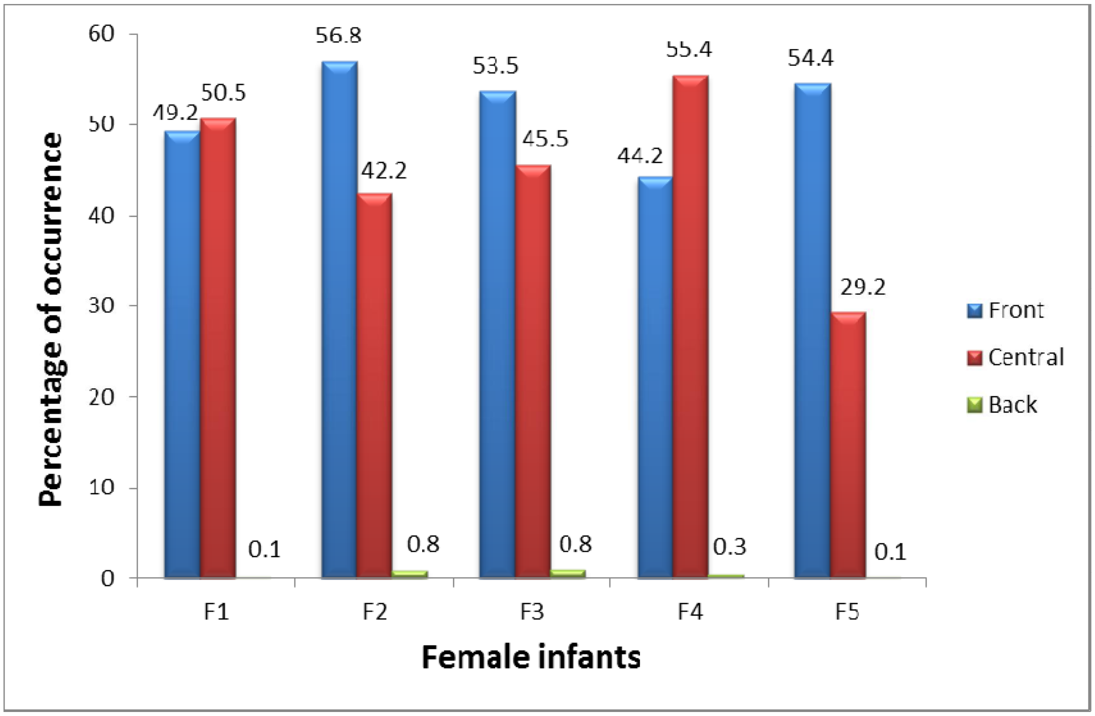
Vowels according to the tongue height and tongue advancement dimensions

Vowels according to the tongue height and tongue advancement dimensions in female infants are provided in Graphs 3 and 4 respectively.



Graph 3: Percentage of occurrence of vowels in females according to tongue height dimension.

Group and individual trends for vowels were apparent for vowel height and tongue advancement dimensions. Graph 3 displays each individual female infantôs percentages for vowels in the entire corpus characterized by height. Some trends resulted from this type of analysis and are similar to that of male infants. Low vowels dominated the vowel types in each of the female infant. Low vowels were followed by mid vowels. Among the two mid vowels (e, o), vowel [e:] predominated in its frequency of occurrence in infant F2. Vowel [o] was less apparent. High vowels were the least occurring vowel type.



Graph 4: Percentage of occurrence of vowels in females according to tongue advancement dimension.

Graph 4 displays individual percentage of occurrence for vowels in the entire corpus for the female infants in terms of tongue advancement dimension. Front and central vowels account for the largest occurrence in the data which is similar to male infants. Front vowel [e:] predominated in 3 female infants (F2, F3 & F5) and central vowel [Ö] dominated in other two infants F1 and F4. Among front vowels, [æ:] predominated the utterances in F3, F4 and F5 which was followed by vowel [e] in F1 and F2. Front vowel [i] was produced with a reduced frequency in all the infants. Among back vowels, [u] was meagrely present in all infants whereas back vowel [o] was present in only two female infants; in F5 with a greater frequency of occurrence (10.49%) than in F2 (0.49%).

2. DIPHTHONGS

Three diphthongs /ɒæ:/ /ɒe:/ and /au/ were found in the corpus of phonemes. Diphthongs /ɒæ:/ occurred in more number of infants. Diphthongs /ɒe:/ and /au/ occurred in less than 5 infants in the age range 3-12 months. Table 8 shows the number of infants producing the 3 diphthongs occurred.

Months	/ɒæ:/	/ɒe:/	/au/
3-4	2	0	1
4-5	6	2	1
5-6	3	2	1
6-7	4	2	2
7-8	3	1	0
8-9	4	2	2
9-10	2	0	0
10-11	2	2	0
11-12	3	2	0

Table 8: Shows no. of infants producing diphthongs.

3. CONSONANTS

The 11 consonants found in the entire corpus of 7233 phonemes were /h/, /p/, /b/, /k/, /g/, /t/, /d/, /v/, /j/, /m/, /n/. However only four consonants /h/, /p/, /b/ and /m/ were considered for statistical analysis based on the criteria that a phoneme to be considered as present in the phonetic repertoire, it should have occurred in a minimum of 50% of the infants considered for the study. Table 9 shows the number of infants producing these four major consonants.

Months	/h/	/p/	/b/	/m/
3-4	0	0	0	1
4-5	2	0	0	0
5-6	3	0	1	2
6-7	4	1	3	4
7-8	4	0	4	7
8-9	2	1	3	2
9-10	1	2	3	7
10-11	2	1	2	5
11-12	2	4	5	8

Table 9: Number of infants producing the major consonants.

< 4 infants > 4 infants

To explain the details in Table 9, though consonant /h/ made its appearance at the age of 4-5 months it was significantly present only in 6-7 and 7-8 months of age that is 4 out of 8 infants produced the glottal /h/ during this age period. Later it declined in frequency. Considering the bilabial voiceless and voiced phonemes, /p/ and /b/ were produced by less than 50% of the infants until 10-11 months period. However at 11-12 months bilabials were produced by more number of infants. The bilabial nasal /m/ was produced by 50% of the infants during 6-7 months and later produced by 100% of the infants during 9 to 12 months period as evident from Table 9.

Months	/k/	/g/	/th/	/dh/	/v/	/j/	/n/
3-4	0	0	0	0	0	0	0
4-5	0	1	0	0	0	0	0
5-6	0	2	0	0	1	0	1
6-7	0	0	0	1	3	2	0
7-8	0	0	1	2	2	0	1
8-9	2	2	3	1	0	0	0
9-10	0	1	2	3	0	2	3
10-11	1	2	2	2	0	2	2
11-12	0	0	3	1	0	2	3

Table 10: Number of infants producing the less occurring consonants.
"0" Indicates the phoneme did not occur in any of the subjects

Table 10 shows the consonants which are not considered for the statistical analysis as they did not occur in a minimum of 50% of the infants at any of the age ranges. Its evident from Table 10 that velar /k/ occurred only during 8-9 and 10-11 months. Its counterpart /g/ occurred earlier at 4-5 months. Both velar sounds were not seen in any of the infants at 11-12 months. Similarly the voiceless dental plosive appeared at 7-8 months and continued to be present at 11-12 months of age. The semi vowel /v/ was seen from 5 to 8 months where as the semi vowel /j/ was present from 9 to 12 months. The dental /n / made its appearance at 5 to 6 months and it was produced by more number of infants during 9 to 12 months.

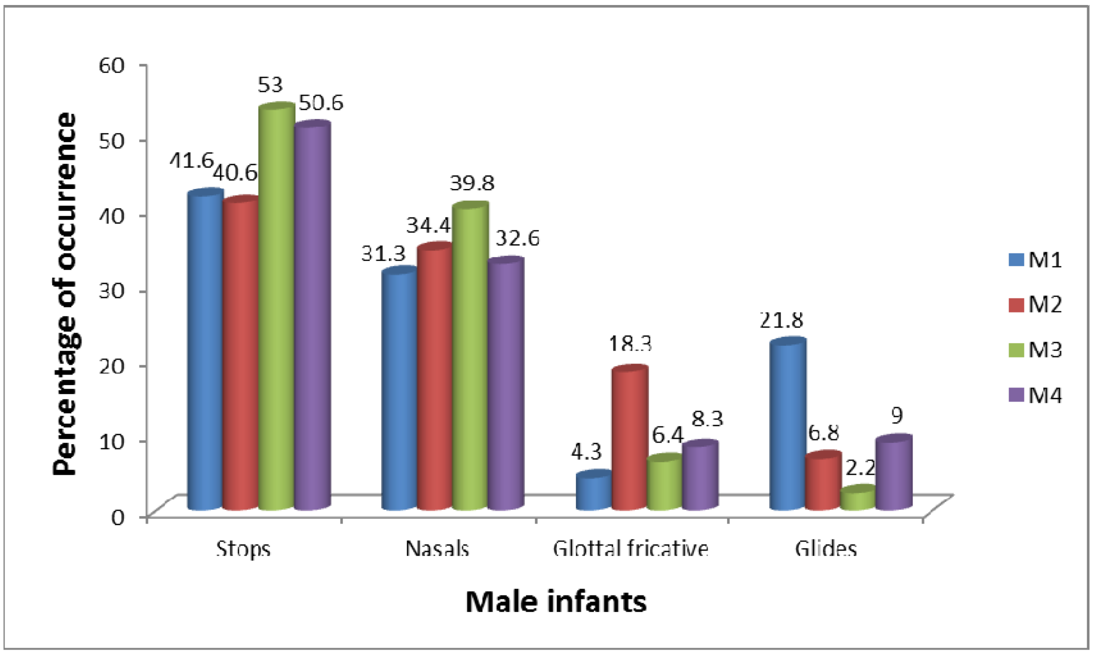
Consonant Characteristics in Male infants

Male infants							
M1		M2		M3		M4	
Cons- -onants	%	Cons- -onants	%	Cons- -onants	%	Cons- -onants	%
/t/	24.08	/m/	32.60	/m/	38.93	/g/	40.27
/m/	14.59	/h/	18.12	/b/	23.47	/m/	23.61
/n/	13.13	/b/	17.22	/t/	9.35	/h/	11.80
/b/	8.75	/t/	14.29	/p/	8.58	/n/	8.33
/v/	6.56	/p/	5.49	/d/	7.63	/j/	6.25
/p/	3.64	d/	1.47	/h/	6.48	/d/	3.47
/h/	2.91	/v/	1.47	/g/	1.14	/k/	3.47
/g/	2.18			/k/	0.57		
				/n/	0.57		
Total no of conson ants	137		273		524		144

***Table11:* Percentage of frequency of occurrence of consonant in males.**

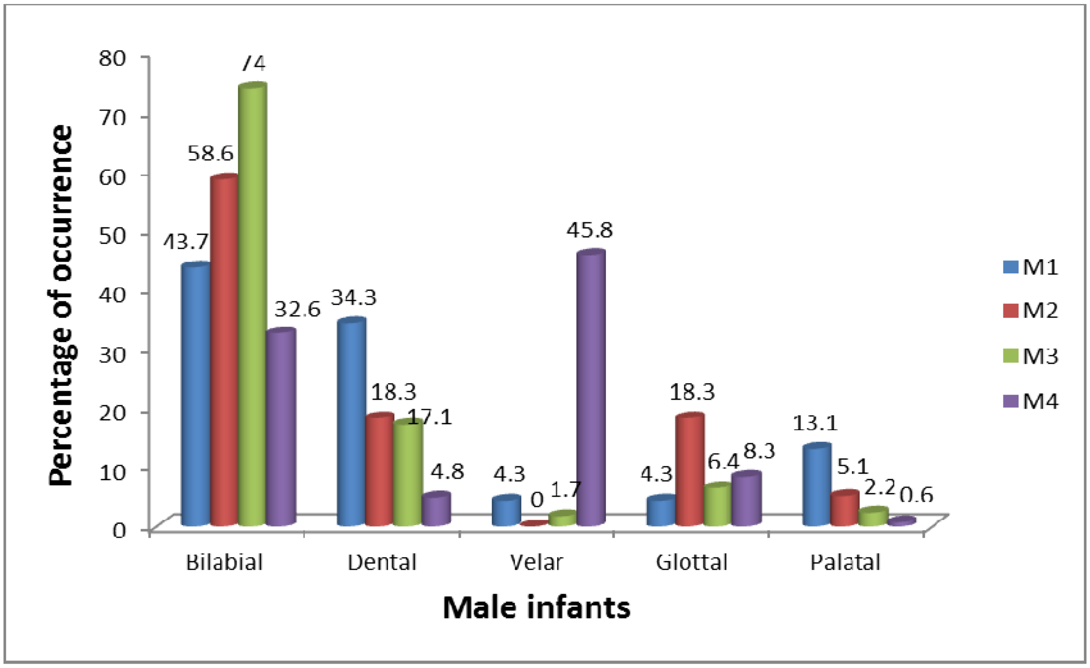
Table 11 shows the percentage of frequency of occurrence of various consonants (occurring > 3 times in each male infant). All consonants occurring with a frequency of 3 times or greater by each of the four male infants are listed in Table 11. Overall 2459 consonants including those occurring less than 3 times were transcribed for the total of 9 infants from 3 months to 12 months. Among the 4 male infants, the maximum number of consonants were produced by M3 (524) and the minimum by M1 (137).

Manner of articulation: Considering the manner of articulation, in M1 out of 8 consonants produced, 5 were stops, 2 were nasals, one glottal fricative and one glide. In the remaining male infants (M2, M3 & M4) also the same manner of productions were present except that M3 did not produce glides, though the highest number of consonants were produced by M3. Stops were the maximally occurring manner of articulation followed by nasals (/m/ & /n/), glides (/v/ & /j/) and glottal fricative (/h/). Graph 5 displays the percentage of occurrence of consonant manner of articulation in the four male infants.



Graph 5: Percentage of occurrence of consonant manner of articulation in males (4 nos).

Place of articulation: Infants M1 and M3 produced bilabials, dentals, velar and glottal places of articulation in a sequential order. M2 also had similar pattern however, velar place of articulation was absent in M2. M4 exhibited slightly different place of articulation, velars were maximally produced followed by bilabial, dental, glottal and palatal places of articulation. It was also observed that, velar /g/ was the least occurring place of articulation in M1 and M3 and it was absent in M2. However, /g/ was the highest produced consonant in M4. On overall observation bilabials, dentals and glottals were the commonly seen places of articulation. Graph 6 displays the percentage of occurrence of consonants for different places of articulation in each of the male infants.



Graph 6: Percentage of occurrence of consonant place of articulation in males (4 no).

Voicing characteristics: In all the male infants voiced consonants were predominantly seen than voiceless consonants. The bilabial nasal consonant /m/ was present in all the four infants and it was the most occurring consonant in M3 (38.93%). Dental nasal /n/ was present in M1, M3 and M4. Bilabial voiced consonant /b/ and voiceless consonant /p/ were produced by M1, M2 and M3 and the percentage of occurrence of /b/ was greater than /p/ in all the 3 infants. Velar consonant /g/ was present in M1, M3 and M4 and it was the most occurring consonant in M4 (40.27%). The voiceless velar consonant /k/ was produced by the infants M3 and M4 and it was the least occurring consonant.

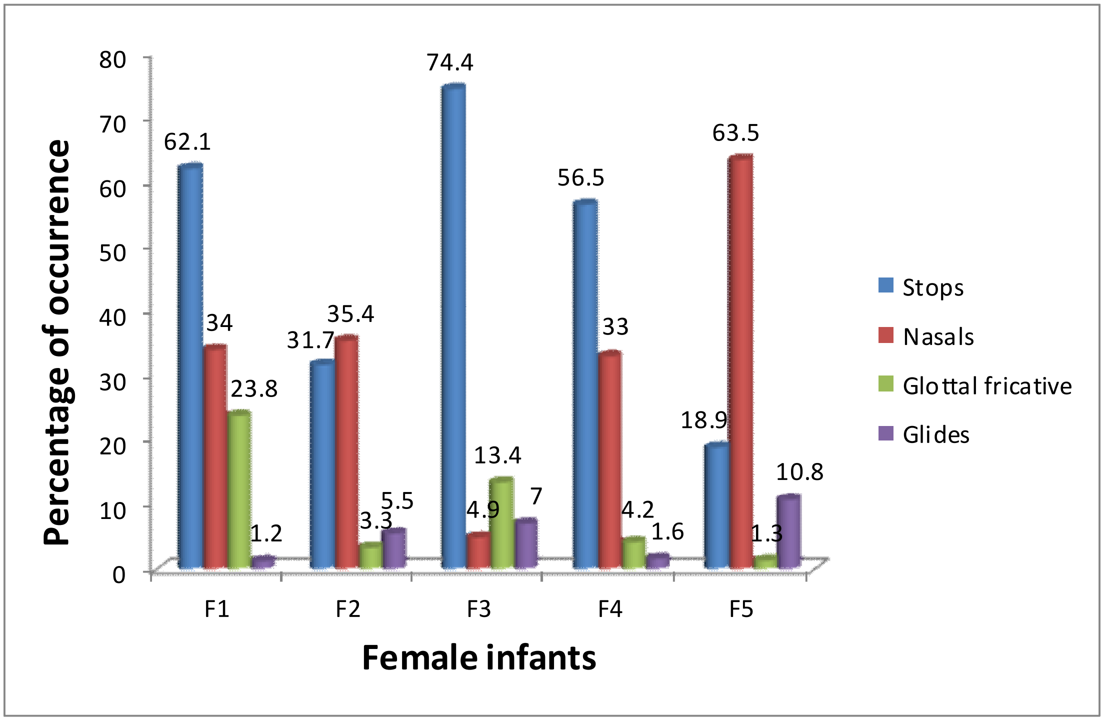
Consonant characteristics in Female infants

Female infants									
F1		F2		F3		F4		F5	
consonant	%	consonant	%	consonant	%	consonant	%	consonant	%
/m/	32.76	/m/	39.17	/t/	35.46	/m/	29.41	/m/	63.51
/h/	23.40	/d/	17.16	/g/	19.14	/b/	17.04	/k/	32.43
/t/	20.00	/b/	9.32	/b/	12.76	/t/	15.83	/j/	24.32
/b/	14.89	/h/	2.23	/h/	12.76	/p/	10.55	/g/	16.21
/p/	2.55	/g/	2.23	/j/	11.34	/d/	9.80	/v/	10.81
/d/	2.12			/v/	5.67	/h/	3.77	/h/	4.05
				/m/	3.54	/n/	3.61		
				/p/	2.12	/g/	2.41		
						/j/	1.50		
						/v/	0.75		
Total no of conso-nants	235		268		141		663		74

Table 12: Percentage of occurrence of various consonants in females.

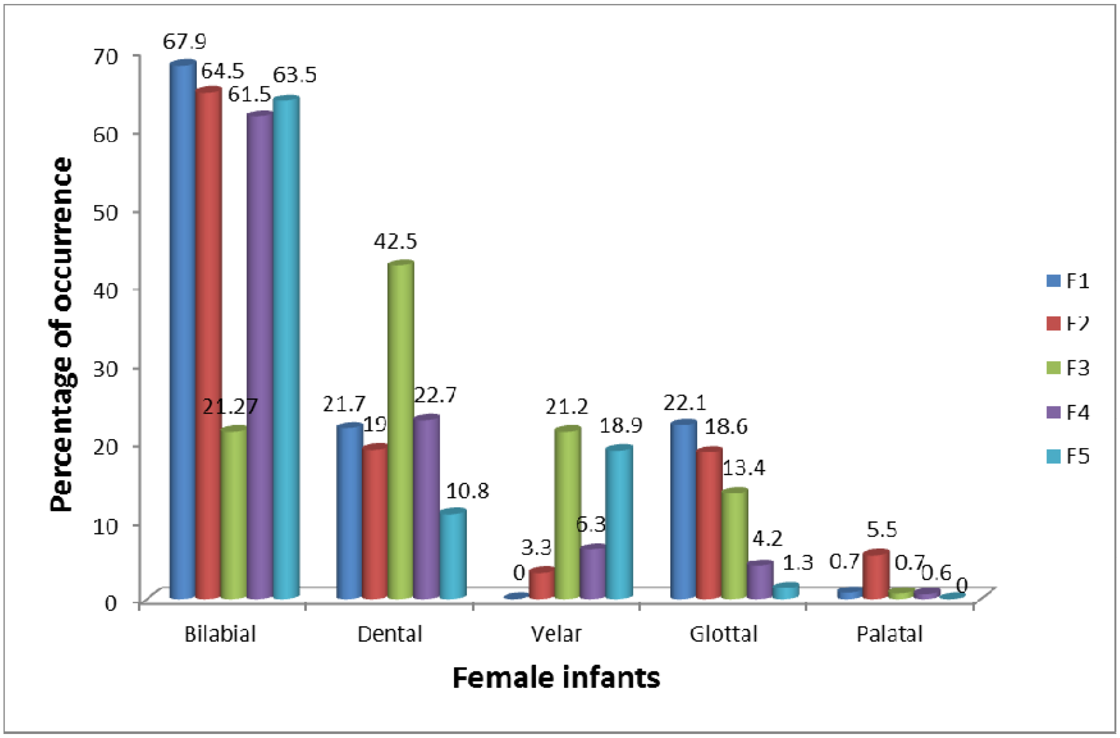
All consonants occurring with a frequency of 3 times or greater by each of the five female infants are listed in Table 12. Among the 5 female infants, the maximum number of consonants were produced by F4 (663) and the minimum by F5 (74). This is because of the less number of recordings in F5.

Manner of articulation: Considering the manner of articulation, F4 produced the maximum number of consonants (10 consonants) out of which 5 were stops, 2 were nasals, one glottal fricative and two glides. In the remaining female infants (F1, F2, F3 & F5) similar manner of productions were present except that F1 and F2 did not produce glides. Nasal /m/ was the highest produced consonant in all the female infants except F3. As shown in Table 12 nasals (particularly /m/) were the maximally occurring manner of articulation followed by stops, glottal fricative (/h/) and glides (/v/ & /j/). Graph 7 displays the percentage of occurrence for various manners of articulation in female infants.



Graph 7: Percentage of occurrence of consonant manner of articulation in females (5 nos).

Place of articulation: Graph 8 displays the percentage of occurrence of place of articulation in each of the female infants. Infants F1 and F2 produced bilabials, glottal fricative, dental, palatal and velar places of articulation in a decreasing order. Whereas F3, F4 and F5 had the same places of articulation but their frequency of occurrence was in different order. However in all these 3 infants, glottal and palatal places of articulation were the least prevalent. Bilabial /m/ was the most occurring place of articulation in all the infants except F3 where the frequency of occurrence of dental place of articulation was high. On overall observation bilabials and dentals were the commonly seen places of articulation.



Graph 8: Percentage of occurrence of consonant place of articulation in females (5 nos)

Voicing characteristics: In all the female infants voiced consonants were predominantly seen than voiceless consonants. Among the bilabial nasal consonants /m/ was present in all the five infants. However it was one of the least occurring consonant in F3 (3.54%). The other bilabial nasal consonant /n/ was present only in F4 with a 3.61% of occurrence. Bilabial voiceless consonant /p/ was produced by F1, F3 and F4 and the percentage of occurrence of /b/ was greater than /p/ in all the 3 infants. Dental consonant /t/ was present in F1, F3 and F4 and it was the most occurring consonant in F3 (35.46%). The voiceless velar /k/ was produced only by the infant F5 with a considerable high production (32.43%).

4. CONTEXTUAL SPECIFICITY OF VOWELS WITH CERTAIN CONSONANTS

Detailed analysis of the consonants occurring with a relatively higher frequency was carried out to see the correlation with the Frame - Content theory. The present study did not show any close adherence to frame content theory. The results showed that there were more occurrences of central vowel /a and ɒ/ occurring with bilabials and relatively less occurrence of front vowel /e/ occurred with bilabials. The other consonants with different places of articulation did not specifically occur in the context of any specific vowel. Hence it can be stated that the results correlated with the third hypothesis of the frame content theory. And the pattern of the first and the second hypotheses were not evident.

Frequently occurring consonants bilabial /m/ occurred in the context of vowels /æ, a, ɒ/. Bilabial consonant /p/ and /b/ occurred in the context of / a, æ and e/ and glottal consonant /h/ occurred in the context of /æ and ɒ/. The less occurring consonants /g, k, t, v, n and r/ were also analyzed for their contextual occurrences. Velar /g/ and /k/ occurred in the context of /a, ɒ/ and /æ/ respectively. Dental /t/ occurred in the context of /ɒ and /e/. Labio-dental /v/ and /n/ occurred in the context of central vowel /a/.

5. SYLLABLE SHAPES

The various syllable shapes in the babbling samples of 9 infants considered in the present study were monosyllables, bi-syllables and multisyllabic utterances. The frequency of occurrence of each of these syllable shapes were determined. Table 13 depicts the frequency of occurrence of various syllable shapes in the nine infants. The monosyllables were sub grouped as open and close syllables and the findings showed that open syllables were significantly higher in production compared to closed syllables. The frequency of occurrence of open mono syllables varied from in number from 26 to 116. M1 had the least production and M2 had the highest production of open syllables. Similarly closed mono syllables varied in the frequency of occurrence from 10ï 33. F3 had the least and F1 had the highest production of closed monosyllables. Monosyllables like VC and CVC occurrences were rare in all the infants.

Infants	Monosyllables		Bi-syllables	Multi-syllables	Total syllables
	Open	Close			
M1	26	14	20	18	78
M2	116	12	50	24	202
M3	107	12	70	82	271
M4	45	16	70	27	158
F1	102	28	54	22	206
F2	58	33	113	58	262
F3	45	10	68	19	142
F4	99	27	107	73	306
F5	34	18	32	7	91

Table 13: Frequency of occurrence of various syllable shapes.

Bi-syllables varied between 20 to 113 occurrences. M1 produced the least and F2 produced the highest number of bi-syllabic utterances. Frequent patterns of bi-syllabic utterances were VCV and CVCV. Multi-syllables varied in frequency of occurrence from 7 ï 82. F5 produced the minimum and M3 produced the maximum number of multi-syllables. The frequently seen multisyllabic pattern was CVCVCV. Up to 6-7 months of age, mono and bi-syllabic utterances were predominantly present. VCV syllables showed a gradual progression in their occurrence as age increased. Multisyllabic utterances were seen from 7 months of age and showed an increase with age.

Table 14 and Table 15 reveal that the frequency of occurrence of reduplicated and variegated babbling was high towards later stages of babbling and the onsets of both were at 4-5 months. Reduplicated babbling increased from 6 months and variegated babbling showed a gradual increase after the age of 7 months. Among the male infants, M1 had the least and M3 had the highest number of reduplicated babbling productions. Similarly among female infants, F5 had the least and F4 had the highest number of reduplicated babbling productions.

From Table 15, it is evident that variegated babbling was relatively more in M2 and F4. Infant M3 did not produce variegated babbling, however reduplicated utterances were highest in this subject. So it can be stated that reduplicated babbling continued to dominate towards the later stages of babbling also. This is contrary to the common notion that the two stages of babbling are sequential in nature. The present finding has been also reported by Anjana and Sreedevi (2008).

Months	Reduplicated babbling									Total
	Infants									
	M1	M2	M3	M4	F1	F2	F3	F4	F5	
3-4										0
4-5		2								2
5-6										0
6-7			8				1			9
7-8		2			7	4	2	1		16
8-9	8		3		16			1		28
9-10		1	41	6	7	16		2	6	79
10-11		8	17	19		4		51		99
11-12	7	5	34	3	2	6	7	46		110
Total	15	18	103	28	32	30	10	101	6	343

Table 14: Frequency of occurrence of reduplicated babbling in individual infants

Months	Variegated babbling									Total
	Infants									
	M1	M2	M3	M4	F1	F2	F3	F4	F5	
3-4										0
4-5					1					1
5-6							1			1
6-7										0
7-8								3		3
8-9					1	2		1		4
9-10		1						2		3
10-11	2	1		1				1	1	6
11-12	5	9						1		15
Total	7	11	----	1	2	2	1	8	1	33

Table 15: Frequency of occurrence of variegated babbling in individual infants.

CHAPTER V

DISCUSSION

In the present study, an attempt was made to analyze the phonetic characteristics of babbling longitudinally in typically developing infants from 3 months to 12 months from Kannada speaking homes. On examining the longitudinal development of babbling from infants in the age range between 3 months to 12 months revealed several salient points of interest.

VOWELS

The vowel data in the present study was analyzed according to tongue height and tongue advancement dimensions. The entire vowel corpus included 8 vowels which were seen across all the nine infants. Vowel analysis showed that low vowels dominated the vowel types in each of the infant. The order of frequency of occurrence is as follows: vowel [æ:] had maximum number of frequency of utterance followed by vowel [Ö] and followed by vowel [e:]. Low vowels were followed by mid vowels. Among the two mid vowels (e, o), vowel [e] predominated in its frequency of occurrence in all the infants whereas, vowel [o] did not make its appearance in any of the male infants. However it was seen less frequently in F2 and relatively higher production of /o/ was seen in F5. High vowels both front and back were the least occurring vowel types. In terms of tongue advancement dimension, front and central vowels account for the largest corpus in the data. These results were similar to the study by Lieberman (1980) where he reports that vowel [e] was heard most frequently (33 % of all the vowels transcribed), and the remaining lax vowels [I,Θ,^, u] each accounted for 11% -17% of the data. The remaining long (tense) vowels each accounted for not more than 5%, with the back-rounded [o:] and [u:] least frequent (1% each). In a study of 10 month old infantôs vowel productions drawn from four linguistic communities-Arabic, Chinese, English, and French, De Boysson-Bardies et al. (1989) found that the categories of front-low and mid-central vowels accounted for the vast majority of vowels similar to the present findings.

In the present study, the occurrence of vowels showed wide variability which has been well documented in the literature. Davis and Mac Neilageôs (1995) longitudinal study with 6 infants (3 males, 3 females) from monolingual English-speaking homes revealed much individual variability in the use of vowels. In addition to variability in the occurrence of vowels, the analysis of vowels in the present study suggested that the vowels that occur in the babbling period are not truly adult-like. Although vowel production is dominant in the first year of life, they have been less extensively investigated, primarily due to the difficulty in characterizing the vowels. Davis and Mac Neilage (1990), in their study on the course of acquisition of correct vowel production in children in the age ranges of 14 to 20 months found that despite a relatively precocious rate of vocabulary acquisition over the period from 14 to 20 months, the subjects studied produced less than 60% of vowels correctly according to evidence from phonetic transcriptions, which suggests that the vowels produced during the babbling period are primitive and the term óvowel-likeô sound may be preferred in place of the term óvowelsô.

In the present study, overall, the vowel repertoire found in the babbling samples of the infants from the age range of 3 months to 12 months were [æ, Ö, a, e, i, u, o]. These results were similar to the study on the developmental milestones of language acquisition in Indian Languages (Kannada and Hindi) by Shyamala and Basanti (2003) which revealed that the cardinal vowels /i/, /e/, /a/ /u/ and /o/ made their appearance by 6-12 months of age in infants from Kannada speaking homes. The additional vowel found in the present study was low front vowel [æ:] which frequently occurred in the samples of all infants from 4 to 12 months. The results were also similar to the cross sectional study by Anjana and Sreedevi (2008) on 30 typically developing infants from Kannada speaking homes in the age range of 6-12 months, vowel repertoire found in their babbling samples were [i, e, ae, a, u, o].

CONSONANTS

The 11 consonants found in the entire corpus of 7233 phonemes in the 9 infants during the period of 3 to 12 months of age were /h/, /p/, /b/, /k/, /g/, /t/, /d/, /v/, /j/, /m/ and /n/,. Like vowels, the first consonants that are produced are guided by the constraints of physical development. Stop consonants (/b, p, t, d, g, k/) and nasal consonants (/m, n/) are the most common that are produced during babbling across languages (Vihman, 1985; Locke, 1983; Davis & Mac Neilage, 1995). The production of these sounds is physiologically similar in that they are all produced with a total occlusion of the oral cavity. With reference to the Western studies, certain occurrence of consonants was found to be similar to the findings of the present study. Locke (1983) reported that /h/, /d/, /b/, /m/, /t/, /v/, and /j/ were the most frequently occurring consonant-like sounds in the late babbling period. In the present study also, stops were the maximally occurring manner of articulation followed by nasals, glides and glottal fricative. Kent, 1992 also accounted for the frequent occurrence of stops and nasals in the early stages of babbling. He opined that stop production is relatively undemanding. Syllables such as [ba], [da], and [na] may be articulated through mandibular action alone. Mitchell and Kent (1990) found manner changes to predominate over place changes in babbling of eight infants studied at 7, 9, and 11 months. Frequency of multi syllables in rank order, were reduplication, manner changes, mixed place and manner changes, and place changes. Complex sounds such as liquids (/l, r/) and consonant clusters are infrequent or were not present which is in consonance with earlier reports (Vihman, 1985). And on overall observation bilabials, dentals and glottals were the commonly seen places of articulation.

Similar to Lockeôs (1983) report, the present study also did not find support for the assumption that infants babble all the sounds of the language or all possible speech sounds rather they babble only a preferred set of sounds with respect to both manner and place of articulation. The findings of the present study related to the consonantal repertoire are similar to the findings reported by Shyamala and Basanti (2003) in Kannada and Hindi in terms of manner of consonants. They reported that stops and nasals had higher frequency of occurrence and glides and glottal fricatives were among the less frequently occurring consonants.

In the present study, bilabials were predominant followed by dentals and the occurrence of velars were limited which is in support of Davis and Mac Neilageôs (1995) study showing that the most frequently produced place of articulation were labials /b/, /m/, /w/, alveolars /d/, /n/, and velars /g/, /ɖ/. Locke, 1983 also reported that velars (/g, k/), produced by the tongue and the back of the throat, have very little incidence in babbling productions. The present study revealed high variability in the production of both vowels and consonants. This observation was also reported by Davis and Mac Neilageô s (1995).

Considering voiced voiceless consonant features, the present study evidenced higher occurrence of voiced cognates. This is a frequent finding in earlier reports that the more common sounds, with the exception of the glottal /h/, were all voiced. Within each minimal pair (two sounds that share the same articulatory movements) the voiced sound was normally present more often (Locke, 1983).

Overall, in the present study, oral stops and nasals were predominant supporting the hypothesis that frame dominance produced by mandibular oscillations exists in the early stages of babbling (Davis & Mac Neilage, 2000). The results were also similar to the cross sectional study by Anjana and Sreedevi (2008) in Kannada in which stops and nasals were the most occurring consonant types in the age range of 6-12 months.

CONTEXTUAL SPECIFICITY OF VOWELS WITH CERTAIN CONSONANTS

Among all the vowel-consonant preferences, the bilabial-central vowel, dental-central vowel, velar-central vowel in all the 9 infants, which indicate that the central vowel [a] was the most preferred vowel with majority of the consonants. This could be correlated with the high frequency of occurrence of [a] in all the age ranges compared to the other vowels and also to the fact that the frequency of occurrence of [a] in Kannada language is also high.

Additional evidences to the findings of the present study can be taken from studies of co-occurrence patterns in young children. Vihman (1992) studied co-occurrence patterns in a group of 23 children in four different language communities in the first 50 words. The claim that the labial-central vowel co-occurrence pattern was largely supported in her study. The other consonants with different places of articulation did not specifically occur in the context of any specific vowel. Hence it can be stated that the present results correlated with the third hypothesis of the frame content theory. And the pattern of the first and the second hypotheses were not evident. However, there are no Indian studies reported on babbling on the issue of contextual specificity of vowels with consonants. Hence, in the process of linking of sound patterns with meaning, the contextual preference of the central vowel with most of the consonant types could be linked to the relatively high occurrence of the vowel [a] with most of the consonants in Kannada language.

SYLLABLE SHAPES

In the present study, the occurrence of open syllables was found to be high than close syllables among the monosyllables. Syllables appear in an infantǒs repertoire as monosyllables (Vihman, 1985). Normally these syllables begin with a consonant and end with a vowel (Mac Neilage, Davis, Kinney, & Matyear, 2000). MacNeilage et al. (2000) state that the CV sequence is so important that it is often given the status of the only universal syllable type. Following the appearance of these syllables in isolation, an infant begins to reduplicate (Oller, 1983). Additional evidence to the finding of CV syllables is provided by Rupela and Manjula (2006). They reported CV syllables to be the most commonly occurring syllable type gradually increasing in frequency of occurrence between 0-18 months.

VC syllables also occurred occasionally between 6 to 11 months and did not occur at 11-12 months. This finding may be linked to the influence of the ambient language on the syllable productions of infants. The occurrence of closed syllables is uncommon because consonants usually do not occur as a coda in the final syllable in Kannada language (Hiremath, 1980). Frequent patterns of bi-syllabic utterances in the present study were VCV and CVCV. VCV syllables such as [aba], [ama], [ada] made a predominant appearance between 8-12 months. This finding is also in general agreement with the structure of the ambient language. The occurrence of open syllables is common and Kannada vocabulary mostly consists of disyllabic words (Hiremath, 1980).

The results of the present study also share certain similar patterns of occurrence of syllable shapes found in other languages of the world. It is reported that a combination of consonant-and vowel-like sounds is said to begin during the exploration stage at about 4 to 6 months (Oller, 1980) and during the later babbling period, open syllables or syllables ending in a vowel are the most frequently occurring syllable shapes (Bauman-Waengler, 1994).

Kent and Bauerôs (1985) study revealed syllable shapes that were predominant during the babbling period. They found that V, CV, VCV and CVCV syllable structures accounted for approximately 94% of all the syllables produced at the end of babbling period. They also emphasized that while closed syllables occurred, they were found to be very limited in the repertoire of the infant at this stage of development. These trends depict an increase in the complexity of the phonetic repertoire, both in terms of quantity and variety of vowels and consonants. These findings reflect upon the phonological development due to neuromuscular maturation.

PERCENTAGE OF REDUPLICATED AND VARIEGATED BABBLING

The present study revealed that reduplicated babbling consisted of reduplication of simple CVCV productions. The variegated form of babbling began at 8-9 months and gradually increased with age. The most common form of variegation observed was place changes, followed by manner changes and a combination of place and manner variations. In comparison of reduplicated and variegated babbling, reduplicated babbling exceeded variegated babbling in all age ranges and this is similar to reports of Anjana and Sreedevi (2008).

Some of the major models of infant vocal development predict developmental increases in phonetic variation in multi-syllable vocalizations. Both Oller (1980) and Stark (1979, 1980) posit two separate stages for phonetically non-varied versus varied multi-syllable babbles. In these views, children engage in a period of phonetically non-varied multi-syllable babbles before passing on to the production of strings of phonetically varied multi-syllables. The increase in phonetic variation distinguishes one stage from the next.

The rank order of multi-syllables in the present study were reduplication at 6-9 months, place changes at 9-10 months, manner changes at 10-11 months and mixed place and manner changes at 11-12 months. The findings of the present study differed from the above studies that place variations were followed by manner variations. The discrepancies in the findings of the present study with that of the English studies could be due to the differences in the structure of the two languages, English and Kannada. The two languages differ in their organization of sounds, English being a phonetic language and Kannada, a syllabic language.

CHAPTER VI

SUMMARY AND CONCLUSIONS

In the present study, an attempt was made to analyze the phonetic characteristics of babbling longitudinally in typically developing infants from 3 months to 12 months from Kannada speaking homes. On examining the longitudinal development of babbling from infants in the age range between 3 months to 12 months revealed several salient points of interest.

The vowel data in the present study was analyzed according to tongue height and tongue advancement dimensions. The entire vowel corpus included 8 vowels which were variable in their frequency of occurrence in all the nine infants. Vowel analysis showed that low vowels dominated the vowel types in each of the infant. The order of frequency of occurrence is as follows: vowel [æ:] had maximum number of frequency of utterance followed by vowel [Ǫ̈] and followed by vowel [e:]. Low vowels were followed by mid vowels. High vowels both front and back were the least occurring vowel types. In terms of tongue advancement dimension, front vowel [e] and central vowels account for the largest corpus in the data. In the present study, the occurrence of vowels showed wide variability which has been well documented in the literature.

The 11 consonants found in the entire corpus of 7233 phonemes in the 9 infants in the age range of 3 months to 12 months were /h/, /p/, /b/, /k/, /g/, /t/, /d/, /v/, /j/, /m/, and /n/. In the present study stops were the maximally occurring manner of articulation followed by nasals, glides and glottal fricative. Bilabials, dentals and glottals were the commonly seen places of articulation. Occurrence of velars was limited. The present study revealed high variability in the production of both vowels and consonants.

Considering voice voiceless consonant features, the present study evidenced higher occurrence of voiced cognates. Among all the vowel-consonant preferences, the bilabial-central vowel, dental-central vowel, velar-central vowel was seen in all the 9 infants, which indicate that the central vowel [a] was the most preferred vowel with majority of the consonants. This could be correlated with the high frequency of occurrence of [a] in all the age ranges compared to the other vowels and also because the frequency of occurrence of [a] in Kannada language is high.

The occurrence of open syllables was found to be higher than close syllables. VC syllables also occurred occasionally between 6 to 11 months and did not occur at 11-12 months. Frequent patterns of bi-syllabic utterances in the present study were VCV and CVCV. VCV syllables such as [aba], [ama], [ada] made a significant appearance between 8-12 months. This finding is also in general agreement with the structure of the ambient language.

Reduplicated babbling consisted of reduplication of simple CVCV productions. The variegated form of babbling began at 8-9 months and gradually increased with age. The most common form of variegation was place changes, followed by manner changes and a combination of place and manner variations. In comparison of reduplicated and variegated babbling, reduplicated babbling exceeded variegated babbling in all age ranges from 6-12 months.

The rank order of multi-syllables in the present study were reduplication at 6-9 months, place changes at 9-10 months, manner changes at 10-11 months and mixed place and manner changes at 11-12 months. The discrepancies in the findings of the present study with that of the English studies could be due to the differences in the structure of the two languages.

Implications of the study

Å This study provides a basic understanding of what is normally expected in an infant at the babbling stage of early communication development.

Å The normative data obtained can aid the Speech Language Pathologists in making appropriate diagnostic and therapeutic decisions in the infant population considering the fact that in the recent years, there has been an increased professional emphasis on the provision of Speech-Language Pathology services to even infants less than 1 year of age.

Å This study will augment our understanding about the vocal productions in pre linguistic stages which is very important in early communication development.

Å The study promotes the importance of developing normative data for the Indian population, as the norms in English and other languages may not prove to be valid since language specificity exists in the later stages of babbling.

Limitations of the study

Å Due to methodological difficulties and attrition factors of longitudinal studies, only 9 infants were involved in this study.

Å The data was recorded with a time interval of one month although weekly recordings would yield more valuable data.

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APPENDIX 1

Informed consent

I have been informed about the aims, objectives and the procedures of the study. The possible risks-benefits of my childôs participation as human subject in the study are clearly understood by me. I understand that I have the right to refuse participation of my child as a subject at any time during the course of the study. I am also aware that by subjecting my child to this investigation, I will not have any direct benefits to me. I have the freedom to write to Chairman, AIISH Ethical Committee, in case of any violation of these provisions without the danger of me being denied any rights to secure the clinical services at this institute.

I, ____, the undersigned, give my consent to my son/daughter to be a participant of this investigation.

Signature of the Parent/Guardian
(Name and Address)

Signature of the Investigator:
Name and Designation:
Date: