THE PHONETIC CHARACTERISTICS OF BABBLING IN KANNADA

Register No: 06SLP001

A Dissertation Submitted in Part Fulfillment of
Final year M.Sc (Speech - Language Pathology)
University of Mysore, Mysore.

ALL INDIA INSTITUTE OF SPEECH AND HEARING
MANASAGANGOTHRI
MYSORE-570006
APRIL, 2008

CERTIFICATE

This is to certify that this dissertation entitled ***"The Phonetic Characteristics of Babbling in Kannada"*** is the bonafide work submitted in part fulfillment for the degree of Master of Science (Speech - Language Pathology) of the student (Registration No. 06SLP001). This has been carried out under the guidance of a faculty of this institute and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

Mysore

April, 2008

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DECLARATION

This is to certify that this dissertation entitled ***"The Phonetic Characteristics of Babbling in Kannada"*** is the result of my own study under the guidance of Dr. N. Sreedevi, Lecturer of Speech Sciences, Department of Speech-Language Sciences, All India Institute of Speech and Hearing, Mysore, and has not been submitted in any other university for the award of any diploma or degree.

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April, 2008 Register No. 06SLP001

ACKNOWLEDGEMENTS

My sincere and heartfelt gratitude goes to my guide Dr. N. Sreedevi, Lecturer, Department of Speech Sciences, AIISH, for her untiring and persistent guidance and support throughout my study. I am deeply indebted to you m'am for your enthusiasm and willingness to help which motivated me and made the study more smooth going. Your careful observations and insights at every stage brought merit to the study.

I would like to thank Dr. Vijayalakshmi Basavaraj, Director, AIISH, Mysore, for permitting me to carry out this dissertation.

I would also like to thank Professor R. Manjula, ,Department of Speech-Language Pathology, AIISH whose valuable suggestions assisted me in planning my study.

My thanks to Professor K.S. Prema, Department of Speech-Language Sciences, AIISH for her timely help and assistance. Interacting with her in the context of research has always broadened my perspective.

My special thanks to Dr. Goswami, Reader, Depeartment of Speech-Language Parhology, AIISH who has always created a convivial environment to work in.

I am grateful to Ms. Vasanthalakshmi, the savior of Statistics, who made the statistical analysis simple and comprehensive.

It's a pleasure thanking Dr. Madhu Patel, Peadiatric intensivist, Dr. Ravi, Peadiatrician and Dr. Shylaja, Makkala Koota, Mysore who provided the much needed cooperation in finding the subjects for my study.

I would also like to thank my superiors, Mrs. Preeja Balan and Vani Rupela for their valuable suggestions for the study.

I am very thankful to my seniors Sapna, Priya and Rehna who helped me find my subjects. I have to certainly count on your help. Thanks to Kavya, my mentor who never had a 'no' for an answer.

My deepest gratitude goes to my family for their unflagging support throughout and especially in the course of completing my dissertation. I am indebted to my father whose inexhaustible patience makes everything easy. You are the best dad! Thanks to Prerana, for being such a lovely sister and helping me in my struggle to complete this task. We shall make better days ahead together !

My special thanks to my best buddies, Shriya, Sufia and Archana. You have been great friends. Those were the days of endless fun and togetherness. I miss those days and miss you all. Hopefully, we should meet in future as colleagues !

The adage "Friends in need are friends indeed" is true with all my friends at AIISH. Thanks to dear friends Neha and Leah for being there whenever I needed, for rekindling a positive hope always. I wish you both a HML (happy mast life). The unforgettable trimurthis, Ankit, Manuj and Chandrakanth, Biswajeet, Achaiah, the hilarious Simsom, Preeti, quaky Prasitha, 'Balaji the Golla' have all been the greater part of memories of AIISH.

I extend my thanks to the library staff and Mr. Shivappa for their assistance.

I cannot end without thanking the generous parents of all my subjects for their cooperation and last but not the least, all those little ones whose babbling was music to my ears !!!

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CHAPTER I

INTRODUCTION

Children continually fascinate adults with their incredible daily developments. One of the most impressive accomplishments is the child's ability to produce speech sounds and the ability to combine those sounds to form 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 child's overall growth in language. In the not so distant past, true articulation and phonological development was thought to begin with the production of the child's first meaningful words. The production of the "first word" was viewed as the child's initial step toward 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 must acquire before he or she can actually produce his or her first words began to flourish in the late 1970s and early 1980s (e.g., Oller, 1980; Oller et al., 1976; Stark, 1978, 1980). Research since then has done away with the notion that vocal behaviours prior to the one-word stage are unimportant productions bearing no relationship to the development of meaningful speech.

Infant Production of Vocal Sounds

The infant's learning of production of speech sounds can be considered as an increasingly complex task, ranging from vocal production per se to communicative use, in context, of adult-based sound patterns, or words (Menyuk, Menn, and Silber, 1986). The tasks include (1) learning to produce a variety of vocal sounds, (2) matching sound patterns produced by adults to some of the well-practiced vocal patterns already in the infant's repertoire, (3) associating certain adult sound patterns with situations where they are often produced, (4) achieving the understanding that sound pattern production can be used as a means to share a focus of attention or to make a request, and (5) marshaling adult-based words to serve communicative goals in novel settings (the referential and symbolic use of words).

The task analysis outlined above identifies the cognitive challenges in learning to speak. Perceptual development plays a role in this process as well. When the process is barely underway, however, the child has already begun work on other aspects of communicative development, including the problem of apprehending the significance of regular and recurrent form-meaning correspondences that is developing comprehension of words and of communicative gestures, such as pointing, clapping, or waving. The cognitive challenges involve matching his or her own productive capacities to the sound patterns of the adult language, developing the ability to use language to refer to events outside, and the immediate situational context. These tasks are largely encountered and mastered in the course of what is called "the transition period"; that is, the phase of development which reflects the transition from babbling to speech.

Babbling is an important first phase of development toward adult speech production ability. It begins at approximately 6-7 months of age and extends until the child's first words appear at age 10-13 months. The initial portion of babbling known as reduplicated babbling (Oller's 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]. The phonetic repertoire at this stage, although limited, may consist of stops, nasals, glides, and the lax vowels /e/, /⋂/, /^/. The production of back sounds (velars) decline sharply, while the production of front sounds (alveolars and bilabials) increase.

Non reduplicated or variegated babbling (Oller's 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 infant's 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 and Stoel-Gammon, 1989; Mitchell & Kent, 1990). Jackobson's (1941/1968) "discontinuity hypothesis" 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 behaviour, 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).

Need for the study

Babbling behaviour is one aspect of early communication that is emerging as a predictor of later language ability. Several researchers have suggested that the quantity and the diversity of vocalizations do indeed play a role in later language development. Results of studies have shown that the amount of prelinguistic vocalizations was positively related to later language measures. 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.

Though the history of infant speech development is long, most of the literature basically refers to Western studies. Lack of Indian studies in this domain provides the motivational rationale for the present study.

Aim of the study

To establish qualitative database on the development of babbling in infants from Kannada speaking homes in the age range of 6 months to 12 months.

Objectives of the study

To transcribe and analyze the babbling samples of 30 infants from Kannada speaking homes in the age range of 6 months to 12 months with the following objectives:

- To establish the phonetic repertoire, including the frequency of occurrence of vowels and consonants, the consonants with reference to their place, voicing and manner of articulation and vowels based on tongue height, tongue advancement.
- To identify the syllable shapes and to quantify their frequency of occurrence.
- To identify preferential occurrence of vowels with certain consonants within syllables.
- To calculate the percentage of reduplicated and variegated babbling

Method

Thirty typically developing children, from Kannada speaking homes served as subjects for the study. The subjects were divided into 6 groups with an age interval of one month (6-7 months, 7-8 months, 8-9 months and so on up to 12 months, i.e. one year). Each group consisted of 5 infants. Audio-recording sessions of 30 minutes for all the subjects took place in the children's homes in the presence of the mother using a digital voice recorder. The recorded data was subject to editing to retain the child's

speech-like utterances for analysis. A minimum of 50 utterances from the 30 minute duration recording were transcribed phonetically using IPA (Broad phonetic transcription method) from the audio tapes for each of the subjects separately by the investigator. Intra-judge reliability and inter-judge-reliability of phonetic transcription were carried out for some of the randomly selected babbling samples.

Implications of the study

- This study provides a basic understanding of what is normally expected in an infant at the babbling stage of early communication development.
- 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 increase professional emphasis on the provision of Speech-Language Pathology services to even infants less than 1 year of age.
- The study promotes the importance of developing normative data for the Indian population, as the Western norms may not prove to be valid since language specificity exists in the later stages of babbling.

Limitations of the study

- Due to the methodological difficulties involved in the study, only 30 infants could be involved in the study.
- Although, longitudinal studies can provide more specific information regarding the phonological developmental stages of an individual child or a group of children, it could not be adopted in the present study due to time

constraints and the subject variables such as the age of the infants, vaccination shots, changes in the general health of the infants and the family dynamics.

- There was no equal distribution of male and female infants in the groups considered as subjects. Hence the gender differences in babbling were not investigated in the present study.

CHAPTER II

REVIEW OF LITERATURE

The study of human infant vocal behavior has grown substantially in recent years and much is now known about the acquisition of speech and language in the early years of life. Child language development is commonly divided into prelinguistic behaviour, vocalizations prior to the first true words, and linguistic development, which starts with the appearance of these first words. This division is exemplified by the use of early nonmeaningful versus later meaningful sound productions. Infant babbling was earlier believed to be random behaviour bearing little or no relationship to the development of meaningful speech. Roman Jakobson's 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 behaviour is seen as clearly separated from the following systematic sound productions evidenced by the first words. The division between prelinguistic 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 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, Wieman, Doyle, and Ross, 1976; Stark, 1980, 1986) has repeatedly documented that:

(1) Babbling behaviour is not random but rather that the child's productions develop in a systematic manner.

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

(3) The transition between babbling and first words is not abrupt but continuous; late babbling behaviour and the first words are very similar in respect to the sounds used and the way they are combined.

Elbers (1982) has traced the development of one child, between 6 and 12 months of age. Elbers views babbling in this period as "a systematic, continuous and largely self-directed process of exploration," in which the child constructs a phonetic "spring board" to speech. Variegated babbling may emerge very soon after the onset of canonical babbling, and because of the difficulty of distinguishing between these two types of babbling, some have suggested that variegated and canonical babbling be considered a single stage of development (Smith, Brown-Sweeney, and Stoel-Gammon, 1989; Mitchell and Kent, 1990).

The vocal repertoire during babbling, while large, is but 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.

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.

Early Stages of Production

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. Oller divides the first six months into three sequential stages, which he terms the phonation stage, the cooing stage, and the expansion stage. He also identifies two stages in the second half of the first year, canonical and variegated babbling. The term 'prelinguistic' in reference to infant vocalizations implies that sound productions at this level are not entirely linguistic since they are not used meaningfully by the child. In essence, these sounds or sound combinations often lack a specific referent and communicative intent, especially in the very early stages. **Oller's stages** are widely accepted and frequently used in reference to prelinguistic vocalizations. Some overlap

in vocalizations exists from one stage to another; however, each new stage is characterized by vocal behaviours not observed in the previous stage. The stages must be viewed only as approximate ages of infant speech production that may differ from one infant to another.

Stage 1: Phonation Stage. This stage progresses from birth to 1 month.

- Reflexive vocalizations such as crying, fussing, coughing, sneezing, and burping predominate. Speech-like sounds are rare.
- Some non-reflexive vocalizations resembling syllabic nasals occur.
- Vocalizations resembling vowels occur. However, these are termed quasi-resonant nuclei since they occur with normal phonation but limited oral resonance.

Stage 2: Coo and Goo Stage. This stage characterizes infant vocalizations from 2 months to about 3 months.

- Sounds are produced that are acoustically similar to back vowels and consonant-vowel (CV) and vowel-consonant (VC) syllables containing back vowels and back consonants (velars, uvulars).
- The syllable sequences produced at this stage are considered primitive because of the irregular timing in the opening and closure of the consonantal and vocalic segments (as compared to those of adults).

Stage 3: Exploration-Expansion Stage. This stage typically progresses from about 4 months to 6 months.

- This stage is characterized as a period of vocal play in which the child gains better control of the laryngeal and articulatory mechanisms.
- Squeals, growls, yells, raspberries (bilabial or lingualabial trills), vowel-like elements, and friction noises may be observed in this stage. These vocalizations attest to the better laryngeal and articulatory functions in the infant.
- The infant's predominant vocalizations may vary daily and weekly.
- Vowels have better oral resonance and are more adult-like. Thus, at this point they are fully resonant nuclei.
- Marginal babbling appears. Productions labeled as such are characterized by CV and VC syllable sequences. However, the timing of opening and closure is still difficult at this point. The distinction between the syllable sequences at this stage is the increased resonance for vowel-like sounds and better constriction for consonant-like sounds.

Stage 4: Canonical Babbling Stage. This stage progresses from 7 months to 9 months. It is also known as the reduplicated babbling stage.

- CV syllables continue and now have more adult-like timing for closure and opening. The sounds are more constricted and resonated so that they now resemble true consonants and vowels.
- The CV syllables become longer at this point and may be reduplicated so that syllable sequences such as [baba], [kaka], and [tata] result.

- Although some reduplicated syllable sequences resemble real words, particularly [mama] and [dada], these are not used with true intention by the infant. That is, the infant may use these productions when alone, when looking at a toy, or when looking at Mom.
- The infant's phonetic repertoire at this stage, although limited, may consist of stops, nasals, glides, and the lax vowels /e/, / ⋂ /, /^/. The production of back sounds (velars) decline sharply, while the production of front sounds (alveolars and bilabials) increase.

Stage 5: Variegated Babbling Stage. The last infant vocalization stage advanced by Oller (1980) progresses from 10 months to about the first year.

- CV syllable sequences continue but are no longer simply reduplicative in nature.
- The infant in the variegated babbling stage combines a variety of CV sequences resulting in productions like [madaga], [putika], and [tikadi].
- The infant's vowel and consonant repertoire increases significantly at this point.
- The infant's intonation patterns take on a more adult-like quality, especially as the first year approximates.
- The infant's connected strings of variegated syllable sequences may resemble statements, questions, and exclamations prosodically; however, these strings do not contain real words.

Elbers (1982) has suggested the following scheme:

- Prerepetitive period
- Repetitive stage,
- Concatenating stage ‘A’ (babbles share same place of articulation but differ in manner of articulation). Concatenating stage ‘B’ (babbles have different place of articulation)
- Mixing stage (in which concatenations are more varied or 'mixed')

According to Elbers, the highest percentage of non-transcribable babbles occurs in the prerepetitive stage and the mixing stage.

Stark (1986) describes the prelinguistic stages of production as follows:

Stage 1: Reflexive crying and vegetative sounds (birth to 2 months)

- This stage is characterized by a large proportion of reflexive vocalizations. Reflexive vocalizations include cries, coughs, grunts, and burps that seem to be automatic responses reflecting the physical state of the infant.
- Vegetative sounds may be divided into grunts and sighs associated with activity and clicks and other noises, for example, which are associated with feeding.

Stage 2: Cooing and laughter (2 to 4 months)

- During this stage, cooing or going sounds are produced during comfortable states. Although these sounds are sometimes referred to as vowel-like, they also contain brief periods of consonantal elements that are produced at the back of the mouth.

- Early comfort sounds have quasi-resonant nuclei; they are produced as a syllabic nasal consonant or a nasalized vowel (Nakazima, 1962; Oller, 1980). From 12 weeks onward, a decrease in the frequency of crying is noted and most infants' primitive vegetative sounds start to disappear. At 16 weeks, sustained laughter emerges (Gesell and Thompson, 1934).

Stage 3: Vocal play (4 to 6 months)

- Although there is some overlap between stages 2 and 3, the distinguishing characteristics of Stage 3 include longer series of segments and the production of prolonged vowel- or consonant like steady states.
- It is during this stage that the infant often produces extreme variations in loudness and pitch. Transitions between the segments are much slower than is the case with children or adults. In contrast to those in stage 2, Stage 3 vowels demonstrate more variation in tongue height and position.

Stage 4: Canonical babbling (6 months and older)

- Although canonical babbling-the collective term for the reduplicated and non reduplicated babbling stages-usually begins around 6 months of age, most children continue to babble into the time when they say their first words.
- Stark (1986) describes reduplicated and non reduplicated, or variegated, babbling as follows: Reduplicated babbling is marked by similar strings of consonant-vowel productions. There might be slight quality variations in the vowel sounds of these strings of babbles, but the consonants will stay the same from syllable to syllable. Non reduplicated or variegated babbling demonstrates variation of both consonants and vowels from syllable to

syllable. Smooth transitions can be noted between vowel and consonant productions.

Stage 5: Jargon stage (10 months and older)

- This babbling stage overlaps with the first meaningful words. The jargon stage is characterized by strings of babbled utterances that are modulated primarily by intonation, rhythm, and pausing (Crystal, 1986).
- Many jargon vocalizations are delivered with eye contact, gestures, and intonation patterns that resemble statements or questions.
- Earlier, the child's segmental productions during the babbling stage were referred to as vocoids and contoids in place of vowels and consonants respectively since the productions do not resemble the true vowels and consonants of a particular language system. These terms were introduced by Pike (1943) to indicate non phonemic speech sound productions.

The term 'babbling' denotes a specific form of production which appears at approximately 6-7 months of age and extends until the child's first words appear at age 10-13 months. Despite controversies regarding the sequential nature of babbling (Holmgren, Lindblom, Aurelius, Jalling, & Zetterstrom, 1986; Smith, Brown-Sweeny, & Stoel-Gammon, 1989; Mitchell & Kent, 1990), babbling continues to be divided into two stages. The initial portion of babbling known as **reduplicated babbling** (Oller's 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/, /⋂/, /^/. 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. The production of back sounds (velars) decline sharply, while the production of front sounds (alveolars and bilabials) increase.

Non-reduplicated or **variegated babbling** (Oller's 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]. The infant's 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 and Stoel-Gammon, 1989; Mitchell & Kent, 1990).

A form of babbling that frequently overlaps with the early period of meaningful speech is characterized by strings of sounds and syllables produced with a variety of stress and intonational patterns. This form of babbling has been called conversational babble, modulated babble, and jargon (Berko Gleason, 1993). Jargon usually begins once the variegated babbling has been reached, at approximately 10 months of age. The primary difference between variegated babbling and jargon is the infant's increasingly varied and consistent use of intonation, rhythm, and pausing in the latter. Jargon may be thought of as variegated babbling with intonation patterns superimposed on the sound productions.

In late babbling, the infant typically has a large repertoire of sound, but the repertoire is only a subset of the set he will have at later stages. Moreover, this subset is very similar across linguistic environments. Boysson-Bardies, Sagart and Nocole (1981b) studied a French boy who was recorded weekly for 45 minutes each session from 1.6 to 1.8 years. The sequences were transcribed using the IPA. The consonant frequencies obtained were very similar to consonant frequencies obtained in other studies conducted with French infants. The labials were mostly bilabials. Even bilabial fricatives outnumbered labiodental fricatives. In general, the hierarchy in frequency of points of articulation is: dental > labial > velar > alveo-palatal. In addition, the infants showed a range of VOT from long lead to short lag types. Fricatives are either voiced throughout or unvoiced, but never aspirated. There were

more front vowels than back vowels. These results concur with those obtained by others for French and other linguistic environments.

Importance of Babbling

Babbling and Its Relationship to Later Language Development

The critical development in the transition period is the linking of sound patterns with meaning, first in comprehension, then in word production. The transition period begins with the onset of comprehension of the adult language, and it closes when word use begins to dominate babble, typically when the child is using about 50 different words spontaneously. The age range in which these developments occur is extremely variable. Babbling behaviour is one aspect of early communication that is emerging as a predictor of later language ability. Several researchers have suggested that the quantity and the diversity of vocalizations do indeed play a role in later language development. Results of studies have shown that the amount of prelinguistic vocalizations was positively related to later language measures.

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. Many of the studies count occurrences of adult-like sounds in the babbled output. Such an approach clearly calls for a metaphonological classification system that is gradually gaining acceptance. In addition, the developmental continuity in the babbled sounds is of great interest.

(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. Losik suggested that auditory development is impeded if babbling is blocked, and observed that babbling occurs mainly during periods of silence in the infant's environment, an observation that has been implied by other researchers. The dominant view, however, is that babbling is a necessary precursor of speech production, and is not necessary for auditory development. If babbling is a precursor of speech, then late babbling and acquisition of first words should overlap to some extent (Lleo, 1990).

(3) Developmental: To what extent is babbling just a manifestation of cell growth or other anatomical and physiological changes occurring in the infant? The relationship between babbling and acquisition of various motor skills has been studied (Hay, 1984, Ramsay, 1984, Ramsay, Willis, 1984). What processes are involved in babbling? One view is that babbling is simply the natural output of an immature production

apparatus, with no link to perceptual mechanisms. Another view is that perceptuo-motor attainments are already operating in babbling.

The first position can be referred to as the '**independence hypothesis'**. It postulates that prelinguistic 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 1983) 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. Inter-infant variability of babbling productions within the same linguistic community has been demonstrated both in sound repertoires and in the acoustic characteristics of productions (Ferguson 1979, 1986, Lieberman1980, Vihman, Ferguson & Elbert 1986). Since inter-infant variability is ascribed to random variations depending on inherent factors, it is regarded as contradicting neither the claim that perception and production in infants are separate processes (Studdert-Kennedy 1986), nor the prediction of universality in babbling productions that follows from that claim.

The second position, **'interactional hypothesis'**, assumes that perceptuo-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: During babbling, "what exactly is the child doing?" 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, which combines the best features of the other approaches.

A production-based theoretical explanation of babbling has been proposed by MacNeilage and Davis (1995), the Frame/Content theory, which argues that babbling, represents a regularization of infant vocalization by rhythmic close/open movements of the mandible, a step towards the production of the speech sounds, the consonants

and vowels (Cs & Vs) of language. During babbling, they have claimed that, infants use this mandibular oscillation almost entirely, to the exclusion of most independent movements of other speech articulators, to produce the percept of consonants and vowels organized into syllable-like CV sequences. Some of the most striking consequences of this limited production method are the distinctive CV patterns of babbling, e.g. [ba ba ba] or [dæ dæ dæ]. These patterns are characterized by the co-occurrence of labial consonants (consonants made with the lips) with tongue-central vowels, e.g. [ba], coronal (tongue-front) consonants with tongue-front vowels, e.g. [dæ], and dorsal (tongue-back) consonants with tongue-back vowels, e.g. [gu]. These dominant co-occurrences in babbling occur, according to MacNeilage and Davis, 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. It is not difficult to understand how these sound sequences are produced. To MacNeilage and Davis these strong co-occurrence patterns are evidence of motor constraints against the production, during babbling, of individual consonants and vowels in the multitudinous combinations typical of adult speech. They are also evidence of the supremacy of the syllable as the fundamental structural unit of speech. In the process of speech acquisition, they claim, the frame (the syllable) emerges first and only later does the content (the segment). That is, only later does the infant develop the motor control to move the various articulators rapidly and in concert to produce individual consonants and vowels with unique and contrasting articulatory features.

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 and Bradbury, 1931). Both types of investigation provide valuable information that leads to a better understanding of child phonology.

Onset of Babbling

Virtually all normal infants begin canonical babbling by 10 months of age, but there is wide variability. As a result of Oller's (1980, 1986) work on metaphonology, it is necessary to revisit earlier studies (which did not use the metaphonology) if they were concerned with the age of onset of canonical babbling or characterizations of pre-canonical vocalizations. Thus, in the literature before 1980, we find several studies that claim that the onset of canonical babbling occurs between the ages of 5 and 7 months.

A variety of methods have been reported for determining the onset of babbling. In most studies, the researcher visits the child in the home and records spontaneous vocalizations while the child plays alone with toys, or during interaction with the mother. The recordings are transcribed. The visits typically occur once every week.

Oller and Steffans (1993) suggested a more accurate method to obtain the age of onset of babbling. The child and a parent visit the laboratory at least once each month from the age of 1 month onwards. From 4 months onward, the staff notes whether marginal babbles are being produced. If so, 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. An infant is said to be in the canonical stage only if repeated occurrences of canonical syllables were observed during a majority of the five consecutive laboratory visits after the parental report of canonical babbles

Reduplicated versus Variegated Babbling

A reduplicated babble is a CVCV production in which the second CV consists of the same phonemes that are present in the first CV. A variegated babble is a CVCV production in which the C or the V is different in the second syllable. Early studies of babbling held that these two types of babble were produced by the infant during different stages, namely, the reduplicated babbling stage and the variegated babbling

stage (Elbers, 1982; Oller, 1980, 1986; Roug, Lundberg, & Lundberg, 1989; Stark, 1980). In contrast, Smith, Brown-Sweeney, and Stoel-Gammon (1989) and Mitchell and Kent (1990) found no clear separation between the use of reduplicated and variegated babbling in subjects before first words. 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 multisyllables. 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). They 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. These studies considered consonant series in multisyllabic utterances. These results suggest that the entire babbling period may be similar to the period of first words in containing both reduplicated and variegated forms.

Phonetic Characteristics of Early Babbling

A number of studies have looked at the sound repertoire and syllable shapes used by infants in the babbling stage.

Vowel Production in the First Year

Vowel production dominates infant vocalization throughout the first year. Vowels have been less extensively investigated, because they are particularly difficult to transcribe reliably and, thus difficult to characterize. 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 [‿ ∩ ˑ˙ ʌ, u↘ and were already present at the earliest session. [e] was heard most frequently (33 percent of all the vowels transcribed), and the remaining lax vowels each accounted for 11 percent-17 percent of the data. The remaining (tense) vowels each accounted for no more than 5 percent, with the back-rounded [o] and [u] least frequent (1 percent each).

Buhr (1980) analyzed recordings of vocal production of an infants aged 16–64 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.

In a study of 10 month old infants' vowel productions drawn from four linguistic communities-Arabic, Chinese, English, and French, de Boysson-Bardies, Sagart, Halle and Durand (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 Irwin's (1957) data with a more recent 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 Irwin's study was /e/, /⋂/, /^/, /⋃/, / ≙/, /u/. Kent and Bauer reported a different rank order: /^/, /‿/, / ·.· /, /≙/, /⋃/. Although the rank order varied slightly, at least four sounds remained constant across the two studies as the most prevalent: / ‿/, /^/, /≙/ and /⋃/.

Davis and Mac Neilage's (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 [ʌ ,ʊ and ɞ], predominated in 3 subjects, while high vowels, particularly [u, ʊ and ʊ̈], predominated in the remaining 3 subjects. In relation to tongue advancement, front vowels, particularly [ɞ ˑ˙ˑ and ʊ̈], predominated in 4 subjects, and the mid vowels [a, ʌ, ə], predominated in the remaining 2 subjects. Some common trends were identified. The most commonly used vowels in the canonical babbling period were identified as [ʌ, ə, ɞ ɐ ʊ ʊ̈ and ˑ˙ˑ], which was consistent with other studies (Irwin, 1957 and Kent and Bauer, 1995).

Sussman, Duder and Dalston (1996) 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.

Consonant Production in the First Year

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.

Davis and MacNeilage's (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/, /ŋ/. Davis and Mac Neilage 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 "frame" 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 "frame dominance" 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 intrasegmental production difficulty.

Syllable shapes in the First Year

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 Bauer's (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.

Robb and Saxman (1990) examined the continuity in development of syllable duration patterns in 7 young children as they progressed from preword to multiword periods of vocalization development. Using a combination of lexical and chronological age points, monthly vocalization samples were analyzed for bisyllable duration and final syllable lengthening. Results revealed no systematic increase or decrease in the duration of bisyllables produced by the children as a group. Lengthening of final syllables was observed across nearly all recording sessions for all children. It is likely that the feature of bisyllable duration is not discernibly sensitive to changes associated with a developing speech mechanism and environmental input. The results suggested that, the regularity in final syllable lengthening is consistent with a continuity theory of development.

Prelinguistic 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 f0 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 prelinguistic 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 Transition Period: From Babbling to Meaningful Speech

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 prelinguistic 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 and Dunn, 1985). Children may even use a combination of babbling and meaningful speech in a single utterance (Branigan, 1977). A child's first meaningful productions have been labeled protowords (Menn,

1975). Protowords, also known as vocables (Ferguson, 1978), phonetically consistent forms (Dore, Franklin, Miller, and Ramer, 1976), invented words (Locke, 1983), sensori-motor phonemes (Carter, 1979) and quasi-words (Stoel-Gammon and 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 "true words". However, they cannot be considered babbling either because they have some phonetic consistency (Stoel-Gammon & Dunn, 1985). Ferguson (1978) described protowords as "babbling-like sounds used meaningfully". 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 begin to be affected by the phonetic makeup of the specific language of the child's 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 subject's productions "sensori-motormorphemes".

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 Cooper's (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 (1985) 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.

Elbers (1986) offers a different explanation for the tendency to produce 'father' words earlier. Elbers claims that the literature is replete with examples in which nasals are commonly produced by infants in the context of crying, whining, whimpering (fussing). Elbers cites a study in which infants use 'mama' as a lament or a general

request before they use it in a referential way. Thus, mothering and 'mama' go together.

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. Consonant clusters were very rare. They found that the most common vowels used were central, mid-front, and low-front ([^, e, ˙.˙]), 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, Buder 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 toward more adult-like values, alveolar slope and y-intercept moved away from adult values and more in the direction of decreased coarticulation 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 3–5-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 in both prelinguistic and linguistic infants: mothers' speech studies by Toda, Fogel and Kawai (1990) and sibling speech studies by Dunn and Kendrick (1982), various conditioning paradigm studies by Hamilton (1997) and learning the rules of communication (Ninio and Bruner, 1978).

Cross-cultural differences in mother's speech: What is the role of the mother's speech at an earlier stage in the development of the infant's speech? To examine this question, Toda, Fogel and Kawai (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. They found that US mothers tend to respond to and stimulate infants' positive vocalization, whereas Japanese mothers show less vocalization, physically contacted the infant more, and were more likely to respond to infants' negative vocalizations. The study only examined 3 month old infants.

Toda, Fogel and Kawai (1990) found that maternal speech to prelinguistic infants is more complicated, more conversational. Maternal speech to infants who were using words was slower and more simplified, perhaps in order to help teach the infant. It was found that "there was no difference in the amount and temporal pattern of 'gaze at mother' between the countries", and "no difference were found in the frequency and duration of gaze at mother". Thus although there are cultural differences between the American and the Japanese mothers in their interaction with their infants, there were no significant difference in the pattern of gaze during mother/infant communication.

Conditioning paradigms: Hamilton (1977) examined the effect of operant conditioning on the learning of vowel and consonant sounds and short words. In previous studies, it was found that adult repetition of an infants sound, sometimes

changed in the direction of correct adult usage, "increased vocalization rates more than the use of touch or food reinforcement did". Hamilton (1977) used four test conditions consisting of (1) operant conditioning (verbal rewards for correctly produced sounds), (2) vocal imitation (the experimenter vocally imitates the infants utterances), (3) modeling (the experimenter produces the target sound several times for the infant), and (4) modeling and social reinforcement (same as modeling except experimenter rewards with smiles and verbal rewards), and a control condition. There was little difference between the control group and the operant conditioning group in the number of emitted sounds and words. The modeling and social reinforcement group showed higher performance on word production, but not on consonants and vowels.

Learning rules of communication: Although not directly relevant to the problem of babbling, learning rules of communication plays an important role in language acquisition. The work of is mentioned to prevent the reader from drawing the mistaken conclusion that word acquisition by the infant just happens, but instead results from an active interaction with others skilled in the target language. Ninio and Bruner (1978) studied mother-infant dyads in the period between 8 months and 1.6 years involved in a ritualized dialogue of picture-book reading. Prior studies have shown that 64% of a child's 50-word vocabulary consists of nominals (names of people and objects), and children seem to "take great delight" in naming objects. The child is seen by the mother as having the intention to point at or name a specified object in a picture-book reading environment, and it is suggested that "the child finds out by the responses of adults what he is assumed to mean by what he is saying".

Thus, a "scaffolding dialogue" ensues between the mother and the child during which the child learns the labeling of objects and the rules of turn-taking.

How good are infants at imitating speech sounds? No studies were found that address this issue for the production of particular kinds of speech sounds. 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 world's 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 – simple stop consonants and nasals are highly frequent in the world's 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 "simple" (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 back- grounds. These differences parallel those found in adult speech in the corresponding languages. Implications of an early build-up of target- language-oriented production skills are discussed.

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. However, the study considered only two infants, one from each language environment.

Taken together, these results may suggest that babbling of sounds that require fine temporal control may not benefit from early linguistic experience whereas babbling of continuants benefits from such experience.

MacNeilage and Davis (1993) found evidence for the existence of common fronting and common tongue-backing but not of the co-occurrence constraint involving labial consonants and central vowels. These results raise the possibility that

the tongue-based constraints postulated for babbling and early speech may have an extremely fundamental status. Acoustic studies of early babbling have provided support for the idea of a predominance of mandibular over lingual movement in early canonical sequences.

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. A favored association between dentals and front vowels was found in English, Swedish and French; between central vowels and dentals in Yoruba. Where infants predicted from differed patterns, Boysson-Bardies suggested the influence of the ambient language as being characteristic of the resulting patterns.

Oller and Steffans (1993) noted some association of consonants and vowels within syllables in a study of four children 10-12 months. Coronal consonants were more frequently associated with front vowels, dorsals more frequently with back vowels. Coronals showed the greatest association with high vowels, labials the greatest association with low vowels. By 16-24 months, CV associations in the subjects had weakened, consistent with the systematic development toward more segmental function, according to the authors.

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 videorecorded 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. Consonantality was defined as the total number of consonants across utterances, while consonant combinations were the number of utterances containing more than one consonant. Both of these variables were divided by the total number of utterances to control for infant differences in rate of babbling or in recording time. 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 were 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

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.

The Indian studies that are reported, focusing on developmental aspects have included children between the ages of 0 to 5 years in their investigations. There are no reported studies in the Indian context focusing particularly on the babbling period. The issues related to babbling have not been explored in the Indian context. Hence the need for the study is amplified. The present study was planned to obtain quantitative database on babbling in typically developing children. The focus of this study is restricted to the transcriptional analysis of the babbling samples in typically developing children.

CHAPTER III

METHOD

Babbling behavior is one aspect of early communication that is emerging as a predictor of later language ability. The qualitative and quantitative analysis of babbling helps to gain an insight regarding what is normally expected in an infant at the babbling stage of early communication development. There is proven evidence from studies that the phonetic repertoire during babbling stage also varies across languages. Hence there is a need to establish data on babbling in the Indian context since the Western data do not prove to be valid enough. In this regard, the present study aimed at investigating the development of babbling for the following aspects in infants from Kannada speaking homes in the age range of 6 months to 12 months:

- Phonetic repertoire, including the frequency of occurrence of vowels and consonants, the consonants with reference to their place, voicing and manner of articulation and vowels based on tongue height, tongue advancement.
- Syllable shapes and their frequency of occurrence.
- Preferential occurrence of vowels with certain consonants within syllables.
- Percentage of reduplicated and variegated babbling

Subjects

Thirty typically developing infants, in the age range of 6-12 months from monolingual homes with Kannada as the native language were selected as subjects

for the study (Kannada is one of the major Dravidian language spoken in the state of Karnataka, South India). The subjects were divided into 6 groups with an age interval of one month that is, 6-7 months, 7-8 months, 8-9 months, 9-10 months, 10-11 months and 11-12 months. Each of these six groups consisted of 5 infants. Hence a total of 30 infants (6x5) were included as subjects in the study. There was no equal distribution of male and female infants in the groups. The subjects 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 subjects and a written consent was obtained prior to the recording of the sample.

Subject selection criteria were as follows:

- Subjects belonged to monolingual Kannada speaking homes from the urban regions of Mysore.
- Parent case history report and chronological age-level performance on selected speech, language, hearing and developmental tests. The Assessment Checklist for Speech and Language skills, Developmental Screening Test and an informal behavioral hearing screening were utilized to establish normal development of the subjects. All thirty infants had achieved normal motor, hearing and language milestones.
- The selected subjects belonged to middle socio-economic class and both parents were educated up to a minimum of 12^{th} class.

Data recording procedure

Recording sessions of 30 minutes for all the subjects took place in the individual children's homes in the presence of the mother. Audio-recordings of all the samples were made using a digital voice recorder (Olympus Digital Voice Recorder) with an external microphone which was placed approximately 20 cm away from the infant. The babbling samples were recorded when the child was fed and was in a comfort state. The recording was carried out in a quiet environment and the experimenter was always present as a passive observer. The parent-child interaction and the use of toys were used as elicitation techniques. The mother was instructed to engage in play or interact naturally with the child. Parents were questioned regarding the representativeness of the child's vocalizations after recording the sample. In cases where the recorded sample was not typical of the child's vocalizations, the recording was repeated and an alternative sample was utilized that was judged to be representative for that particular infant. With the older infants to identify the occurrence of protowords, parents were questioned regarding the occurrence of any items they identified as words or protowords within the child's usual vocal patterns. During the recording, parents were asked to signal the examiner when these items occurred.

Data analysis

The recorded data was subject to editing to eliminate the parent's speech and the non-vegetative vocalizations (such as cries, burps, and coughs etc.) The child's speech-like utterances were retained for analysis. After data reduction, the investigator listened to the samples and analyzed them according to the parameters under investigation. A minimum of 50 utterances from the 30 minute duration recording were transcribed phonetically using IPA (broad phonetic transcription

method) from the audio tapes for each of the subjects separately. Hence a corpus of 1500 utterances (30 subjects x 50utterances) was transcribed. Vowels were grouped according to tongue height and advancement variations. Tongue height variations included high, mid and low categories and tongue advancement variations included front, central, and back categories. The consonants were grouped based on manner and place, and voicing dimensions. Manner variations included stops, nasals, continuants, laterals and fricatives (glottal). Place variations included bilabial, dental, palatal, velar and glottal. The consonants were also qualitatively analyzed for the occurrence of voiced and unvoiced counterparts. Inventories of syllable shapes and multisyllabic utterances in the entire corpus of 50 utterances for each subject in all the groups were tabulated. The vowels, consonants, syllable shapes and multisyllabic counts were established for the 5 individual subjects in all the six groups. 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], [babubi] 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. The raw scores were converted to percentage scores for the vowels, consonants, syllable shapes, multisyllabic utterances and for the reduplicated and variegated babbling utterances. Singleton consonants and vowels were also considered under syllable shapes. Percentage of occurrence of different categories of vowels and consonants were tabulated for each of the five subjects within a group and for the entire group. Percentage of occurrence of various syllable shapes was also calculated using the following formula (as given by Valleman, 1998).

Eg.

a) Percentage of CV syllables = $\frac{\text{No. of CV syllables}}{\text{Total No. of syllables}} \times 100$

Similarly, the percentage of occurrence of V,C, VC, CVC and VCV syllables were calculated. The percentage of reduplicated and variegated babbling was calculated using the following formula:

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

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

The characteristics of multisyllables were also qualitatively analyzed to determine the preferential occurrence of vowels with certain consonants within the syllables.

Reliability

Intra-judge reliability

After completing the original analysis, the investigator randomly selected 10% of the total samples and repeated the procedure of transcription. Reliability was calculated based on point-to-point percentage of agreement i.e., the number of items judged to be same was divided by the total number of items selected. To assess intra-judge reliability, the investigator randomly selected 10% of the total samples, a week after completing the original transcription (broad IPA) and repeated the procedure of

transcription. A point to point method was used to assess the reliability of transcription of the babbling samples which resulted in a reliability index of 94%.

Inter-judge reliability

To check the reliability of transcription, inter-judge reliability was carried out. An experienced Speech-Language Pathologist transcribed 10% of the whole sample. The point to point agreement between the experienced Speech-Language Pathologist and the investigator was prepared. This was converted into percentage to get reliability index. Point to point method was also employed to assess inter-judge reliability which resulted in a reliability index of 92%.

Statistical analysis

Descriptive statistics and appropriate non-parametric statistics were used to statistically analyze the data. Kruskal-Wallis test and Mann Whitney tests were used to make between age group comparisons (vertical comparisons). Friedman test and Wilcoxon Signed Rank test were used for within group comparisons (horizontal comparisons).

CHAPTER IV

RESULTS & DISCUSSION

The aim of the present study was to establish quantitative and qualitative database on the development of babbling in infants from Kannada speaking homes in the age range of 6 to 12 months with the following objectives:

- To establish the phonetic repertoire, including the frequency of occurrence of vowels and consonants, the consonants with reference to their place, voicing and manner of articulation and vowels based on tongue height and tongue advancement.
- To identify the syllable shapes and to quantify their frequency of occurrence.
- To identify preferential occurrence of vowels with certain consonants within syllables.
- To calculate the percentage of reduplicated and variegated babbling.

Data included audio recorded babbling samples of 30 infants in the age range of 6 to 12 months from monolingual homes with Kannada as the native language. The subjects were subdivided into six age groups with an inter age interval of one month. That is, 6-7, 7-8, 8-9, 9-10, 10-11 and 11-12 months respectively, with each age group comprising of 5 subjects. The recorded data was transcribed phonetically using IPA (broad transcription method) and analyzed keeping in view the above mentioned objectives. The results will be discussed under the following sections:

1. Vowels
2. Consonants
3. Syllable Shapes/Types

4. Preferential occurrence of vowels with certain consonants within syllables
5. Percentage of reduplicated and variegated babbling

1. VOWELS

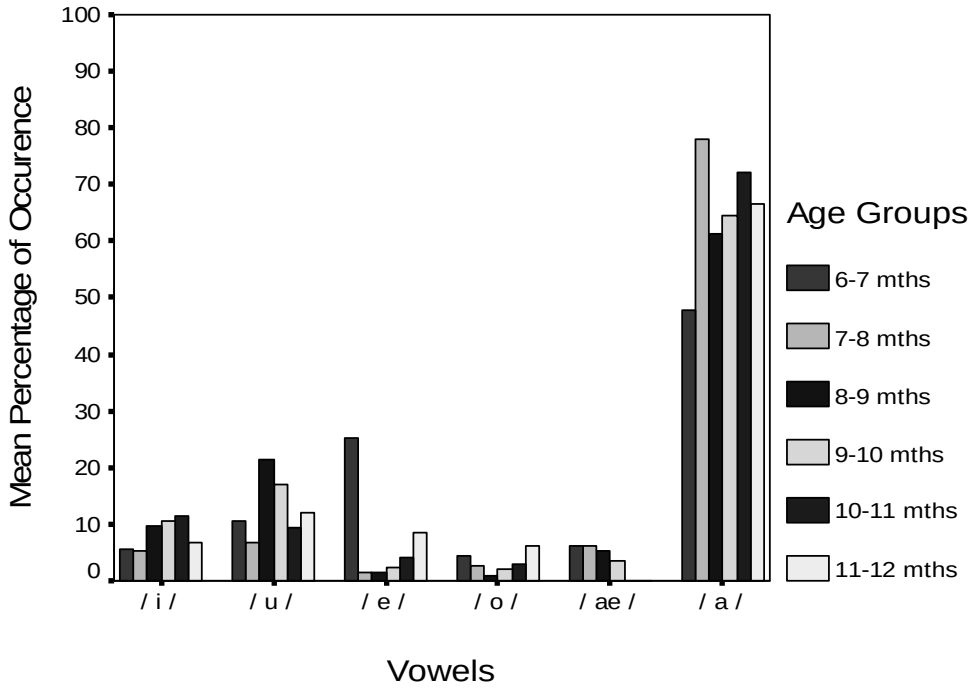
Overall, singleton vowels and vowels occurring in various syllables and multisyllabic utterances were transcribed and analyzed for each subject in all the six age groups from the entire corpus of 1,500 utterances. The vowels were phonetically transcribed using IPA (broad transcription method) for individual vowel types in the following categories:

1. Vowels classified according to tongue height - high [i, u], mid [e, o] and low [ae, a]
2. Vowels classified according to tongue advancement - front [e, ae, i], central [a] and back [u, o]

The frequency of occurrence (in percentage) of each of the individual vowel types for all the subjects in all the groups was established. Mean values and standard deviations for all the age groups, of the vowel types classified according to tongue height and tongue advancement parameters are presented in Table 1. Graph 1 represents the mean percentage of occurrence of vowels in all the six age groups.

Age (months)	[i]	[u]	[e]	[o]	[ae]	[a]
	Mean & SD	Mean & SD	Mean & SD	Mean & SD	Mean & SD	Mean & SD
6-7	5.45(2.97)	10.66(4.74)	25.3(16.15)	4.37(1.87)	6.27(1.91)	47.92(10.9)
7-8	5.19(3.26)	6.73(3.01)	1.42(2.06)	2.53(2.06)	6.01(3.81)	78.09(8.73)
8-9	9.58(6.37)	21.4(5.07)	1.53(1.50)	0.85(1.50)	5.19(4.11)	61.35(9.19)
9-10	10.48(3.92)	16.93(6.49)	2.44(0.44)	2.17(0.44)	3.46(2.33)	64.50(1.94)
10-11	11.47(8.53)	9.50(3.58)	4.08(3.24)	2.79(3.24)	0.0(0.0)	72.14(8.88)
11-12	6.74(2.55)	12.0(4.22)	8.47(3.03)	6.14(3.03)	0.0(0.0)	66.61(4.25)
Total	8.15(5.26)	12.8(6.55)	7.21(10.6)	3.14(10.6)	3.49(3.57)	65.10(12.0)

Table 1: Mean percentage of occurrence and standard deviations of vowels.



Graph 1: Mean percentage of occurrence of vowels.

From Table 1 and Graph 1, it can be noted that, overall the low-central vowel [a] dominated in the utterances of all the subjects in all the age groups, followed by high-back vowel [u] and high-front vowel [i]. The occurrence of the high-front vowel

[i] was low in the younger age groups, i.e. 6-9 months and showed an increase in its occurrence at 9-11 months, followed by a decline in the older group, i.e. at 11-12 months. The mid-front vowel [e] made a predominant appearance in the youngest group, i.e. at 6-7 months, followed by a decline in the occurrence in the older age groups. The occurrence of the low-front vowel [ae] showed a gradual decline as the age increased and did not occur at 10-11 and 11-12 months. The low-central vowel [a] made its highest frequency of occurrence at 7-8 months. The occurrence of the high-back vowel [u] was scattered across age groups and lastly, the mid-back vowel [o] appeared less frequently at all age groups compared to all the other vowels.

Vowels classified according to tongue height

According to tongue height dimension of the vowels, the frequency of occurrence of [i] was higher across all age groups compared to [u], among the high vowels. Overall, the mid vowels made fewer appearances across age groups. The occurrence of low vowel [a] was the highest across all age groups compared to the other low vowel [ae].

Vowels classified according to tongue advancement

According to tongue advancement dimension, reflecting on all the front vowels together, the vowel [i] made more frequent appearances in all the six age groups compared to the other front vowels [e] and [ae]. The central vowel [a] made predominant appearances across all age groups. The back vowels [u] and [o] were lower in their frequency of appearance in all the age groups.

Two types of statistical analysis were employed for obtaining the results.

- An analysis of the across age group comparisons (vertical developmental trends) was carried out using the nonparametric Kruskal-Wallis test and Mann Whitney tests which provided information on the significant differences occurring between the six age groups, i.e. the changes occurring as the age increased, which revealed the developmental trend in babbling.

- The second type of statistical analysis was for within group comparisons (horizontal trends). The within group comparisons were made for all the six age groups using Friedman test and Wilcoxon Signed Rank test, which provided information on what parameters were more predominant than the others in each age group.

- The chi square values were generated from the results of the above non parametric statistical tests.

Across age group comparison of the vowels

The non-parametric Kruskal Wallis test was used to test whether there were significant differences with the high-front, mid-front, low-front, low-central, and high-back and mid-back vowels between groups, with age as the factor. The results of this test indicated an overall significant effect of age for the mid-front vowel [e]{ χ^2 (5) = 20.615, $p < 0.01$}, low-front vowel [ae] { χ^2 (5) = 18.095, $p < 0.01$}, low-central vowel [a] { χ^2 (5) = 18.760, $p < 0.01$}, high-back vowel [u] { χ^2 (5) = 17.053, $p < 0.01$} and mid-back vowel [o] { χ^2 (5) = 14.183, $p < 0.05$} except for the high front vowel [i].

Mann Whitney test was performed to exemplify the significant differences in the occurrence of vowels across all pairs of age groups (Table 2). The vowels that showed significant difference in their occurrence between each pair of age group are given below in Table 2.

Age Pairs (months)		Vowels that are significant
6-7 with	7-8	[e]**, [a]**
	8-9	[u]**, [e]**, [o]*
	9-10	[i]*, [e]**, [o]*, [ae]*, [a]**
	10-11	[e]**, [ae]**, [a]**
	11-12	[e]*, [ae]**, [a]**
7-8 with	8-9	[u]**, [a]*
	9-10	[u]*, [a]*
	10-11	[a]*
	11-12	[e]**,[ae]*,[a]*,[u]*
8-9 with	9-10	---
	10-11	[u]**, [ae]*
	11-12	[u]*, [e]**, [o]**, [ae]*
9-10 with	10-11	[u]*, [ae]**
	11-12	[e]**, [o]**, [ae]**
10-11 with	11-12	[o]*

* Significant at 0.05 level
**Significant at 0.01 level

Table 2: Pair-wise comparison of vowels across age groups.

Table 2 provides information about the developmental trend in the occurrence of vowels with increase in age from 6 to 12 months with respect to the occurrence of

vowels. It can be noted from Table 2 that as age increased, the occurrence of certain vowels declined and certain others increased (refer to the mean and standard deviation scores in Table 1). Thus, the youngest group, i.e. 6-7 months differed significantly from the 7-8 month group only in the production of two vowels [e] and [a] since the occurrence of [e] reduced significantly in the 7-8 month group and the occurrence of [a] was significantly high. In comparison of the 6-7 month group with the 8-9 month group, the 6-7 month group differed significantly from the 8-9 month group in the production of three vowels {[u],[e] and [o]} and by five vowels {[i], [e], [o], [ae], [a]} from 9-10 month group and three vowels {[e], [ae], [a]} from the 10-11 month group and also 11-12 month group. The developmental trend in the occurrence of certain vowels is evident with these findings. For example, the 6-7 month group had a significantly high occurrence of vowel [e] and thereafter it declined to the 11-12 month group, though not linearly. The low-front vowel [ae] also declined from 6-7 month group and did not occur in the 11-12 month group of subjects.

Similarly, the 7-8 month group, 8-9 month group and the 9-10 month group differed significantly from the 11-12 month group. The observation here is that the younger groups differed significantly for more number of vowels with the higher age groups which indicates the difference in the occurrence of vowels as age increased. However, the occurrences of some of the other vowels were scattered in the age range of 6-12 months .

Within age-group comparison of the vowels

A comparison of the occurrence of the vowels within the age groups will be useful in determining what vowels made more appearances than the others in each

month. The Friedman test was used to detect if significant differences existed in the occurrence of all the six vowels observed within each of the six age groups. The test results revealed that there were significant differences in the occurrence of the six vowels within each age group. i.e. 6-7 months, $\{\chi^2(5) = 19.655, p<0.01\}$, 7-8 months, $\{\chi^2(5) = 17.879, p<0.01\}$, 8-9 months, $\{\chi^2 = 21.734, p<0.01\}$, 9-10 months, $\{\chi^2 = 22.069, p< 0.01\}$, 10-11 months, $\{\chi^2 = 21.190, p< 0.01\}$ and 11-12 months, $\{\chi^2 = 20.402, p<0.01\}$. Wilcoxon Signed Ranks test was run to determine the pairs of vowels which had significant difference within age groups, the results of which are presented in Table 3.

Vowel Pairs	6-7 months	7-8 months	8-9 months	9-10 months	10-11 months	11-12 months
[i-u]	----	----	*	----	----	----
[i-e]	*	----	*	*	----	----
[i-o]	----	----	*	*	----	----
[i-ae]	----	----	----	*	*	*
[i-a]	*	*	*	*	*	*
[u-e]	----	----	*	*	----	----
[u-o]	*	----	*	*	----	*
[u-ae]	----	*	*	*	*	*
[u-a]	*	----	*	*	*	*
[e-o]	*	----	----	----	----	----
[e-ae]	*	*	----	----	*	*
[e-a]	----	*	*	*	*	*
[o-ae]	----	----	----	----	----	*
[o-a]	*	*	*	*	*	*
[ae-a]	*	*	*	*	*	*

* Significant at 0.05 level and ---- Not significant

Table 3: Pair wise comparison of vowels within the age groups.

Table 3 shows the pairs of vowels which differ significantly in their occurrence within each of the six age groups. Correlating these results with the mean scores in Table 1, it can be noted that in the 6-7 month group, the mean occurrence of the mid-front vowel [e] was high and significant differences were seen between the high-front vowel [i] and [e]. The mean occurrence of [i], [u] and [o] were relatively low, whereas the mean occurrence of [a] was high which brought about a significant difference between the pairs [a-i], [a-u] and [a-o].

In the 7-8 month group, the occurrence of the low-front vowel [ae] was relatively low; hence its occurrence differed from the high-back vowel [u], mid-front vowel [e] and low central vowel [a]. The occurrence of the low-central vowel [a] was high and hence it differed significantly from the high front vowel [i], mid-front vowel [e], mid-back vowel [o] and low-front vowel [ae]. The high-back vowel [u] differed significantly in its occurrence only from [ae].

The situation in the 8-9 month group was considerably different from that of the 6-7 and 7-8 month group. The occurrence of high vowels [u] and [i] was high in 8-9 month group and hence differed significantly from the occurrence of most of the other vowels that occurred in 6-7 and 7-8 months.

Similar trends were seen in the 9-10 month group, where the mean occurrence of the vowels [i] and [u] was higher. In the 10-11 and 11-12 month groups, the low-central vowel [a] made its highest appearance compared to other vowels and differed significantly from most of the other vowels. It was found that the vowel [a] was the

most preferred vowel in the environment of majority of the consonants in the 10-11 and 11-12 month old subjects.

Referring to the mean percentage of occurrence of vowels within each of the six age groups (Table 1); the following rank order of vowels can be established as shown in Table 4.

Age (in months)	Rank order of the vowels (in the decreasing order)
6-7	[a, e, u, ae, i, o]
7-8	[a, u, ae, i, o, e]
8-9	[a, u, i, ae, e, o]
9-10	[a, u, i, ae, e, o]
10-11	[a, i, u, e, o]
11-12	[a, u, e, i, o]

Table 4: Rank order of the vowels within each of the six age groups.

` Kent and Bauer (1985) reported the rank order of vowels at the end of the variegated babbling stage to be /^/, /‿/, / ae /, /a/, /U/. It can be noted that the rank order of occurrence of vowels in infants from English speaking homes differ from the rank order of the occurrence of vowels in the subjects of the present study in Kannada. This finding indicates that the preference in the phonetic repertoire of infants, even in the babbling stages varies with the linguistic backgrounds.

Lieberman (1980) in his single case study reported that [ɨ, ae,] were the lax vowels that were present frequently in the babbling period and the tense vowels [o] and [u] were less frequent. The results of the present study also indicated that [u] was the least occurring vowel in all the age groups. The high front vowel [i] also made fewer appearances between 6-8 months and gradually increased with age. With reference to the rank order (Table 4) the lax vowel [a] occurred maximally in all the age groups.

On examining the developmental trend in babbling between the six age groups, the finding that the 6-7 month old group showed minimal significant differences with the 11-12 old month group, is probably due to the fact that singleton utterances of these vowel types was higher in the youngest age group, whereas the same vowels repeatedly occurred in multisyllabic utterances in the older age groups resulting in similar percentage of occurrence count in the youngest and the oldest groups considered here.

The low-front vowel [ae] made its appearance only in the younger age groups, i.e. from 6 months to 9 months, and it's frequency of occurrence gradually diminished with increase in age. The fact that [ae] did not occur in the 10-12 month group indicates that babbling assumed more language-specificities as age increased. In support of the view that language specificities assume as age increases, Boysson-Bardies and her colleagues (1989) reported differences in the production of vowel types of infants from different linguistic backgrounds. 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. This can also be explained with Lieberman's (1990) finding that lax vowels such as [ae] are predominant only in the early stages of babbling.

The evidence also comes from a study on vowels by Levitt and Utman, (1992) in American and French infants. He found that the two groups of infants belonging to different linguistic communities produced vowels with different formant frequencies and this variability was evident 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. Hence the results should be interpreted keeping in view, the linguistic background of infants.

In the present study, the occurrence of vowels within as well as across age groups showed wide variability. Variability in the production of vowels during babbling has been well documented in the literature. Davis and Mac Neilage's (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 'vowel-like' sound may be preferred in place of the term 'vowels'.

Overall, the vowel repertoire found in the babbling samples of the subjects from the age range of 6-12 months were [i, e, ae, a, 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 higher-low front vowel [ae] which frequently occurred in the samples of younger subjects. The lax vowel [ae] exists only in the colloquial form of Kannada (Upadhyaya, 1972).

2. CONSONANTS

The 14 consonants found in the entire corpus in the babbling samples of the 30 subjects were [p, b, m, n, th, dh, t, d, h, k, g, l, y, w]. Overall, singleton consonants and consonants occurring in syllables and multisyllabic utterances were transcribed (broad IPA) and analyzed according to manner and place of articulation. The consonants were categorized into the following categories:

1. According to manner of articulation – stops, nasals, continuants, laterals and fricatives.
2. According to place of articulation – bilabials, dentals, palatals, velars and glottals.

The frequency of occurrence of the consonant types for all the subjects in all the six groups was established. Consonants will be discussed with reference to manner of articulation and place of articulation.

CONSONANTS WITH REFERENCE TO MANNER OF ARTICULATION

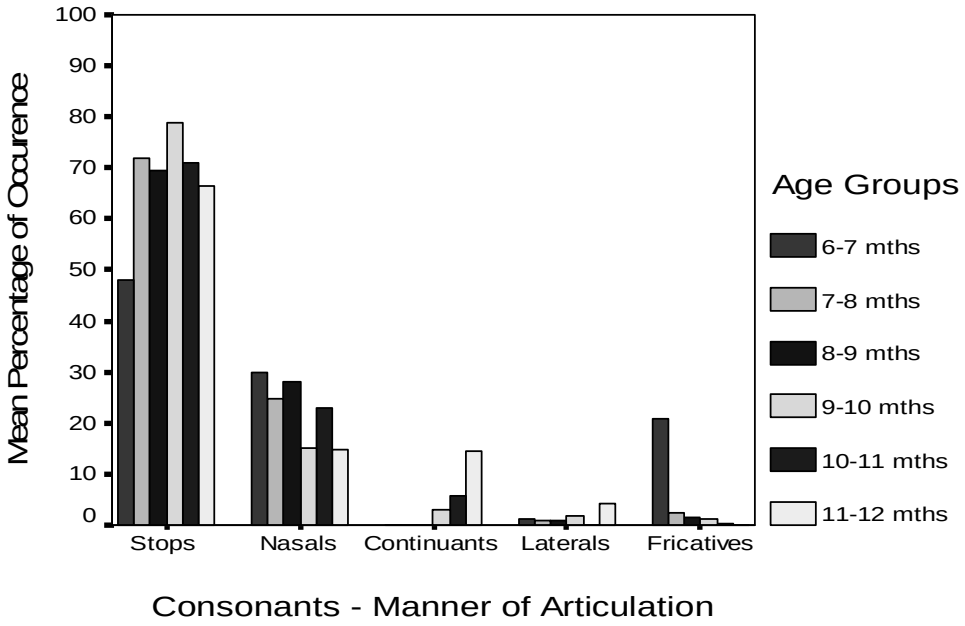
The consonants that occurred in the babbling samples analyzed were:

- Stops: [p, b, t, d, t, d, k, g]
- Nasals: [m, n]
- Continuants/ Glides: [y, v]
- Laterals : [l]
- Glottal fricative : [h]

Mean values and standard deviations per age group, of the consonant types classified according to manner of articulation are presented in Table 5. Graph 2 represents the mean percentage of occurrence of the consonants based on manner of articulation.

Age (months)	Stops	Nasal	Continuant	Lateral	Fricative (glottal)
	Mean & SD	Mean & SD	Mean & SD	Mean & SD	Mean & SD
6-7	47.99(13.44)	29.85(9.34)	0.0(0.0)	1.21(2.71)	20.93(6.10)
7-8	71.83(5.86)	24.8(3.42)	0.0(0.0)	0.93(1.27)	2.43(3.33)
8-9	69.51(9.70)	27.94(10.36)	0.0(0.0)	0.93(1.34)	1.6(2.21)
9-10	78.74(7.54)	15.03(4.94)	3.13(2.89)	1.83(1.08)	1.24(1.72)
10-11	71.09(6.4)	22.86(5.64)	5.6(4.17)	0.0(0.0)	0.43(0.97)
11-12	66.36(10.61)	14.93(7.93)	14.53(18.27)	4.16(3.2)	0.0(0.0)
Total	67.59(12.86)	22.57(8.93)	3.87(8.8)	1.51(2.19)	4.44(8.05)

Table 5: Mean percentage of occurrence and standard deviations of consonants for manner of articulation.



Graph 2: Mean percentage of occurrence of consonants (manner of articulation)

As seen from Table 5 and Graph 2, stops dominated in their occurrence across all the six age groups, followed by nasals. These two consonant types accounted for a large part of the data. The 9-10 month old infants showed the highest occurrence of stops. It was interesting to note that stops had the least occurrence in the youngest group, i.e. 6-7 months and had a higher occurrence in the other older groups. Stops [p, b, th, dh, t, d, k, g] were the highest occurring consonant type in the 9-10 month group. A similar trend was maintained in all the other age groups, where stops were the dominant consonant types compared to other consonant types. Nasals [m] and [n] were the second highest consonant type to occur. The occurrence of nasals was the highest in the youngest 6-7 month group. The occurrences of nasals in the other age groups were scattered. Continuants/ glides [y] and [v] made their appearance only at 9-10 months and thereafter increased till 11-12 months. The occurrence of laterals was below 5% in all age groups. The corpus of the 6-7 month old infants consisted of the glottal fricative [h] which accounted for 21% of the data. The occurrence of [h]

was rare in all the other age groups and did not occur at all in the 11-12 month old infants.

Across age group comparisons of consonants according to manner of articulation

To determine if significant differences existed in the occurrence of these consonant types between groups, the Kruskal Wallis test was run on the means of stops, nasals, continuants, laterals and glottal fricatives, with age as the factor. The results revealed significant difference of age for stops, $\{\chi^2 (5) = 13.906, p<0.05\}$, nasals, $\{\chi^2 (5) = 12.556, p< 0.05\}$, continuants, $\{\chi^2 (5) = 16.774, p<0.01\}$ and glottal fricative, $\{\chi^2 (5) = 17.458, p<0.01\}$. Mann Whitney test was used to determine the significant difference between each of the pairs of age groups for the consonant types. The consonants that showed significant difference in their occurrence between each pair of age group are specified below in Table 6.

Age Pairs (months)		Consonants that are significant
6-7 with	7-8	Stops**, Glottal fricative**
	8-9	Stops*, Glottal fricative**
	9-10	Stops**, Nasals*, Glottal fricative**
	10-11	Stops**, Continuants**, Glottal fricative**
	11-12	Stop*, Nasals*, Continuants*, Glottal fricative**
7-8 with	8-9	----
	9-10	Nasals*
	10-11	Continuants**
	11-12	Nasals*
8-9 with	9-10	Nasals*
	10-11	----
	11-12	----
9-10 with	10-11	Laterals*
	11-12	Stops*
10-11 with	11-12	Laterals*

*Significant at 0.05 level & **Significant at 0.01 level

Table 6: Pair-wise comparisons of the consonants across age for manner of articulation.

Table 6 provides information about the developmental trend in the occurrence of consonants during babbling. The 6-7 month group differed significantly from the 7-8 and 8-9 month groups in the occurrence of stops and fricatives. In the youngest group, i.e. 6-7 months, the occurrence of the fricative [h] was high whereas the occurrence of the stops was relatively low in comparison with the 7-8 and 8-9 month groups. On the contrary, the occurrence of stops was high in the 7-8 and 8-9 month groups and the glottal fricative occurred very rarely. Hence 6-7 month group differed from the 7-8 and 8-9 month groups significantly in the production of stops and glottal fricative.

The 7-8 month group had significant higher occurrences of nasals compared to the 8-9 and 9-10 month groups. Continuants did not occur in the 7-8 month group and hence showed significant difference with the 10-11 and 11-12 months. Similarly 7-8 month group had a significantly high occurrence of nasals as compared to the 11-12 month group.

The 8-9 month group did not differ significantly for the consonants in comparison with the other older groups. On similar comparison with the older groups, the salient observation was that the 9-10 and 11-12 months groups had significant higher occurrence of laterals compared to the 10-11 month group as the laterals did not occur in the 10-11 month group.

Within age-group comparison of the consonants according to manner of articulation

A comparison of the occurrence of the consonants within the age groups was used to determine what consonants made more appearances than the others in each age group. The Friedman test was used to determine if significant differences existed in the overall occurrence of all the five consonants types within each of the six age groups. The test results revealed that there were significant differences in the occurrences of the five consonant types within all the six age groups i.e. 6-7 months $\{\chi^2 (5) = 18.232, p<0.01\}$, 7-8 months $\{\chi^2 (5) = 18.356, p<0.01\}$, 8-9 months $\{\chi^2= 18.356, p<0.01\}$, 9-10 months $\{\chi^2= 17.915, p< 0.01\}$, 10-11 months $\{\chi^2 = 19.833, p< 0.01\}$ and 11-12 months $\{\chi^2 = 16.041, p<0.01\}$. Wilcoxon Signed Ranks test was used to find which pairs of consonants had significant difference within each age group, the results of which are presented in Table 7.

Consonant Pairs	6-7 months	7-8 months	8-9 months	9-10 months	10-11 months	11-12 months
Stops-nasals	----	*	*	*	*	**
Stops-Continuants	*	*	*	*	*	*
Stops- Laterals	*	*	*	*	*	*
Stops- Glottal fricatives	*	*	*	*	*	*
Nasals - Continuants	*	*	*	*	*	----
Nasals -Laterals	*	*	*	*	*	*
Nasals- Glottal fricatives	----	*	*	*	*	*
Continuants-Laterals	----	----	----	----	*	----
Continuants-Glottal fricatives	*	----	----	----	*	----
Glottal fricatives-Laterals	*	----	----	----	----	----

* Significant at 0.05 level
---- Not significant

Table 7: Pair-wise comparison of the consonants within each group for manner of articulation.

As seen from Table 7, it is evident that, on within group comparison of consonant types, the occurrence of stops differed significantly with all the other consonant types except for nasals in the 6-7 month group. In the 6-7 month group. The stop category of consonants differed in their occurrence from laterals and glottal fricatives since the mean occurrence of stops was higher compared to laterals and glottal fricatives. Continuants/glides did not occur in the 6-7 month group. The mean occurrence of nasals was higher and hence it differed from the occurrence of laterals which occurred rarely (refer to the mean and standard deviations of consonants, Table 5). There was significant difference in the occurrence of glottal fricatives and laterals, since the mean occurrence of glottal fricatives was higher and that of laterals was lesser.

In the 7-8 month, the mean occurrence of stops increased, and the stops differed significantly from all the other consonant types. Continuants did not occur even in the 7-8 month group. Nasals also had a relatively higher occurrence compared to laterals, hence they differed significantly. The occurrence of glottal fricatives declined significantly and thus, did not differ significantly from laterals which also occurred rarely.

The trends in the occurrence of consonants remained the same as 7-8 month group in the 8-9 month group and in the 9-10 month group, with the exception that, in the 9-10 month group, continuants began to emerge, and significant differences were found with stops and nasals.

In the 10-11 month group, the mean occurrence of stops was high and consequently significant differences were found with nasals, continuants, laterals and glottal fricatives. The mean occurrence of nasals was also high and significantly differed from continuants, laterals and glottal fricatives. The mean occurrence of continuants increased in this group, hence significant differences were seen between continuants-nasals and continuants-glottal fricatives.

In the oldest group of the present study, i.e. 11-12 months, the mean occurrence of nasals decreased and the occurrence of continuants increased to the same extent. Thus, no significant difference was found in the occurrence of continuants and nasals. The occurrence of stops remained high and significantly differed from nasals, continuants, laterals and glottal fricatives.

Referring to the means of consonants with respect to manner of articulation, the following rank order for the occurrence of consonants within the six age groups was established as provided in Table 8.

Age (in months)	**Rank order of the consonants (in the decreasing order)**
6-7	Stops, Nasals, Glottal fricatives, Laterals
7-8	Stops, Nasals, Glottal fricatives, Laterals
8-9	Stops, Nasals, Glottal fricatives, Laterals
9-10	Stops, Nasals, Continuants, Laterals, Glottal fricatives
10-11	Stops, Nasals, Continuants, Glottal fricatives
11-12	Stops, Nasals, Continuants, Laterals

Table 8: Rank order of the consonants with respect to manner of articulation

In conclusion, Table 8 reveals that the occurrence of stops dominated across all the age groups, followed by nasals. Continuants emerged at 9-10 months, the occurrence of which became stable in the later stages. Laterals and glottal fricatives had the least occurrence compared to other consonants in all the age groups.

CONSONANTS WITH REFERENCE TO PLACE OF ARTICULATION

The consonants observed in the babbling samples were classified as follows for place of articulation.

- Bilabials: [p,b,m]
- Dentals: [t, d, l, n] and the labio-dental: [v]
- Palatals: [t , d]*,[j,]
- Velars: [k,g]
- Glottals: [h]

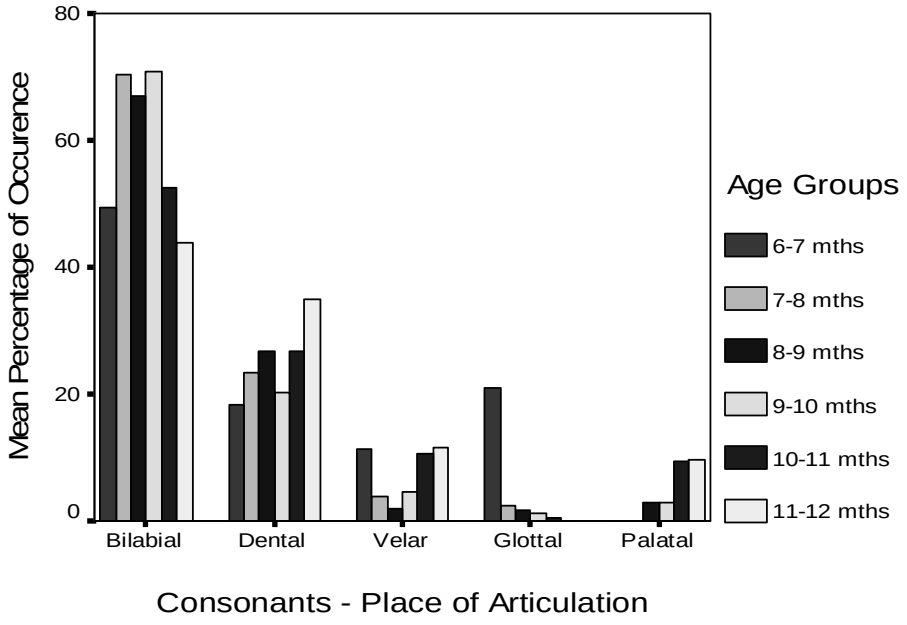
[t] and [d] are considered under palatals and not as retroflex as these consonants perceptually sounded more closer to palatal place of articulation. This finding is acceptable, as the production of retroflex involves retraction/curling of the tongue to contact the palate which requires higher muscular coordination and are achieved much later in development.

Mean values and standard deviations in all age groups, of the various consonant types classified according to place of articulation are presented in Table 9.

Graph 3 represents the mean percentage of occurrence of the consonants based on place of articulation.

Age (months)	Bilabial	Dental	Palatal	Velar	Glottal
	Mean & SD	Mean & SD	Mean & SD	Mean & SD	Mean & SD
6-7	49.41(14.54)	18.4(12.56)	11.25(3.85)	20.93(6.1)	0.0(0.0)
7-8	70.36(10.46)	23.45(11.07)	3.75(2.41)	2.43(3.33)	0.0(0.0)
8-9	66.99(6.55)	26.75(4.61)	1.88(2.69)	1.6(2.21)	2.77(1.02)
9-10	70.82(2.53)	20.32(8.08)	4.66(6.53)	1.24(1.72)	2.93(2.77)
10-11	52.57(14.8)	26.86(13.28)	10.71(3.48)	0.43(0.97)	9.41(2.9)
11-12	43.8(8.2)	34.83(9.11)	11.6(5.19)	0.0(0.0)	9.75(2.73)
Total	58.99(14.51)	25.1(10.76)	7.31(5.61)	4.44(8.04)	4.14(4.48)

Table 9: Mean percentage of occurrence and standard deviations of consonants for place of articulation.



Graph 3: Mean percentage of occurrence of consonants (place of articulation).

It can be noted from Table 9 and Graph 3 that overall, the bilabials [p, b, and m] were the most predominant consonant type occurring across all the age groups,

followed by dentals [t, d, and n]. The mean occurrence of velars [k and g] was found to be high in the youngest age group (6-7 months) which declined in the 7-8 and 8-9 month group and again increased in the 10-11 and 11-12 month groups. The glottal fricative [h] made a predominant appearance in the 6-7 month group and declined in the later stages and was absent in the 11-12 month group. Palatals [t and d] made their appearance at 9-10 months; however the occurrence of [t] and [d] remained minimal even in the 10-11 and 11-12 months also given the complexity of its production. The other palatal consonant [y] which made its appearance at 9-10 months occurred more frequently than [t] and [d].

Across age group comparisons of consonants according to place of articulation

To determine if significant differences existed in the occurrence of these consonant types across age groups, the Kruskal Wallis test was done on the means of bilabials, dentals, velars, glottals and palatals with age as the factor. The results revealed significant difference for age for bilabials {χ^2 (5) = 16.582, $p<0.01$}, velars {χ^2 (5) = 16.196, $p< 0.01$}, glottals {χ^2 (5) = 17.458, $p<0.01$} and palatals {χ^2 (5) = 25.083, $p<0.001$}. There was no significant difference found for the dentals. To determine the significant difference between each of the pairs of age groups for the consonant types, Mann Whitney test was used. The consonants that showed significant difference in their occurrence between each pair of age group are given below in Table 10.

Age Pairs (in months)		Consonants that are significant
6-7 with	7-8	Velars**, Glottals**
	8-9	Velars**, Glottals**, Palatals**
	9-10	Bilabials*, Glottals**, Palatals*
	10-11	Glottals**, Palatals**
	11-12	Glottals**, Palatals**
7-8 with	8-9	Palatals**
	9-10	Palatals*
	10-11	Velars*, Palatals**
	11-12	Bilabials**, Velars**, Palatals**
8-9 with	9-10	----
	10-11	Velars*, Palatals**
	11-12	Bilabials**, Velars**, Palatals**
9-10 with	10-11	Bilabials**, Palatals*
	11-12	Bilabials**, Dentals*, Palatals*
10-11 with	11-12	----

**Significant at 0.01 level
* Significant at 0.05 level

Table 10: Pair-wise comparisons of the consonant types across age groups for place of articulation.

The following findings are evident in Table 10: The 6-7 months group differed significantly from the next age group, i.e. 7-8 months, in the occurrence of velars and glottals. The high occurrence of velars and glottals in the 6-7 months group declined significantly in the 7-8 months group. In comparison with the 8-9 months group, there were no occurrences of palatals in the 6-7 months group, which made its appearance in the 8-9 months group. The 6-7 month group also differed from the 9-10 months group in the occurrences of bilabials, the mean occurrence of which increased in the 9-10 months group. The mean occurrence of glottals, considered as more primitive sounds was significantly higher in the 6-7 month group; whereas the occurrence of palatals considered as more complex sounds made their appearance only in the 8-9

month group and gradually increased in the older groups, i.e. the 10-11 and 11-12 month groups.

The occurrence of palatals distinguished the 7-8 month group with the 8-9 months and 9-10 months group. In comparisons with the 10-11 and 11-12 month group, the 7-8 month group differed in the occurrences of velars, palatals and bilabials. The occurrence of velars showed an increase in the 10-11 months group; whereas bilabials declined in its occurrence in the oldest group.

The 8-9 month group did not differ from the 9-10 month group in the production of the consonant types described above. The occurrence of velars which was relatively low in the 8-9 month group increased at 10-11 months and 11-12 months; whereas the bilabial occurrences declined in the 11-12 month group which significantly distinguished it from the 8-9 month group.

There was a transition in the production of certain consonants from 9-10 months to 10-11 and 11-12 months. The occurrence of bilabials declined at 10-11 months, followed by a further decline in the 11-12 months. The transition was also evident in the occurrence of palatals. There was a gradual rise in the occurrence of palatals in the 10-11 and 11-12 month groups.

Within age-group comparison of the consonants according to place of articulation

The Friedman test revealed that there were significant differences in the occurrence of the five consonant types within all the six age groups i.e. 6-7 months {χ^2 (4) = 17.526, p<0.01}, 7-8 months {χ^2 (4) = 18.538, p<0.01}, 8-9 months {χ^2 (4) = 16.958, p<0.01}, 9-10 months {χ^2 (4) = 15.629, p< 0.01}, 10-11 months {χ^2 (4) = 17.760, p< 0.01} and 11-12 months, {χ^2 = 18.707, p<0.01}. Wilcoxon Signed Ranks test was utilized to determine which pairs of consonants had significant difference within age groups, the results of which are presented in Table 11.

Consonant Pairs	6-7 months	7-8 months	8-9 months	9-10 months	10-11 months	11-12 months
Bilabial-Dental	*	*	*	*	----	----
Bilabial-Velar	*	*	*	*	*	*
Bilabial-Glottal	*	*	*	*	*	*
Bilabial-Palatal	*	*	*	*	*	*
Dental- Velar	----	*	*	----	*	*
Dental-Glottal	----	*	*	*	*	*
Dental-Palatal	*	*	*	*	*	*
Velar- Glottal	----	----	----	----	*	*
Velar- Palatal	*	----	----	----	----	----
Palatal-glottal	*	----	----	----	*	*

** Significant at 0.05 level
---- Not significant

Table 11: Pair-wise comparison of the consonants within groups for place of articulation.

Table 11 reveals certain trends within the six age groups. In the 6-7 months group, the mean occurrence of bilabials was the highest compared to dentals, velars and glottals (Table 9). Palatals did not occur in the 6-7 months group. Hence a significant difference occurred between the occurrences of bilabials with the other consonants.

In the 7-8 months group, a significant difference was found in the occurrence of bilabials with other consonants and dentals with the other remaining consonants. The mean occurrence of bilabials as well as dentals was high compared to the other less frequently occurring velars and glottal consonants. A similar trend was seen in the 8-9 months and 9-10 months group.

Some transitions were evident in the later stages. In the 10-11 months, there were significant differences found in the occurrence of velars with other consonants, since the occurrence of velars was high in this group. There was no significant difference between the bilabial-dental pair since there was a decline in the mean occurrence of bilabials. However, the mean occurrence of bilabials remained the highest compared to other consonants. Similar findings were obtained in the 11-12 months group.

Similar to Locke's (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. In accordance to this finding, a rank order of the

occurrence of consonants, with reference to place of articulation is presented in Table 12.

Age (in months)	Rank order of the consonants (in the decreasing order)
6-7	[Bilabials, Glottals, Dentals, Velars]
7-8	[Bilabials, Dentals, Velars, Glottals]
8-9	[Bilabials, Dentals, Palatals, Velars, Glottals]
9-10	[Bilabials, Dentals, Velars, Palatals, Glottals]
10-11	[Bilabials, Dentals, Velars, Palatals, Glottals]
11-12	[Bilabials, Dentals, Velars, Palatals, Glottals]

Table 12: Rank order of consonants with respect to place of articulation.

In conclusion, it is clear from Table 12 that bilabials were the most predominantly occurring consonant types across all the age groups. Glottals were higher in the youngest group, i.e. 6-7 months and declined in the later stages. Dentals also occurred frequently in all the age groups. Glottals were rarely found between 7-12 months.

CONSONANTS ACCORDING TO VOICING DIMENSION

A qualitative analysis of the voicing feature of consonants was also explored in the present study. According to this feature, the consonants were categorized into voiced and unvoiced consonants. The unvoiced consonants that were found in the babbling samples analyzed were [p, t, t, k, h] and the voiced consonants were [b, m, n, d, d, g, l, v and j]. A comparison of the occurrence of unvoiced and voiced consonants was made across the six age groups. The prominent findings are discussed in the following section.

In the 6-7 month group, the occurrence of the voiced consonants largely exceeded compared to the occurrence of the unvoiced consonants. It was found that the occurrences of the unvoiced consonants [p], [k] and [h] were low in the 6-7 month group, except the glottal fricative [h] which occurred frequently in this group. Among the voiced cognates, [m] and [b] were the highest occurring consonants, followed by [d] and among the velar cognates only [g] made its appearance.

The 7-8 month group also exhibited a higher production of voiced consonants compared to the unvoiced counterparts. The voiced consonant [d] which was minimal in the 6-7 month group showed a further increase, the occurrence of [p] remained minimal and the occurrence of [h] declined at 7-8 months. However, the occurrence of other voiced consonants [b], [m] and [n] was relatively higher than the unvoiced consonants.

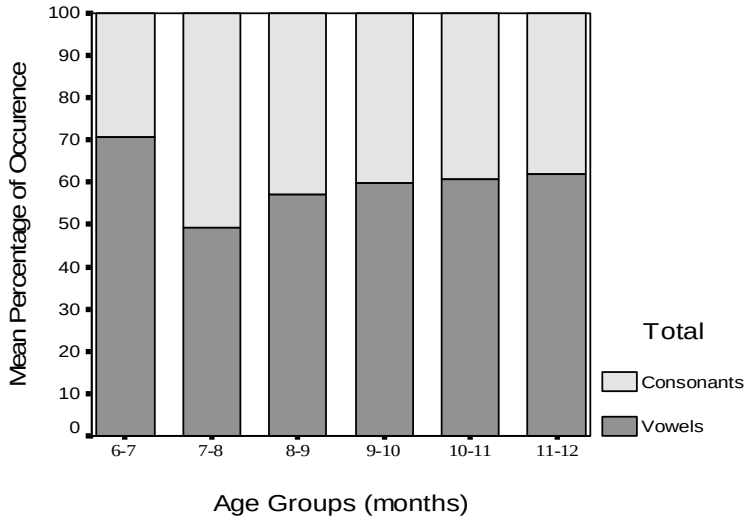
The new feature that was noted in the 8-9 month group was the emergence of the unvoiced consonant [t]. However, the occurrence of its voiced counterpart [d] was higher compared to that of [t] and [p]. The occurrence of [p] remained minimal even in the 8-9 month group. Among the other voiced consonants, [b], [m], [n], [l] and [j] also made common appearances. Overall, there was a small rise in the occurrence of unvoiced consonants, which did not exceed the occurrence of voiced consonants.

In the older groups, the 9-10 month group showed an increase in the occurrence of [p] followed by [d]. Among the voiced consonants, [m, n, b, d, j, v, l] occurred frequently. There was a further increase in the occurrence of the unvoiced consonant [p] and [t] in the 10-11 month group. The occurrence of the voiced

consonants [b, j, v] also increased compared to the other voiced consonants. In the 11-12 month group, the occurrence of [p] and[b] was almost equal. However the two cognate pairs [t] and [d] occurred less than 2% of the total consonant data. The unvoiced [k] occurred more frequently than [g] in the higher groups.

The findings of the present study suggest that the voicing feature of consonants was acquired earlier than the unvoiced feature in the youngest groups and as infants transit from the babbling stage to the first word stage, they begin to produce more voiceless consonants. This finding is in agreement with Locke's (1983) observation that among the stops, voiced stops are more frequent in babbling than the unvoiced stops. He also observed that first words typically tend to be composed of front voiceless stops and nasals. Locke (1983) presumes that the articulatory factors play a role in the voiced/unvoiced feature acquisition.

The predominance of voiced stops in babbling may be a consequence of insufficient articulatory control for the production of unvoiced sounds, which requires the vocal folds to be held apart. The high proportion of voiced stops over voiceless stops in babbling and the gradual increase in the production of voiceless consonants accounts for the claim that children assume language specificities as they move towards the first word stage. Overall, the total percentage of vowels and consonants in each of the six age groups is presented in Graph 4.



Graph 4: Mean percentage of occurrence of vowels and consonants (total) in each of the six age groups

Graph 4 reveals that vowels dominated across all the age groups, with the exception in the 7-8 month group, where the consonants were predominant. This incongruity may be related to the onset of reduplicated babbling in the 7-8 months period. The onset of reduplicated babbling was marked by consonant-vowel reduplications with a relative decline in the singleton vowel utterances. In the youngest group, i.e. 6-7 months, singleton vowels were more frequent than vowels occurring in the multisyllable babbles. The 11-12 month group also showed a relative high occurrence of vowels. The occurrences of vowels in this group were more in the multisyllabic utterances than as singleton productions of vowels. The finding that vowels dominate infant vocalization throughout the first year is well acknowledged in the literature (Lieberman, 1980; Buhr, 1980)

The findings of the present study related to the consonantal repertoire are similar to the findings reported by Shyamala and Basanti (2003). They reported that stops and nasals had higher frequency of occurrence and glides and glottal fricatives

were among the less frequently occurring consonants. They also reported that the subjects from Kannada speaking homes had a repertoire of 12 consonants i.e. [p, b, m, n, t, d, h, k, g, l, j, v] where as 14 consonants were found in the present study.

With reference to the Western studies, certain trends in the occurrence of consonants were 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, stops were predominant followed by nasals. Davis and MacNeilage's (1995) study also revealed certain common trends in 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/, /ŋ/. The authors found that oral stops occurred with the highest frequency, followed by nasals and glides.

There is evidence in the literature regarding the early and frequent occurrence of oral stops and nasals. Neumann, Davis and Mac Neilage (2000) suggested that this is due to a "frame" produced by mandibular oscillation, with very little active contribution from intra syllabic or inter syllabic tongue movements. Kent, 1992 also accounted for the frequent occurrence of stops, nasals and dentals 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.

Overall, in the present study, stops and nasals were the frequently occurring consonant types and hence no significant transition in the occurrence of these consonant types was evident across age groups. Certain transitions occurred with continuants. Continuants/glides emerged at 9-10 months and gradually made more frequent occurrences thereafter. The glottal fricative [h] also showed a declining pattern as age increased. Taking the findings of 6-9 month age groups together, it can be noted that the back sounds declined gradually from 6 months to 9 months whereas the production of front sounds increased. These findings are in agreement with Oller's (1980) descriptions of the canonical babbling stage that the production of back sounds (velars) decline sharply, while the production of front sounds (alveolars and bilabials) increase.

In the present study, the findings of subjects from 9-12 months showed much variability. However, certain common trends that were noted were a decline in the occurrence of bilabials and an increase in the occurrence of continuants and palatals. The higher variability in this group of subjects may be due to an increase in the phonetic complexity that was evident in the types of multisyllabic utterances used and the variegated concatenations in those utterances. Certain consonants were preferred more than the others with certain vowels in the utterances of the older age group subjects.

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.

3. SYLLABLE SHAPES

The various syllable shapes that were found in the babbling samples of 30 subjects in all the six groups considered in the present study were V, C, CV, VC, CVC and VCV. Apart from these syllable shapes, multisyllabic utterances consisting of varied patterns such as CVCV, VCVCV were found in the samples analyzed. Although, singleton vowels (Vs) and singleton consonants (Cs) are not strictly syllables, they are also considered here since their occurrence was significantly high and also for the ease of comparison. The frequency of occurrence of each of these syllable shapes was determined for all the 30 subjects in all the six groups. The mean values and standard deviations of the syllable shapes and multisyllables in all the age groups are presented in Table 13.

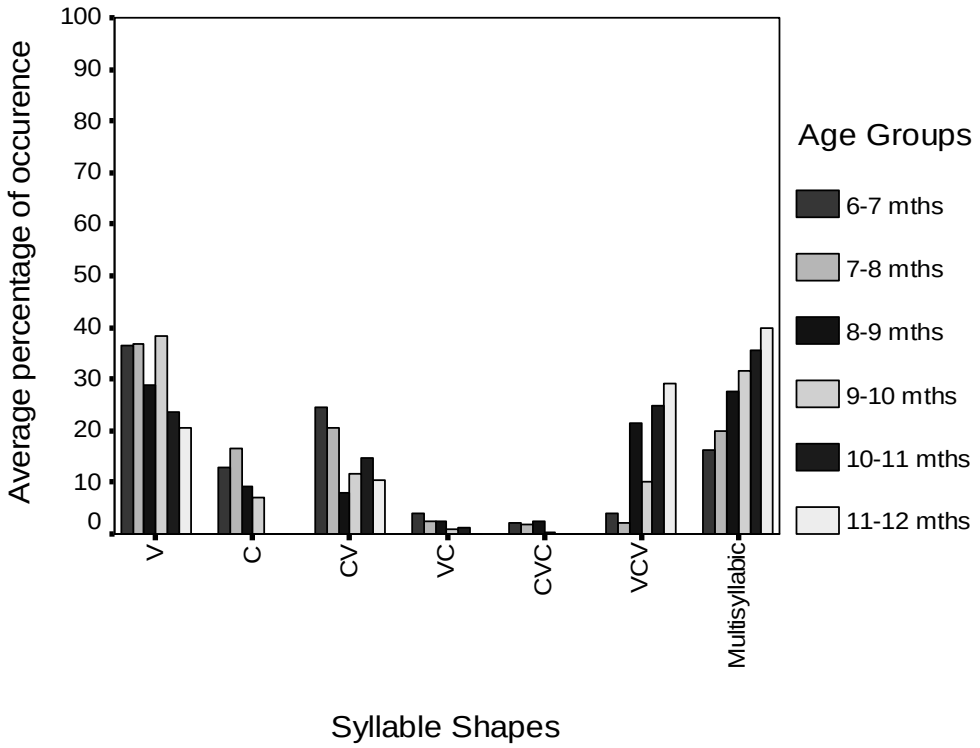
Age (months)	V	C	CV	VC	CVC	VCV	*Multi
	Mean & SD	Mean & SD	Mean & SD	Mean & SD	Mean & SD	Mean & SD	Mean & SD
6-7	36.4(9.52)	12.8(5.4)	24.4(7.5)	4.0(2.8)	2.0(2.0)	4.0(4.6)	16.4(8.2)
7-8	36.8(8.07)	16.6(6.9)	20.4(7.5)	2.4(2.1)	1.8(1.7)	2.0(4.4)	20.0(11.3)
8-9	28.8(11.4)	9.2(4.1)	8.0(4.8)	2.4(3.5)	2.4(3.5)	21.6(13.1)	27.6(9.9)
9-10	38.4(4.7)	7.2(3.0)	11.6(6.0)	0.8(1.7)	0.4(0.8)	10.0(6.3)	31.6(5.1)
10-11	23.6(7.7)	0.0(0.0)	14.8(9.1)	1.2(2.6)	0.0(0.0)	24.8(8.0)	35.6(7.1)
11-12	20.4(7.7)	0.0(0.0)	10.4(7.2)	0.0(0.0)	0.0(0.0)	29.2(8.8)	40.0(11.9)
Total	30.7(10.4)	7.6(7.2)	14.9(8.7)	1.8(2.5)	1.1(1.9)	15.2(12.9)	28.5(11.9)

*****Multi = Multisyllabic utterances

Table 13: Mean percentage of occurrence and standard deviations of different syllable shapes

Overall, the singleton vowel utterances, i.e. Vs were the frequent in the younger age-groups, and appeared to decline from 9-10 months. The singleton consonant occurrences, i.e. Cs were the highest at 7-8 months and declined in the

older age groups. The 10-11 months group and the 11-12 months group did not exhibit Cs. CV productions were the highest in the 6-7 months group, followed by a minimal decline in the 7-8 and 8-9 month groups and a further increase in the 9-10 and 10-11 month groups. VC and CVC occurrences were rare across all the age groups. VCV syllables showed a gradual progression in their occurrence as age increased. On the other hand, multisyllabic utterances also increased with age. Graph 5 represents the mean occurrences of the syllable shapes by age.



Graph 5: Mean percentage of occurrence of different syllable shapes

Across age group comparisons of syllable shapes and multisyllabic utterances

To determine if significant differences existed in the occurrence of the syllable shapes between groups, the Kruskal Wallis test was done on the means of with age as the factor. The results revealed significant difference for age for V {χ^2 (5) = 13.009,

p<0.01}, C {χ^2 (5) = 24.079, p< 0.01}, CV {χ^2 (5) = 13.217, p<0.01} and VCV{ χ^2 (5) = 21.206, p<0.01}. There was no significant difference found for the VC and CVC syllables. To decipher the significant difference between each of the pairs of age groups for the syllable shapes, Mann Whitney test was performed. The syllable shapes that showed significant difference in their occurrence between each pair of age group are given below in Table 14.

Age Pairs (months)		**Syllable shapes that are significant**
6-7 with	7-8	----
	8-9	CV*, VCV*
	9-10	CV*, Multisyllabic*
	10-11	C**, VCV**, Multisyllabic*
	11-12	V*, C**, CV*,VC*,VCV**,Multisyllabic*
7-8 with	8-9	CV*, VCV*
	9-10	C**, VCV*
	10-11	V*,C**, VCV**,Multisyllabic*
	11-12	V**, C**, CV*, VC*, VCV**,Multisyllabic*
8-9 with	9-10	----
	10-11	C**
	11-12	C**
9-10 with	10-11	V*,C**,VCV*
	11-12	V*,C**,VCV*
10-11 with	11-12	----

*Significant at 0.05 level
**Significant at 0.01 level

Table 14: Pair-wise comparisons of syllable shapes across age groups.

The following findings are evident from Table 14: The 6-7 month group and 7-8 month group did not differ significantly in the occurrence of syllable shapes. The transition in the occurrence of CV and VCV syllables can be noted in comparison of the 6-7 months group with the 8-9 month group, wherein the occurrence of CV syllables declined and the occurrence of the VCV syllables increased. However, this

group did not differ from the 8-9 month group in the occurrence of multisyllabic utterances. In comparison with the 9-10 month group, the 6-7 month group differed significantly again in the CV occurrences and multisyllabic utterances. Further, the 6-7 month group differed markedly from the older groups, i.e. the 10-11 and the 11-12 month groups in the occurrences of all syllable shapes. Cs and CVCs did not occur in the 10-11 and 11-12 month groups. A gradual increase in the multisyllabic utterances with age also contributed to the differences in the 6-7 month group and the older age groups.

The transition from the 7-8 month and 8-9 month was markedly seen with the pattern of occurrences of CV and VCV syllables. There was a significant decline in the CV occurrences and a rise in the VCV occurrences in the 8-9 months group. In comparison with the 9-10, 10-11 and 11-12 month groups, the 7-8 month group differed significantly in the occurrences of majority of the syllable shapes and multisyllabic utterances, indicative of a gradual increase in the complexity of syllable shapes.

The 8-9 month group did not differ significantly from the 9-10 month group. Since Cs did not occur in the 10-11 and 11-12 month groups, the 8-9 month group differed from the older groups.

The 9-10 month group differed from 10-11 and 11-12 month group in the occurrences of V, C and VCV syllables. The Vs declined; Cs did not occur and VCV syllables were more frequent in the latter two groups. The 10-11 month group was

similar to the 11-12 month group in the production of syllable types and multisyllabic utterances.

Within age-group comparison of the syllable shapes and multisyllabic utterances

The Friedman test was used to find out if significant differences existed in the overall occurrence of all the syllable shapes within each of the six age groups. The test results revealed that there were significant differences in the occurrence of the syllable shapes within each of the six age groups i.e. 6-7 months {χ^2 (6) = 24.838, $p<0.01$}, 7-8 months {χ^2 (6) = 24.370, $p<0.01$}, 8-9 months {χ^2 (6) = 23.737, $p<0.01$}, 9-10 months {χ^2 (6) = 26.935, $p< 0.01$}, 10-11 months {χ^2 (6) = 26.350, $p< 0.01$} and 11-12 months {χ^2 (6) = 28.708, $p<0.01$}.

The across group and within group analysis reveals certain trends. On the one hand, singleton consonants (Cs) such as m…, and [h] declined with age and did not occur at 10-12 months and on the other hand the occurrences of VCV syllables and multisyllabic utterances increased. Thus, the singleton consonants were replaced by disyllabic and multisyllabic utterances with increase in age. This finding may be linked to the fact that with increase in age, the length and complexity of the syllables also increased. The older age group subjects used more combinations of syllables than the younger subjects.

The occurrence of singleton vowels (Vs), however, remained relatively higher in all the age groups as compared to the singleton consonants (Cs). The singleton vowels occurred in the younger age groups, i.e. 6-9 months as vocalizations and later

as monosyllabic protowords such as [a] meaning 'that'. Study on phonotactic development in Kannada by Rupela and Manjula (2006) had shown similar trends in children between the age ranges of 6months to one year. They reported that singleton vowels were predominant at 0-6 months gradually declining by 18-24 months initially as vocalizations and later as monosyllabic words.

The occurrence of CV syllables was found to be high in the 6-7 month group, followed by a gradual decline in the 7-8 and 8-9 months and a further increase at 9-10 months and remained consistent thereafter. It was noted that majority of the CV syllables produced by the 10-12 month old subjects were protowords such as [ba] meaning 'come'; [be] meaning 'no' which qualitatively differed from the non-meaningful CV productions of 6-8 month old subjects. 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.

In the present study, CVC syllables such as [pap], [bab] were found to occur occasionally between 6-10 months and did not occur at 10-12 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).

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 trends of the occurrence of syllable shapes found in the Western studies. 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, 2000).

Kent and Bauer's (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.

4. PREFERENTIAL OCCURRENCE OF VOWELS WITH CERTAIN CONSONANTS WITHIN SYLLABLES

The overall organization of utterances in the babbling stage is also important in understanding phonological development because sound organization preferences in babbling presumably relate to preferences in early words. Whether certain vowels tend to preferentially co-occur with certain consonants within syllables has been addressed in this section. Some of the trends found in the analyzed samples are documented below.

Low central vowel [a] which was found to be the predominant vowel to occur at all the six age groups was found to occur more frequently with bilabials [p], [b] and [m] in the 6-9 month range. The vowel [a] also occurred with dentals at 6-8 months. As age advanced, [a] was found to occur predominantly in the environment of velars [k, g] and continuants [y] and [w] in multisyllabic utterances. These combinations occurred more frequently in the 9-12 month range.

The high-back vowel [u] was preferred with bilabials, dentals and velars in all the age groups. High front vowel [i] was found to preferentially occur with dentals and velars and less frequently with bilabials. The mid-front vowel [e] which occurs significantly at 6-7 months was preferred with the glottal fricative [h].

The remaining mid-back vowel [o] which accounted for less than 10% of the total vowel data at all age groups was found to occur in the environment of continuant [y] and this preferential feature was found in the 11-12 month old group. Among all

the vowel-consonant preferences, the bilabial-central vowel, dental-central vowel, velar-central vowel, continuant- central vowel preferences were strong across the age groups, 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 groups 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 there are labial-central vowel and velar back-vowel co-occurrence constraints was largely supported in her study.

The present finding that the high-front vowel [i] was frequently preferred in the environment of dentals is supported by Davis and MacNeilage's study (1990). They studied the course of acquisition of correct vowel production over the period from 14 to 20 months. They observed the favoring of high front vowels in the environment of alveolar consonants. They also reported the preference of high-back vowels after velars, and central vowels after labials.

However, there are no Indian studies reported on the issue of preferential occurrence of vowels with consonants. Hence, in the process of linking of sound patterns with meaning, the preferential occurrence 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.

5. PERCENTAGE OF REDUPLICATED AND VARIEGATED BABBLING

A reduplicated babble is a CVCV production in which the second CV consists of the same phonemes that are present in the first CV such as [baba], [dada] etc. A variegated babble is a CVCV production in which the C or the V is different in the second syllable as in [bada]. Multisyllabic utterances from the entire corpus of utterances for all the 30 subjects in the entire six groups were analyzed and assigned to the category of reduplicated and variegated babbling. The mean percentage of occurrence and standard deviations of reduplicated and variegated babbling by age is presented in Table 15.

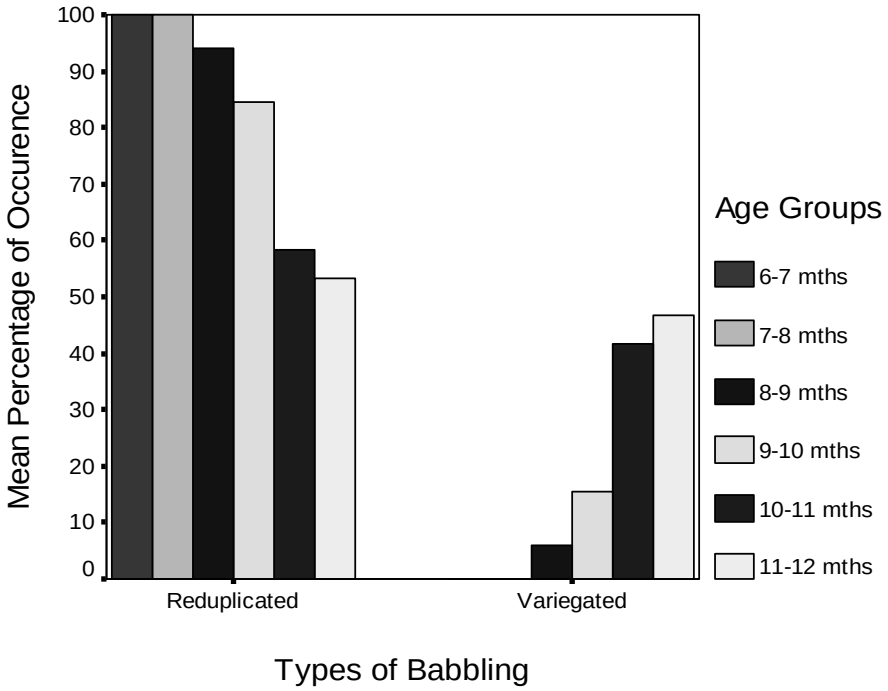
Age (months)	**Reduplicated**	**Variegated**
	Mean & SD	**Mean & SD**
6-7	100.00(0.00)	0.00(0.00)
7-8	100.00(0.00)	0.00(0.00)
8-9	94.19(7.97)	5.80(7.97)
9-10	84.42(7.17)	15.58(7.17)
10-11	58.45(13.78)	41.55(13.78)
11-12	53.39(16.14)	46.60(16.14)
Total	81.74(21.28)	18.25(21.28)

Table 15: Mean percentage of occurrence and standard deviations of reduplicated and variegated babbling.

Table 15 reveals that the percentage occurrence of reduplicated babbling declined gradually with increase in age. Reduplicated babbling accounted for 100% of

the data in the younger 6-7 month and 7-8 month groups. The decline in the occurrence of reduplicated babbling began in the 8-9 month group.

Variegated babbling had its onset in the 8-9 month group, but only two of the five subjects exhibited variegated babbling which gradually increased in the older age groups, i.e. from 9-12 months. Graph 6 depicts the percentage occurrence of reduplicated and variegated babbling by age. It was also observed that though the reduplicated babbling declined with age, it continued to dominate in the older groups also to a larger extent.



Graph 6: Mean percentage of occurrence of reduplicated and variegated babbling.

Across group comparison of reduplicated and variegated babbling

The Kruskal Wallis test was run on the means of reduplicated and variegated babbling, with age as the factor to establish significant differences between the six age groups. The test revealed significant difference for age between the six groups for reduplicated babbling {χ^2 (5) = 25.950, p<0.001} and variegated babbling {χ^2 (5) = 25.950, p<0.001}. Mann Whitney test was used to further illustrate the pairs of age groups which had significant differences. The results of Mann Whitney are given in Table 16.

Age Pairs (in months)		Reduplicated	Variegated
6-7 with	7-8	--------	--------
	8-9	---------	--------
	9-10	**	**
	10-11	**	**
	11-12	**	**
7-8 with	8-9	----------	--------
	9-10	**	**
	10-11	**	**
	11-12	**	**
8-9 with	9-10	---------	--------
	10-11	**	**
	11-12	**	**
9-10 with	10-11	**	**
	11-12	**	**
10-11 with	11-12	---------	--------

**Significant at 0.01 level

------ Not significant

Table 16: Pair-wise comparison of reduplicated and variegated babbling.

Table 16 reveals that the youngest group, i.e. 6-7 months had no significant difference in the occurrence of reduplicated and variegated babbling with the 7-8

month and 8-9 month group. Actually, variegated babbling did not occur in the 6-7 and 7-8 month group. The 6-7 month group had higher occurrence of reduplicated babbling compared to 9-10, 10-11 and 11-12 month groups. The difference is due to the onset of variegated babbling in the older three groups accompanied by a substantial decline in the reduplicated babbling.

The 7-8 month group did not differ from the 8-9 month group, whereas differed significantly from the older age groups, i.e. from 9-12 months in the two types of babbling. Although, variegated babbling was demonstrated in the 8-9 month group, its occurrence was only limited to 5% of the total data as seen from Table 15.

Thus, 8-9 month had a relatively higher occurrence of reduplicated babbling and hence did not have significant difference with the 9-10 month group, whereas it differed significantly from the 10-11 and 11-12 month groups, since the occurrence of variegated babbling was relatively higher in the older age groups, with a relative decline in the occurrence of reduplicated babbling (Table 15).

Within group comparison of reduplicated and variegated babbling

Wilcoxon Signed Ranks Test was used and Z values were generated to compare reduplicated and variegated babbling within each of the six age groups. A significant difference was seen for the types of babbling in the 6-7 month group {$|Z| = 2.236$ ($p<0.05$)}, 7-8 month group {$|Z| = 2.236$ ($p<0.05$)}, 8-9 month group {$|Z| = 2.060$ ($p<0.05$)}, and 9-10 month group {$|Z| = 2.023$ ($p<0.05$)}. There was no significant difference found for reduplicated and variegated babbling within 10-11 month and 11-12 month groups as both types of babbles occurred frequently. The

important finding here is that although, the occurrence of variegated babbling increased with age, it did not exceed the occurrence of reduplicated babbling even in the older groups.

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

The issue of phonetic variation with increase in age was explored in the present study. The multisyllabic babbles were considered to determine the nature and complexity of the phonetic variation. As age advanced the phonetic repertoire of the infants increased which allowed them to produce more number and variety of syllabic combinations. The phonetically non-varied multisyllable babbles were predominant from the age of 6 months to 9 months. The reduplicated forms when compared to variegated forms certainly seem more basic. The phonetically varied multisyllable babbles made their first appearance at 8-9 months. In this group, only two infants demonstrated variegated babbling, which was characterized by place variations such as [badaba]. The occurrence of variegated syllables increased in the 9-10 month group, and further increased in all the other older age groups. Place variations continued to dominate in the 9-10 month group. In the 10-11 month group, place variations occurred more frequently, with fewer other manner concatenations and

mixed variations, i.e. both place and manner variations such as [ajada]. The complexity of multisyllable babbles was more evident in the 11-12 month group of infants. A combination of place and manner variations occurred more frequently than place or manner variations alone.

The earlier claim of reduplicated and variegated stages of babbling suggested a plausible progression from simple to complex. Stoel-Gammon's (1989) study with 10 infants at four month intervals from 6-18 months of age 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.

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.

The findings of this study differed from the above studies from the result that place variations were followed by manner variations. The rank order of multisyllables 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 Western studies could be due to the differences in the structure of the two languages, majorly English being the language background in the Western studies and Kannada, the language background of the present study. The two languages differ in their

organization of sounds, English being a phonetic language and Kannada, a syllabic language.

The findings of the present study are also in agreement with the accepted models of infant development which predict increasing phonetic variation in multisyllable vocalizations before one year of age, and which posit separate ‘stages’ of repetitive and phonetically varied multisyllable babbling (Mitchell and Kent, 1990).

CHAPTER V

SUMMARY AND CONCLUSIONS

Babbling is an important milestone of early communication which can serve as a predictor of later language ability. It is also an important milestone in the development of articulation and phonological skills. Babbling lies at the juncture of prelinguistic and linguistic phonological development. Typically developing children pass through the reduplicated and variegated stages of babbling before the acquisition of the first words which is characterized by acquisition of vowel-like sounds, consonantal sounds and syllable shapes. In the present study, an attempt was made to analyze the phonetic characteristics of babbling in typically developing infants from Kannada speaking homes.

The aim of the study was to establish quantitative and qualitative database on the development of babbling in infants from Kannada speaking homes in the age range of 6 months to 12 months with the following objectives:

- To establish the phonetic repertoire, including the frequency of occurrence of vowels and consonants, the consonants with reference to their place, voicing and manner of articulation and vowels based on tongue height and tongue advancement.
- To identify the syllable shapes and to quantify their frequency of occurrence.
- To identify preferential occurrence of vowels with certain consonants within syllables.
- To calculate the percentage of reduplicated and variegated babbling.

Thirty typically developing children, from Kannada speaking homes served as subjects for the study. The subjects were divided into 6 groups with an age interval of one month, i.e. 6-7 months, 7-8 months, 8-9 months, 9-10 months, 10-11 months and 11 to 12 months. Each group consisted of 5 infants. Audio-recording sessions of 30 minutes for all the subjects took place in the children's homes in the presence of the mother using a digital voice recorder. The recorded data was subject to editing to retain the child's speech-like utterances for analysis. A minimum of 50 utterances were transcribed phonetically using IPA (Broad phonetic transcription method) from the audio tapes for each of the subjects separately by the investigator. The vowels transcribed were analyzed with respect to tongue height and tongue advancement dimensions. The consonants were analyzed with respect to manner and place and voicing dimensions of articulation**.** The syllable shapes were analyzed from the entire corpus of 50 utterances from each subject in all the groups. The reduplicated and variegated utterances were analyzed from the multisyllabic utterances of each subject in all the groups. The percentage occurrence of vowels, consonants, syllable shapes and reduplicated and variegated babbling was determined. Statistical analysis was carried out to determine the developmental trend across and within the six age groups. A qualitative analysis was done to determine the preferential occurrence of certain vowels with consonant within syllables. Non-parametric statistics was used wherever appropriate.

The vowel repertoire consisted of [i, e, ae, a, u, o] between 6-12 months. The occurrence of low vowel [a] was consistently the highest across all age groups and the mid-back vowel [o] was the least occurring vowel, indicating that lax vowels are easier than the tense vowels. The low-front vowel [ae] (a vowel not found in the

Kannada phonemic system) also declined with increase in age indicating that the production of vowels assumes language specificities as age increases. The occurrences of all vowels showed variability across the age groups.

The consonantal repertoire in the entire babbling period consisted of 14 consonants [p, b, m, n, t, d, t, d, h, k, g, l, j, v]. Stops [p, b, t, d, t d, k, g] and nasals [m,n] were the highest occurring consonant types in all the age groups. In the reduplicated phase of babbling, i.e. between 6-9 months, stops, nasals, laterals [l] and glottal fricatives [h] were the consonants that occurred commonly. Continuants/glides [j, v] emerged at 9-10 months. There was a decline in the occurrence of glottal fricative with age. Oral stops and nasals were predominant supporting the hypothesis that frame dominance produced by mandibular oscillations exists in the early stages of babbling (Davis and MacNeilage, 2000). There was an increase in the quantity of occurrence as well as in the number of occurrences. With respect to voiced and unvoiced features of the consonants, the occurrence of voiced consonants predominated in the entire babbling period. Similar to some of the earlier reports on babbling, 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 syllable shapes found were V, C, CV, CVC, VC and VCV. Singleton vowel utterances, i.e. Vs were the frequent in the younger age-groups, and appeared to decline from 9-10 months. The singleton consonant occurrences, i.e. Cs were the highest at younger age groups and declined in the older age groups. CV productions were the highest in the 6-7 months group, followed by a minimal decline in the 7-8

and 8-9 month groups and a further increase in the 9-10 and 10-11 month groups wherein the majority of the CV productions were protowords. VC and CVC occurrences were rare across all the age groups, probably because closed syllables at word final positions are rare in Kannada. VCV syllables showed a gradual progression in their occurrence as age increased, associating with the fact that open ended syllables are frequent in Kannada (Hiremath, 1980). The mean occurrence of multisyllabic utterances increased with age. These findings suggest that the organization of syllables closely resemble the word order structure existing in the ambient language.

A strong preference was documented for the low-central vowel in the environment of most of the consonants. In other words, [a] was the preferred vowel compared to other vowels to occur with consonants. The high-front vowel [i] was found to be preferred with dentals predominantly.

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 groups.

Future directions

- A longitudinal study, with one week interval can be planned to accurately determine the transitions occurring in the phonetic complexities in the babbling period.
- The development of babbling with respect to gender differences can also be investigated.
- A more detailed analysis and quantification of the preferential occurrence of vowels with consonants and the organization of syllable shapes can be investigated to closely examine the transition from the late babbling period to early speech.
- An acoustic analysis can be undertaken for the babbling samples to establish the vowel triangle in infants.

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