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Table of contents

*Language acquisition: Ontogenetic and phylogenetic considerations* .....10-28  
Eva M Luef, Annemarie Peltzer-Karpf

*Nature of vowels and diphthongs in babbling of Malayalam infants* .....29-42  
R. Reeny, N. Sreedevi



## Language acquisition: Ontogenetic and phylogenetic considerations

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### Abstract

Neurolinguistic research has revealed commonalities between apes and humans concerning the processing of communication in the brain. Homologous regions to Broca's and Wernicke's areas have been discovered in chimpanzees (and other great apes) and functional correspondences have been implied. Tying in with this brain-based evidence are a number of milestones of language development in our own species that are not uniquely human but have precursor events that can be found in other primate species as well. Human language is too complicated to have arisen ad hoc in the Homo lineage and there is now mounting evidence that many aspects that are crucial to language acquisition and development in humans are also present in our closest living relatives, the great apes. In the following, we will outline hallmark events of early human language acquisition and trace the evolutionary origins of them. Relating developmental milestones of the human language acquisition process to skills in non-human primates allows us to draw inferences as to which cognitive developments may have played an important role in the evolution of human language.

**Keywords** First language acquisition, language development, Faculty of Language in a Broad sense, Faculty of Language in a Narrow sense, evolution

### 1. Introduction

The quest for the evolutionary origins of human language has been a debated topic in science for a long time and has brought forth a wide range of ideas that try to account for this unique skill of our species. Evidence for one hypothesis or another is difficult to obtain so research in evolutionary linguistics is left to rely on inferences based on the communicative abilities of our closest living relatives, the great apes. While no ape species is similar to humans in their means of communication, there are important lessons to be learned by discovering 'precursor abilities' in the apes' communication, id est communicative skills that are comparable to specific human linguistic skills. In order to learn how the complexity of human language was able to develop on an evolutionary scale, it is important to trace the evolutionary history of particular linguistic aspects and look for related abilities in other primate species, in particular the great apes.

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## 2. Brain evolution and communication

Developmental hallmarks of conscious thought and language in *Homo sapiens* were largely dependent on the evolution of the neocortex (2009). In particular, the enlargement and species-specific elaboration of neocortical areas hold important cues concerning the evolution of human mental abilities. The neocortex dates back to rodents (Striedtler, 2005) but the most recent changes happened during the evolution of primates, where the formerly smooth surface area developed convolutions due to size expansion (Rakic, 2009). For human language, most relevant are two functionally distinct neocortical regions that have developed only recently: Broca's and Wernicke's area, where, according to the classical brain-language model, production and comprehension processes are computed. This dichotomous model has been adapted by more recent neuroanatomical findings and newer models suggest more differentiated roles for each of the two regions (see, e.g. Ben Shalom & Poeppel, 2007; Friederici, 2002; Price, 2000). However, Broca's and Wernicke's areas remain the focus of neurolinguistics and their evolutionary speciation may hold crucial information as to the functional evolution of language.

One of the most interesting facts about language processes in the human brain is the apparent multimodal processing of the language areas. Spoken as well as signed languages show involvement of similar cortical regions (Söderfeldt et al., 1997) and most language areas are involved in communication of a poly-modal nature. The left planum temporale is strongly associated with Wernicke's receptive language area and takes a crucial part in language processing in the human brain (Frost et al., 1999). Specifically, the left planum temporale is suggested to integrate and execute mosaic communicative information, vocal-auditory and gestural-visual, that is distributed within the temporal, parietal, and frontal lobe association cortices (G. J. Gannon, Kheck, & Hof, 2001). For humans, asymmetric proportions of the planum temporale are characteristic with the left side being enlarged. Asymmetric planum temporale is also present in chimpanzees and other great apes (P. J. Gannon, Holloway, Broadfield, & Braun, 1998) and the polymodal organization of the planum temporale in humans may have evolutionary precursors in the great apes (G. J. Gannon et al., 2001). Most recently, Meguerditchian et al. (2012) provided neuroanatomical evidence that two brain regions in chimpanzees which are homologous to humans' Broca's and Wernicke's areas (left planum temporale and inferior frontal gyrus) govern manual gesturing in chimpanzees. They proposed a link between right-handedness, communicative gesturing, and the neural asymmetries, furthering speculations that the human language areas evolved from brain regions processing manual gesture. Similarly, Broca's area also seems to have its functional roots in the great ape brain. Cantalupo and Hopkins (2001) describe a homologous region to Broca's area in chimpanzees (and other great apes) and suggest that in apes the area is associated with the processing of gestural communication. One piece of evidence is posed by apes' predominant right hand use when producing communicative gestures, indicating left hemispheric dominance in the processing of gestural communication (Hobaiter & Byrne, 2013; Meguerditchian, Vauclair, & Hopkins, 2010). Cantalupo and Hopkins (2001)



suggest that during the evolution of Broca's area, the region was first associated with gestural expression and only later did vocal language come into the picture. This link between manual gesture in apes and human spoken language has been central to a variety of hypotheses regarding the proposed evolution of language from the gestures of apes (see for example [Call & Tomasello, 2007](#); [Corballis, 2002](#)).

Evidence is strong that the neurological basis of language processing dates back to structures that were associated with communicative functions in the great apes. Searching for the neurological substrates of language in closely related species can give valuable hints regarding functional aspects of language in recent evolutionary history. We will, in the following, present an overview of topics and trends in language acquisition research to date, and relate them to relevant studies on nonhuman primates to shed some light on the evolution of human linguistic abilities.

### **3. The language faculties**

If we give communication a more generous definition which does not require including language proper and whole systems of behaviour we cannot help saying that despite all physical and behavioural differences between nonhuman primates and humans, communicative commonalities are undoubtedly there. What we find is the adaptation of species to the exigencies of the environment. Species have conscious behaviour attuned to their ecological niches and show (among other modalities) different levels of cognitive development.

The waves putting forward the FOXP2 gene as the bearer of our language faculty have ebbed down being replaced by a more down-to-earth albeit by no means less vehement debate about its structure and evolution and in particular the uniqueness of our human language instinct. In a joint behavioral study, Noam Chomsky ([2002](#)) expands the scope of language study to the investigation of complex behaviors in animals. The basic assumption of their endeavor is that something about the faculty of language must be unique in order to explain the differences between humans and other animals. To cut a long story short: the results urge a massive reduction of human-only attributes and to make allowances for two language faculties: FLN (Faculty of Language in a Narrow sense) only includes recursion and is the only uniquely human component of language. FLB (Faculty of Language in a Broad sense) contains the rest, e.g. a sensory-motor and a conceptual-intentional system. Criticizing this recursion-only-hypothesis is neither here nor there; suffice to say that other authors like e.g. Jackendoff and Pinker ([2005](#)) take a more amplified view and also allow for articulate speech sounds, morphological rules and many properties of speech perception as ingredients of the human toolkit.

Recently discovered common ground is the activity of mirror neurons which were first discovered in the simian primary motor and premotor cortex ([Gallese, Fadiga, Fogassi, & Rizzolatti, 1996](#); [Rizzolatti & Craighero, 2004](#)). Given extensive research, we are on safe grounds to appreciate the role of the primate brain's mirror system for manual action in the evolution of the human language-ready brain. Rizzolatti and Arbib ([1998](#)) proposed that a

shared understanding of action grounds the emergence of gesture, leading eventually to language. In different wording, the discovery of a neural mechanism for matching executed actions with observed actions provides the biological basis for our understanding of complex sensorimotor and cognitive processes involved in verbal and nonverbal communication, noticeably the nature of the theory of mind. In the given context, it is important to refer to two specific categories of mirror neurons: audio-visual mirror neurons and communicative mouth mirror neurons. Both are leading players in gesture and vocal development.

Taking one step and a decade further we find ourselves in dynamic systems theory ([Hohenberger & Peltzer-Karpf, 2009](#); [Kaneko & Ichiro, 2000](#); [Peltzer-Karpf, 2012b](#); [Smith & Thelen, 1993](#)) combined with the task to unite mirror neurons and the evolution of embodied language ([Fogassi & Ferrari, 2007](#)) and to consider how our minds share actions and emotions ([Rizzolatti & Sinigaglia, 2008](#)).

Where do we go from here knowing that many of our strongholds are shared? We all agree that humans have a language faculty. What is at issue is how specific it is and how we define language. For many linguists language delineates an abstract core of computational operations, central to language and probably unique to humans. For many biologists and psychologists language has much more general and various meanings, roughly captured by communication system used by human beings. If we follow this line of argumentation, we might assume that the individual functions of FLB have different evolutionary histories. As will be shown in the ensuing chapters profiling children's prelinguistic communication skills has proved quite helpful in calculating the proportion of innate and acquired knowledge.

Chomsky ([1982](#)) provides an innate Universal Grammar for this multilevel enterprise which sets the guidelines for the setting of parameters and the percolation of linguistic information in a given language. We do not know much about the onset of human language but it may be a safe guess that some of it bears great resemblance to prelinguistic behaviour with hand-to-mouth activities, gestures, the emission of sounds, and the naming of objects.

In human language development, several major phase transitions have been traced up to the age of three. They occur at more or less regular intervals and bring about waves between silent and explosive periods ([see Hohenberger & Peltzer-Karpf, 2009](#)). The age of two seems to be a particularly blooming period when significant changes in all systems take place. The time-course of these behavioural changes is linked to system-specific developmental changes in the central nervous system with more functional specialization opening up information that is more efficiently processed. This implies a changing sensitivity to input cues with different tasks being fore-grounded at different times ([Peltzer-Karpf, 2012a](#)).

The late maturation of the frontal lobe, both in phylogeny and ontogeny, suggests the late arrival of complex structures in syntax and morphology. Concerning the itinerary from holistic to fine-grained behaviour we may well assume that the early communication systems of our ancestors have something in common with the forms found at the transition from pre-



functional to functional behaviour in children. Concerning chimpanzees we know that they hold it well with the syntactic competence observed in two-year-old toddlers ([Tomasello, 2008](#)).

The driving forces of change in early language development are feature segmentation and binding. This can be explained as follows: as for the processing of input data highly specialized perceptual filters process postnatal stimuli according to their pre-programming. The choice is influenced by a bundle of parameters such as frequency, transparency, saliency and repeated occurrence in a comparable configuration. Binding mechanisms, then, unite matching features in clusters which contribute to the formation of first patterns. By splitting up the first clusters (= bifurcations) a system can acquire novel qualities and become more complex (the most impressive bifurcation concerns the onset of syntax around 24 months). What is important to note is that maturational factors and experience play complementary roles in forming specialized systems, which display different degrees of experience-dependent modification and operate at different time scales ([Hohenberger & Peltzer-Karpf, 2009](#)). Behavioural neuroscientists find that the integration of information from multiple sensory channels is crucial for attention and perception in humans, monkeys, birds and insects, particularly in the processing of stimuli associated with posture and movement ([Partan & Marler, 1999](#); [Winkler & Salwiczek, 2003](#)).

#### **4. Developmental milestones of communication in humans and nonhumans**

##### *4.1. Vision and gesture*

As the classical study on neonates by Meltzoff and Moore ([1977](#)) has shown, humans do not come into the world as a *tabula rasa* but rather possess abilities relating to cognition and perception of the world. Imitation or facial mimicry seem to be innate mechanisms triggered by environmental circumstances and this also holds true for neonate rhesus macaques who, three days after birth, demonstrated the ability to imitate mouth movements of human experimenters ([Ferrari et al., 2006](#)). Similarly, newborn chimpanzees are able to imitate facial movements shortly after birth ([Myowa-Yamakoshi, Tomonaga, Tanaka, & Matsuzawa, 2004](#)). Imitation, being an innate ability in humans and some nonhuman primates, could serve the function to increase social interaction between the caregiver and the young neonate and may thus lay the foundation for early communication in the mother-infant dyad ([Nadel, 2002](#)). Mirror neurons are proposed to underlie the imitative skills as they enable the neural matching of another's behavior with one's own behavior. An important aspect in this regard is eye gaze and gaze following in young nonhuman primates. It is known from neurophysiological studies that the direction of the eyes is neurally coded in monkeys ([Ferrari, Kohler, Fogassi, & Gallese, 2000](#)). In particular the superior temporal sulcus, a structure on the temporal lobe, of macaque monkeys has been implicated in head and gaze following of conspecifics ([Perrett, Hietanen, Oram, & Benson, 1992](#)). The anatomically homologous regions in humans is also activated during observation of eye gaze direction which indicates that eye-gaze following may play an equally important role for monkeys than it does for humans ([Ferrari et al., 2000](#)). Researchers have

stressed the link between gaze following and the development of a theory of mind ([Baron-Cohen, Campbell, Karmiloff-Smith, Grant, & Walker, 1995](#)) as perception of eye gaze represents the starting point for reading others' intentions. By understanding what a conspecific is attending to, it may only be a short step to understanding what the conspecific is thinking about. As Ferrari et al. (2000) suggest, the use of eye cues by others is not restricted to great apes and humans, but may have evolutionary precedents in monkeys. Recent studies on humans suggest that vision in young infants differs in a very fundamental respect from adult vision. Navigation in the adult visual world is governed by the saliency of the visual features, which "pop-out" from the background, and act as attractors for eye and head movements. A comparison of gaze following behaviour in great apes to that of human infants demonstrated that humans are especially reliant on eyes in gaze following situations ([Tomasello, Hare, Lehmann, & Call, 2007](#)) – a clear argument for the ocular share in the evolution of social functions. The first year does not merely bring visual acuity but also other visual qualities which intensify the infant's contact with the outside world ([Sireteanu, Encke, & Bachert, 2005](#)). Colour vision, binocular stereopsis and movement emerge in relation to the progressive development of visual acuity. Changes in visual perception around the end of the first year trigger communicative spurts through the pooling of resources in sensory development. For the developmental process eye movement, especially eye gaze and manual gestures play a significant role in early development: they signal joint attentional focus, are used to convey labels and to indicate search behaviour. Judging from previous studies, the development of perceptual and cognitive skills is largely influenced by interacting movement patterns with eye movement and gestures being a harbinger of communicative and linguistic capacities to come ([for background information on development and assessment see Vital-Durand, Atkinson, & Braddick, 1996](#)). A hotbed of research is face recognition which is also primordial for the onset of early communication. The infant's pre-speech repertoire is predominantly nonverbal ranging from knit brows (of concentration), jaw drop (of strongly focused attention), smiles to making coos and hand gestures, usually with the right hand, ([for face-to-face interaction see Trevarthen, 1995](#)).



Fig. 1: Early facial expressions.

Within the early phases eye contact/eye gaze and pointing function as cornerstones in the structuring of discourse. Infants make heavy use of eye contact both in human- and object-oriented discourse. In order to establish interpersonal communicative patterns and to signal joint attention both the children and their caretakers make intensive use of eye contact and face-to-face interaction.



Fig. 2: Eye contact between caregiver and infant during communication.

Previous results taken together we can state that the visual world of the neonate is quite narrow. Anatomical maturation enhancing functional capacities and the infant's keen interest in forms and patterns do, however, open up space, multiply and diversify visual input. The child's exploration of visual scenes becomes increasingly sophisticated, gaining in flexibility and perspective. Changes in visual perception around the end of the first year trigger communicative spurts through the pooling of resources in sensory development.

For the development of human communication, the end of the first year in infants is particularly interesting as social communication undergoes significant changes concerning dyadic versus triadic interactions ([Trevarthen & Hubley, 1978](#)). Before that age, infants engage with caregivers in dyadic interactions which are characterized by conveying attitudes and emotions face-to-face to a social partner ([Trevarthen, 1979](#)), as opposed to triadic interactions where an external object is included in the communicative dyad between sender and recipient ([Trevarthen & Aitken, 2001](#)). Engaging in triadic interactions represents a crucial enrichment to the communicative competence of infants and endows them with a variety of socio-cognitive skills, such as the ability to convey emotional information about the third object to the partner ("[social referencing](#)", see [Feinman, 1982](#)) and the ability to refer to objects by producing deictic gestures ([Bates, Camaioni, & Volterra, 1975](#)). These gestures function to initiate triadic interactions by either expressing a request in relation to the pointed-at object (proto-imperative) or by merely showing an object to share interest in it with the communicative partner (proto-declarative). While some authors see the two types of deictic gestures as being governed by cognitively different mechanisms, in particular with regards to acquisition ([Brinck, 2004](#)), others take the viewpoint that the two concepts are not strictly separable ([Southgate, van Maanen, & Csibra, 2007](#)).

Concerning the evolutionary history of triadic referencing, there is a current debate whether great apes possess similar cognitive abilities and are able to reference triadically ([Carpenter & Call, 2009](#); [Gomez, 2010](#); [Leavens & Racine, 2009](#)). The question of joint attention is at the heart of the disagreement and some researchers claim that apes are not able to engage in joint attention upon objects with other individuals ([Carpenter & Call, 2009](#)), whereas others are convinced that apes and humans have similar abilities in this regard ([Leavens & Racine, 2009](#)). The different definitions of “joint attention” further complicate matters as the concept may refer to two partners merely looking at an object at the same time ([Butterworth & Jarrett, 1991](#)), while others stress the mutualness of the activity and require both interactants to understand that they are sharing attention upon the same object ([Tomasello, 1995](#)).

Nonverbal interaction plays a central role in socializing human children to engage in communicative acts. Recent longitudinal studies make the link between action, gesture and word more explicit. In addition, as to the preferred mode of communication there is a very interesting species-specific shift to observe. Around 18 months the imbalance in the use of verbal and nonverbal communication tips in favour of verbal exchange. As shown in fig. 3 toddlers obviously prefer verbal messages ([Wagner, 2006: 122ff](#)).

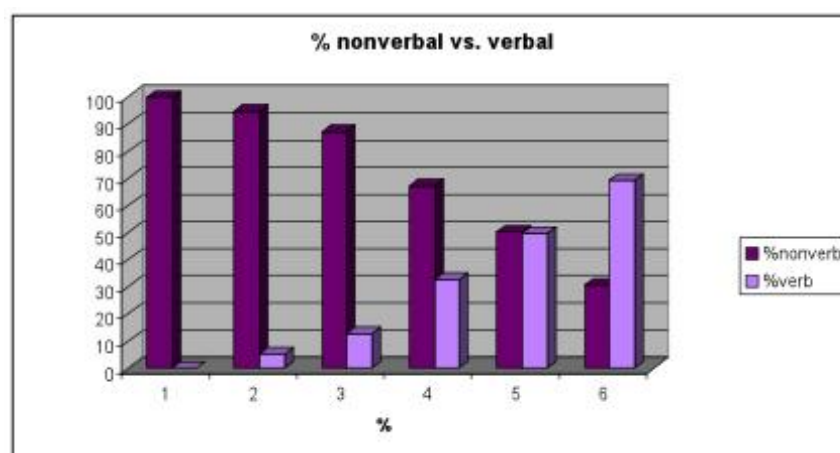


Fig. 3: Proportion of nonverbal communicative intents (dark blocks) and verbal communicative intents (light blocks).

In apes a change in gestural communication, similar to human infants, can be found. After a certain age, the gestural repertoire has reached its peak and declines ([see Call & Tomasello, 2007](#)). In humans, this void is filled with vocal communication which human infants start to prefer over gestures at a certain age. In apes, on the other hand, after the juvenile phase the gestural repertoire becomes smaller ([Call & Tomasello, 2007](#)) with no apparent supplementation. Vocalizations and gestures in apes are used for different communicative needs ([Tomasello & Zuberbuehler, 2002](#)) and one does not seem to stand in for the other. The increase in gestural signals in juvenile apes may be explained by a period of “trying out” various gestures and their possible functions until the repertoire stabilizes and becomes more rigid in adulthood ([also see Hobaiter & Byrne, 2011](#)). The juvenile growth stage evolved as a developmental intermediate between infancy and adulthood in



social mammals. Juvenility provides benefits to a species as it allows for an extended period of brain growth and learning time so that the animals can acquire more skills to prepare for adulthood ([Janson & van Schaik, 1993](#)). In the human brain, myelination, which is essential for cognitive skill development, is not finished before the age of 12 (in the prefrontal cortex not before the age of 20) while in rhesus macaques the process is completed around the age of 3.5 years ([Gibson, 1991](#)). An extended period of brain maturation can equip the brain with more elaborate cognitive functions. Juvenile apes are better capable of acquiring novel skills than other age groups, including communication. A similar development occurs in humans: after juvenescence language learning becomes increasingly difficult and will not result in as great a success as when it is started during the juvenile developmental stage ([Lenneberg, 1967](#)).

The juvenile phase is equally important for nonhuman and human communicative development as in both species a significant increase in communicative competence can be observed. While in the gestural communication of apes a decline follows the juvenile zenith where adults' repertoires become smaller again, in humans communicative competence only declines at an older age. Apes show the longest juvenile periods and recent endocranial measurements suggest that juvenility was prolonged in the evolution of *Homo sapiens*; earlier hominids, such as *Homo erectus*, presumably underwent shorter juvenile developmental periods ([Coqueugniot, Hublin, Veillon, Houet, & Jacob, 2004](#)). These findings carry important implications for the evolution of complex cognition, including language, and can help pinpoint when human language may have started.

Recent pragmalinguistic studies suggest that early gesture use in human infants might be an index of global communicative skills ([Leroy, Mathiot, & Morgenstern, 2009](#)). Of particular interest are the fine-grained correlations between pointing gestures, prosody and gaze. Concerning mirror neurons Montgomery, Isenberg and Haxby ([2007](#)) suggest their involvement in communicative hand gestures and object-directed hand movements. Even neonates show cross-modal matching of head movement and tongue protrusion gesture in (repeated) imitation ([A. Meltzoff & Moore, 1989](#)).

Before human infants combine gestures with words they are complemented by gaze and vocalizations. These combinations might already carry pragmatic, social and semantic functions. Conventional symbolic gestures like pointing appear at the end of children's first year to be followed by combinations of gesture and word in the second year. The data assessed in a cross-linguistic study of Italian and American-English pre-speech children suggest a protolanguage consisting of onomatopoeic words, animal sounds, evaluative sounds combined with pointing gestures indicating objects, sounds or locations ([Iverson, Capirci, Volterra, & Goldin-Meadow, 2008](#)). As shown in an extensive study by Row and Goldin-Meadow ([2009](#)) the age at which children first produce gesture-speech combinations reliably predicts the age at which they first produce two-word utterances. And there is longstanding evidence linking communicative gesture to early language and to delays in early language development ([Bates & Dick, 2002](#)).

#### 4.2. *Vocality*

Contrary to vision, which is unique among the senses in that it is not used prior to birth, auditory activities occur prenatally from the last trimester of pregnancy onwards when the middle ear structures are normally complete. The infant's task can be specified as organizing an array of overlapping signals, contrasts and contours, which in language learning translates to discovering phonetic features, word boundaries and grammatical regularities. Infants are competent categorizers: They are able to discriminate between but not within categories both in native and non-native stimuli after 1-2 months. They exhibit correct categorization of equivalence classes of vowels by the age of 6 months showing perceptual constancy and a disregard of incidental variation. Furthermore, evidence exists of a prototype magnet effect in infant speech perception (but not rhesus monkeys) at 6 months of age in which prototype vowels are more difficult to discriminate from other stimuli than non-prototypes ([Kuhl, 2004](#); [Vihman, 1996](#)). By 4 months localisation of speech sounds begins which gives evidence of central auditory function; two months later very soft speech can be localized. Such as early gestures can be interpreted as precursors to later linguistic achievements the scores achieved in head turn tests show significant correlations between early speech perception and later language understanding and production ([Tsao, Liu, & Kuhl, 2004](#)).

The developmental trajectory of speech production starts with utterances of non-speech sounds until approximately the age of 3 months when vowel-like sounds appear in the vocal repertoire ([Kuhl, 2004](#)). During the cooing-stage, velar consonants occur more frequently than during the later babbling stages (canonical and variegated) when alveolar and dental consonants are preferred by infants ([Vihman, Ferguson, & Elbert, 1986](#)). From early on tongue movements are involved in sound production.

Several developmental steps are required as infants learn to segment, identify and represent the phonetic forms of spoken words, and map those word forms to different concepts. Within the first year of life auditory perception gives rise to a complex picture with systemic changes at different ages resulting in a gradual move from universal (= decrease) to language-specific sensitivity (= increase). Age-related system changes coupled with phase shifts lead to important advances in perceptual performance which can be related at least to two control factors: (1) brain maturation and (2) domain-general cognitive advances. Further changes can be traced in motor, attention and motivation systems ([see Werker & Yeung, 2005](#)).

The following chart summarizes the most important shifts in auditory processing within the first year of life. It once again evinces the high dynamics in early speech perception with selective tuning to different kinds of information depending on the respective basis leading to increasingly complex form-function mappings ([details in Vihman, 1996](#)).



newborn to 4 months
<ul style="list-style-type: none"> <li>▪ Ability to discriminate own from non-native language</li> <li>▪ Preference for native language</li> <li>▪ Preference for mother's voice</li> <li>▪ Preference for story and song heard prenatally</li> </ul>
6 months
<ul style="list-style-type: none"> <li>▪ Structure of native language vocalic categories changing</li> <li>▪ Some decline in discrimination of non-native vowels</li> <li>▪ Preference of pauses at clause boundaries in native language only</li> <li>▪ Preference of word lists reflecting native language prosody</li> </ul>
10 months
<ul style="list-style-type: none"> <li>▪ No longer discrimination of non-native consonant contrasts</li> <li>▪ No longer discrimination of non-native vocalic contrasts</li> <li>▪ Preference of words that correspond to native phonotactic rules</li> <li>▪ Preference of words with common native stress</li> </ul>

Table 1: The most important shifts in auditory processing within the first year of life.

Throughout the first year of life, when the basic guidelines for language acquisition are set, three major perceptual shifts have been traced. First, infants seem to move from sensitivity to psychoacoustic categories to phonological ones. Second, the ability to perceive phonetic contrasts is narrowed down to those of the native language. Thirdly, there is a shift from perceiving suprasegmental properties of prosody to segmental ones. In general, frequent, transparent and salient input signals function as organizing points on the word/sentence level and the construction of natural classes. Language specific segmentation exhibits a transition in sensitivity from rhythm, to lexical units and - at the transition from pre-functional to functional processing - a break into syntax around age two.

The relationship between human language and the vocal output of non-human primates is a matter of considerable debate. The majority of monkey and ape vocalizations are under genetic control with learning taking a limited role in vocal development. Squirrel monkeys, when raised in isolation from species-specific call input, develop a normal vocal repertoire with only minor deviations in acoustic detail and context of call use ([Winter, Handley, Ploog, & Schott, 1973](#)). However, there are some indications that a higher degree of flexibility exists in the vocalizations of certain non-human primates. Talapoin monkeys ([Gautier, 1974](#)) and cotton-top tamarins

([Snowdon, Cleveland, & French, 1983](#)) develop specific calls by going through structural maturation until the stable adult-like form is reached. Furthermore, calls of macaque infants closely resemble those of their mothers ([Masataka & Fujita, 1989](#)), indicating external influences on call structure. In their study of vervet monkeys, Seyfarth and Cheney ([1986](#)) demonstrated age-related improvement in alarm calls, implying that developmental maturation processes contribute to the shaping of the vocal repertoire of the species. For great apes, evidence for vocal learning is scarce and mostly stems from chimpanzees 'dialects' concerning particular vocalization types ([Marshall, Wrangham, & Arcadi, 1999](#)). It is, however, not unequivocated that vocal learning takes place in monkeys or apes and research is at present on-going to clarify which factors influence call acquisition in nonhuman primates.

By comparing results among primates and children of various ages we might begin to understand where on the continuum of intelligent beings each of the groups fall. Proto-communication in chimpanzees seems to be based on their genetic blueprint and environmental stimulation, just as in humans. Review of monkey and ape communication demonstrates greater flexibility in the use of hands and body than for vocalization. Nonetheless the gestural repertoire of any group of nonhuman primates is small compared with the vocabulary of any human language.

The performance of language is multimodal, not confined to speech. Since there is no direct evolutionary path from nonhuman primate vocalization to human speech ([see Arbib, Liebal, & Pika, 2008](#)) the question arises what incipient human communication comes up to. A newborn can move face, eyes, hands and the whole body to express feelings in ways which other people easily empathise. And the baby is extremely sensitive to the quality of vocalisation, holding, moving and facial expression of pleasure or indifference in a person giving care ([Trevathan, 1995](#)). Mothers join in conversational play with infants of 6 weeks of age, when the cerebral cortex is very immature, when foveal acuity, feature analysers and the capacity for binocular stereopsis are just beginning ([details in Vital-Durand et al., 1996](#)). The infant's pre-speech repertoire is predominantly nonverbal ranging from knit brows (of concentration), jaw drop (of strongly focused attention), smiles to making coos and hand gestures (usually with the right hand). For the first few months an infant is far better at interacting with persons than at dealing with objects and the layout of the world. Later the caregiver-infant dyad develops into a system that can take account of objects. This might be the watershed for chimpanzee and human communication ([except for special animal training which may at best lead to primitive syntax and a basic lexicon, for details see Savage-Rumbaugh, McDonald, Svecik, Hopkins, & Rubert, 1986](#)).

Similarities between humans and apes are reflected in the relationship between vocality and gesture. The general trend of gesture decrease in apes is mirrored by human development. While young children rely more on gestural communication, with age and increasing language abilities, gestures move to the background ([Peltzer-Karpf, Wagner, & Sireteanu, 2007](#)). Vocal communication can, to a certain extent, substitute for gestures and less effort is involved in the production of the signal. This may hold cues as to



why vocal communication underwent a transformation from closely related apes and became the primary communicative medium for humans. The articulatory development in nonhumans may also show similarities to human infants: vocal development begins with scream-like sounds that only later are refined to harmonic vocal signals. Babbling stages, as in human infants, have been described for monkeys ([Elowson, Snowdon, & Lazaro-Perea, 1998](#)) but so far there are no reports of babbling in apes. It seems plausible that some type of phonetic activity precedes the appearance of fully developed calls in great apes. Questions concerning the articulatory development from apes to humans have to take into consideration the evolutionary pressures that led to the rise of human spoken language. Tongue involvement as well as laryngeal actions for the production of sounds have to be put into the larger framework of the phylogeny of vocal tract development that endowed us humans with the ability to produce the large number of phonetic contrasts that distinguish today's languages.

## **5. Conclusions**

The completion of the sequence of the human genome, and that of the genomes of other species provided unprecedented opportunities to begin to determine the functional elements and the functional variability of these genomes. Current research places great emphasis on the 2% which make humans so outstanding in the universe. The genetic highway is now not merely followed by anthropologists and geneticists but also by an ever-increasing number of psychologists and linguists.

The Origin of Species ([Darwin, 1959](#)) makes no mention of evolution. The word was first used in biology to describe the changes in shape of an embryo as it developed. Not until much later did evolution begin to suggest the gradual transformation of one form into another. Now the study of development is unrolling the scroll of biological history. Darwin assumed that 'the several races [are] descended from a single parent stock, which must have been almost completely human in structure, and to a large extent in mind, before the period in which the races diverged from each other' ([Darwin, 1872/ 3 1998: 355](#)).

We know little about linguistic systems in paleolithic times. The only hint as to complexity we can get is from the reconstruction of brain size. Moreover, we do get useful information from the developmental cognitive neurosciences. So what is unique about the human brain? We have the highest neuronal density in the cortex and something more: the prefrontal cortex required the longest time to develop across the ages and is the last to achieve full maturity in man. This part where problem solving, creativity and mental reasoning are said to be located forms 29 % of the central nervous system in man, whereas only 16.9% in chimpanzees, 8.3% in lemurs and 2.2% in rabbits. Further reports on how wide a chasm separates us from other primates are transferred to anthropological research labs.

Owing to the biogenetic law that ontogeny repeats phylogeny the evolution of language is often brought into perspective with language development. Recent findings suggest that the relationship between the two is not merely a matter of analogy but does indeed offer a physiological dimension. The

parallel shows most clearly on the maturational scale in the sense that those parts of the brain that are most recent from an evolutionary perspective are the last to mature. This shows in particular in the corticalization index of the individual parts of the brain. Moreover, signal transmission in the frontal cortex is last enhanced by a full supply of myelin around age 20 ([for a summary of anatomical and neurological prerequisites see Johansson, 2005: 116-117](#)).

As it is not opportune to get too extensive brain-wise we make do with the most important phylogenetic and ontogenetic events: Milestones in the emergence of the *Homo* pattern are the reorganization of the frontal lobes, an increase in cerebral asymmetries and the refinement in cortical organization. *Homo sapiens* has a slightly smaller brain than his ancestors but a much higher neural density. With regard to speech it should be added that the upper respiratory tract made speech possible as the high larynx seen in species like the chimpanzee dropped, creating an expanded pharynx ([Corballis, 2002](#)). The early neural events in humans establish an initial connectivity among sensory, limbic and medial temporal structures, improve the integration of the two hemispheres, connect the frontal lobe to the above sites and promote a massive connectivity among all brain sites around age 6. Due to the spiral of reciprocal interaction between the brain and the environment a relatively small set of genetic rules suffices to generate highly differentiated structures ([Kagan & Baird, 2004](#)).

How did we (meaning the human species) find our workable key to map *life's grandeur* ([to borrow from Darwin, 1872, and Gould, 1992](#)) onto language? Psycholinguistic research gives us to understand that language acquisition (this comprises comprehension and production) requires detecting, extracting, storing, retrieving, and mapping units onto specific functions within a (more or less) precisely defined time window. If we extend the focus to the cognitive neurosciences we learn that early development is characterised by the blossoming of sensory higher-order processing as well as massive changes in brain organisation. This increasing complexity might well be the touchstone of linguistic performance but certainly not of communication.

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## **Nature of vowels and diphthongs in babbling of Malayalam infants**

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### **Abstract**

Recent studies of human infant vocal behaviour have shown an influence of the ambient language on the early stages of vocalizations. The influence of the ambient language has a certain subset of vocalizations of which can be produced with their vocal tract (MacNeilage & Davis, 2001). In this context, it is quite essential to gain insights into the vocal tract articulatory dimensions of infants. This would suggest some developmental check that may shape speech acquisition. Present paper is focused on the appearances of vowels and diphthongs during early exploration period of babbling extending till 12 months of age in infants of native Malayalam speaking families. The participants comprised of 20 infants, 5 girls each in the age range 4 to 12 months from native Malayalam (A Dravidian language spoken in Southwest of India) speaking families. The audio recorded babbling data of the participants were analysed using IPA (2005) to obtain the frequency and type of vowel and diphthong utterances. Vowels were classified according to tongue height and tongue advancement dimensions. Diphthongs were classified according to the degree of opening or/and closing positions. On statistical analysis, results for tongue height and tongue advancement dimensions, the frequency of occurrence was high for mid front vowels followed by low centre vowels and least for high back vowels. Overall results indicated a reduction in the singleton vowels and diphthongs in infants of older age range indicating emergence of more complex syllabic patterns and word forms in them. These findings on normal phonological development would be highly relevant for clinical practice in the area of communication disorders in young infants.

**Keywords** Diphthongs, Early vocal production, Malayalam, Tongue advancement, Tongue height, Vowels

### **1. Introduction**

The patterns of infant vocalizations in the recent years have increasingly gained attention. Much is now known about the acquisition of speech and language in the early years of life. The appearances of vowels and consonants in infant phonetic repertoire have known to be universal in almost all the world's languages (Jacobson, 1968). Research has supported

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the influence of the ambient language environment on the child's later language development. Such exposure has been known to have moulded the patterns of babbling into true words of the target language. Canonical babbling is a random series of vocalizations in which many different sounds are produced with no apparent order or consistency.

Canonical babbling is defined as rhythmic alterations between consonant and vowel-like properties, giving a percept of rhythmic speech that simulates adult output without conveying meaning (Davis & MacNeilage, 1995; Oller, 2000). Longitudinal studies on canonical babbling to first words have shown continuity (Oller, 1980; Stark, 1980; Stoel-Gammon & Cooper, 1984; Vihman, Ferguson & Elbert, 1986). This continuity supports babbling to first words as benchmarks for a child's mastery of the ambient language. Research has shown that Consonant-Vowel interactions are present in the early phonetic repertoire (Stoel-Gammon, 1983; Davis & MacNeilage, 1990; Tyler, 1996). Vowels and diphthongs may provide additional insights to the issue of universal patterns of development. These patterns obtained during babbling could provide a retrospective view into Khul's native language magnetic model (Khul & Meltzoff, 1996). Khul's theory suggests that native language skills improve towards the end of the first years of life showing a continuity between early phonetic measures and later language skills.

Diphthongs do play a vital role in phonological development. Lindau, Norlin and Svantesson (1985) found that diphthongs occur in approximately one-third of the world's languages. Ling (1989) stated that diphthongs frequently occur in children's early words. Ingram's (1997) hypothesis suggest that diphthongs with least featural complexity (i.e. least difference between the two constituent vowels) will be acquired first. It is assumed that children will have to "mark" the difference between the two constituent diphthong vowels in their underlying representation. Therefore, according to the generative phonology, it is suggested that children acquire unmarked features before marked ones and the phoneme with the least featural complexity (least marked features) would be acquired first (Ingram, 1997).

Early phonetic behaviors on vowel patterns were studied using spectral analysis. De Boysson-Bardies, De Halle, Sagart, & Durand (1989) performed spectral analysis using formant measurements for vowels on 10 month old preverbal infants' drawn from four linguistic communities-Arabic, Chinese, English, and French, 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, with more high-front vowels for English, 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. Acoustic studies of early babbling have provided support for the idea of a predominance of mandibular over lingual movement in early canonical babbling (McNeilage & Davis, 1995).

Variability in vowel and consonant patterns has been reported in both longitudinal and cross sectional studies as well. 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. According to the tongue height dimension, mid vowels, particularly [ʌ, Y and E], predominated in 3 subjects, while high vowels, particularly [u, Y and I], predominated in the remaining 3 subjects. In relation to tongue advancement, front vowels, particularly [E, ɵ and I], predominated in 4 subjects, and the mid vowels [a, ʌ, ə], predominated in the remaining 2 subjects. The most commonly used vowels in the canonical babbling period were identified as [ʌ, ə, E, ε, Y, I and ɵ].

Similarly, another cross-sectional study by Anjana and Sreedevi (2008) was carried out in Kannada from 6 months to 12 months of age with an age interval of one month. They found that vowel repertoire [I, e, æ, a, u, o] showed variability across age groups. Vowel [i] made more frequent appearances in all the six age groups compared to the other front vowels [e] and [æ]. The central vowel [a] made predominant appearance across all age groups. The back vowels [u] and [o] were lower in their frequency of appearance in all the age groups.

A longitudinal study by Sreedevi and Jyoti (2012) was conducted in Kannada. They observed seven vowels [I, e, æ, a, u, o, ə] which were highly variable in frequency across the nine participants. Vowel data showed that the appearance of low vowels dominated from 3 - 12 months which were followed by mid vowels.

Vowels from the lower left quadrant of the vowel space such as mid and low front and central vowels are most often observed during early phonological development at 10-18 months (Bhur, 1980; Lieberman, 1980; Bickly, 1983; Kent & Bauer, 1985; Davis & Mac Neilage, 1990; Stoel- Gammon & Harrington, 1990). Davis et al., (1990) suggests the low to mid front and front to central vowel productions as “pure dynamics”. Tse (1991) found that his subject acquired longer vowels [ε, a, i] at an earlier age. of 14 to 36 months for Cantonese. He found maximally contrasted vowels /i/ and /a/ to be acquired first. According to Jacobson's (1968/1941) prediction front – rounded vowels do not appear before unrounded vowels during the early mastery of vowels. Wong (2001) found that coronal vowels were produced in the earliest age period of 10-15 months, this finding is supported by Bhur's study (1980) that claimed the musculature of lips, jaw and frontal portion of the tongue develop at a faster rate compared to the lowering of the larynx and rear portion of the tongue. Height dimensions in vowels are easily attained by mandibular movements at 10-15 months (Matyear 1997) and for backness Bhur (1980) the rear portion of the oral cavity develops at a slower rate; hence the coronal and dorsal contrasts develop at a later stage of the phonological development at around 24-27months. However, the present study investigates the nature of singleton vowels in the early pre-linguistic period of 4 to 12 months. . The patterns observed in the above studies relate much to the emergence of vowels and consonants and not on the nature of diphthongs.

It has been proposed that learning from the ambient language influences and shape vocalizations in late babbling periods. Appearances of the ambient language in the infants early vocalizations has been examined for utterance and syllabic structures ( Boysson- Bardies, 1993; Kopkalli- Yavuz&Topbac,

2000) and Vowel repertoire ( Boysson- Bardies, Halle, Sagart & Durand, 1989 and 1992). Levitt & Utman (1992) compared one French and one English learning infant. The French infant favoured front low vowels and the English infant preferred mid central vowels, consistent in their ambient languages. Khul's native language magnet (NLM) model encompasses infant vocalizations. It is hypothesized that infants listening to the ambient language store perceptually derived representations of speech sounds they hear which in turn serve as a target for production (Khul & Metzloff,1996). Therefore, it is expected that the phoneme in a child increases when the frequency of occurrence of that phoneme is high with the ambient language. The high front vowels are frequent in English (Bernhardt & Stamberger, 1998), so they are acquired first. By contrary, vowels [u], is the least frequent in Cantonese (Fok, 1979). The late mastery may be attributed to its low frequency of occurrence in the ambient language.

The effect of ambient language was also noted in vowel and diphthong development in 40 Cantonese speaking children aged 10 to 27 months (Wong, 2001). The results suggested a hierarchy of vowel feature development with decreasing order of height >backness> roundness. Diphthongs with round and dorsal elements appeared in the later stages.

Westermann and Miranda (2004) support the above findings by indicating there is growing evidence that the pre-linguistic stage significantly influences the later development of phonological skills in children. Hence literature suggests that babbling is a predictor of later language complexity as well as language delay.

Studies on infant vocalizations report that early laryngeal vocalizations such as vegetative and reflexive sounds are differentiated from "speech like" vocalizations after the first trimester in life (Davis & MacNeialge,1990; Eilers,1992; Oller,2000). Findings also suggest that infants gain increasing control over speech mechanism resulting in increased vocal play from 3 - 4 months onwards which continues beyond the first year of life. Investigating the phonetic behavior as early as 4 months would present the emerging patterns of vowels and diphthongs providing an insight to the phonetic and phonotactic patterns in the developing phonological system. Hence the present study intends to study the vocal behavior of infants from 4 - 12 months of age which is a significant phase of the pre-linguistic period. Research findings have indicated that pre-linguistic vocalizations to a large extent depend on the ambient language as every language has its own phonotactic patterns.

There is dearth of studies in the Indian context on the appearance and nature of vowels and diphthong productions in the early phonetic repertoire period. In the Indian context, a cross linguistic study in Hindi and Kannada was carried out by Shyamala and Basanthi (2003). They reported that five vowels /i/, /e/, /a/, /u/ and /o/ in Kannada made their appearance during 6-12 months. In Hindi, only four vowels (/i/, /e/, /a/ and /u/) including their longer counterparts were seen during the same period. The differences in phonetic repertoire across languages, as early as in the babbling stage were evident in this study. Diphthongs were not considered in their study. To date, research has focused on singleton vowels and only a few studies have paid attention to the nature of diphthongs. India being a multilingual



country, there is a need to study productions in other major Indian languages such as Malayalam also. The emergence of early vowels and diphthong must be studied. There is no reported literature on the phonetic characteristics of vowels and diphthongs in Malayalam as early as the prelinguistic period; hence the present study was taken up. The purpose of the study was to examine the patterns of vowels and diphthongs and their frequency in infants from 4 to 12 months using a cross-sectional design.

The aim of the present study is to investigate the emergence of vowels and diphthongs of infants with a native language background of Malayalam from 4 to 12 months of age using a cross-sectional design. The objectives of the study were:

- To determine the nature of vowels and diphthongs in infants, between the ages 4;0-6;0, 6;0-8;0, 8;0-10;0 and 10;0-12;0 months in Malayalam<sup>1</sup>
- To investigate the type and frequency of vowels and diphthongs as a function of age.

## **2. Methodology**

### *2.1. Participants and inclusion criteria*

Twenty infants were audio recorded from native Malayalam speaking families, five girls in each age group at 4-6 months, 6-8 months, 8-10 months and at 10-12 months. An informed consent was obtained from the caretakers/ parents for the participation of the infants in the study. Care was taken to ensure that the participants had typical development and had not been exposed to any other languages. Participants were identified from native Malayalam speaking families and were assessed using the Developmental Screening Checklist (Swapna, Jayaram, Prema, & Geetha, 2010) for receptive and expressive communication skills, auditory, motor and cognitive skills. It was mandatory that both the parents were educated up to a minimum of 10<sup>th</sup> grade. The proficiency of the native language of the parents was assessed using the Language Proficiency Questionnaire: An adaptation of LEAP-Q in the Indian context by RamyaMaitreyee and Goswami (2009).

### *2.2. Measures considered in the study*

Based on transcription of the babbling data, the type and frequency of vowels and diphthongs utterances were calculated from the babbling sample of each of the 20 participants.

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<sup>1</sup> Malayalam belongs to the Dravidian family of four major languages with a rich literacy tradition. According to 2011 census, Malayalam is spoken by 33,066,392 people, primarily in the state of Kerala. Malayalam language consists of eleven vowels. The front vowels are /i, i:, e, e:/ . The short vowels are /I and e/ and the long vowels include /i: and e:/ . The central vowels are /ə, a and a: / and the back vowels.

Concerning the vowel system, length is contrastive and four diphthongs or vowel clusters occur. The syllable structure of Malayalam is given by the following (items in parentheses are optional): (C) (C) (C) V(C).

### 2.3. Procedure

Audio recordings were carried out by the investigator in a fairly quiet room with minimal distractions at the respective homes of the participants. Vocalization samples were recorded when the child was fed and in a comfort state. Parents were asked to interact naturally with the child. No additional play materials were introduced into the environment to capture the infants' typical vocalizations in familiar surroundings. The infant was stimulated more with toys and facial expressions than verbal utterances to avoid verbal imitation. Sony M55 audio recorder was utilized for recording each participant's vocalizations for 1 hour to obtain a minimum of 100 utterances. All the recordings were transferred to a computer and were analyzed using the VLC media player software.

### 2.4. Data analysis

The recorded samples were transcribed by the primary investigator using broad and narrow International Phonetic Alphabet (2005). Sounds such as grunts, gurgles, laughs, shrieks and whisper etc. were excluded from transcription. A criterion for the transcribed sample was utilized, to consider a phon/ syllable to be present in the infants' vocalizations. It is known that the complexity and frequency of vocal utterances will increase with age. Hence even a one-time production of a vowel/diphthong was considered as to be present in the infants' productions at 4-6 months, two or more productions at 6-10 months, whereas three or more productions of a vowel/diphthong was considered to be present in the infants' productions at 10-12 months. After identifying the phonemes, their frequencies were calculated. Inter and intra transcriber reliability was calculated for 10% sample of each participant. Cronbach's alpha co-efficient was found to be 0.66 and 0.75 for inter and intra transcriber reliability respectively.

## 3. Findings and Discussion

The present study considered 20 participants for the analysis of early phonetic repertoire from 4 to 12 months of age. Participants were subdivided into four age bands with an interval of 2 months i.e 4 to 6 months, 6 to 8 months, 8 to 10 months and 10 to 12 months. The recorded data was phonetically transcribed using International Phonetic Alphabet (2005) which yielded a total of 2106 phonemes in the entire phonetic repertoire of the twenty infants. The transcribed data was subjected to further statistical analysis using various non-parametric tests. Based on the frequency of occurrence of vowels and diphthongs, the results are discussed on the following lines:-

- (1) The types and frequency of singleton vowels and vowels based on tongue height dimension in all age groups
- (2) Types and frequency of vowels based on tongue advancement dimension in all age groups
- (3) Types and frequency of diphthongs.

The total corpus of 2106 phonemes, consisted of 720 vowels in the babbling samples of 20 infants from 4 to 12 months of age. The vowels were mainly singleton occurrences. Tongue height classifications were as high, mid, low



vowels and tongue advancement classification was as front, back and central vowels. The mean frequency of singleton vowels in each age group and vowels based on tongue height dimensions are shown in Table 1. Mean Frequency of singleton vowels based on tongue advancement dimension in all age groups is depicted in Table 2 and the mean frequency of the occurrence of diphthongs and its types is provided in Table 3.

Age range (in months)	Mean Frequency Of Singleton Vowels	Frequency Based On Tongue Height		
		<b>HIGH</b>	<b>MID</b>	<b>LOW</b>
(Group1) >4 ≤ 6	229	0	107	122
(Group2) >6 ≤ 8	202	4	137	61
(Group3) >8 ≤ 10	183	26	79	78
(Group4) >10 ≤ 12	106	8	51	47
<b>TOTAL</b>	<b>720</b>	<b>38</b>	<b>374</b>	<b>308</b>

Table 1. Mean Frequency of occurrence of singleton vowels and frequency based on tongue height.

Age range (in months)	Vowel Tongue Advancement Dimensions		
	<b>FRONT</b>	<b>BACK</b>	<b>CENTRE</b>
	Frequency	Frequency	Frequency
Group1) >4 ≤ 6	154	0	75
(Group 2) >6 ≤ 8	187	0	15
Group3) >8 ≤ 10	129	3	51
(Group 4) >10 ≤ 12	97	0	9
<b>TOTAL</b>	<b>567</b>	<b>3</b>	<b>150</b>

Table 2. Mean Frequency of occurrence of singleton vowels based on tongue advancement

Age range (in months)	Diphthongs				
	Mean frequency of diphthongs	Mean frequency of types of diphthongs			
		<b>OD<sup>3</sup></b>	<b>CD</b>	<b>HHD</b>	<b>CNTD</b>
(Group 1) >4 ≤ 6	29	11	3	12	3
(Group 2) >6 ≤ 8	31	0	4	28	1
(Group 3) >8 ≤ 10	21	3	1	17	0
(Group 4) >10 ≤ 12	25	1	2	22	0
<b>TOTAL</b>	<b>106</b>	<b>15</b>	<b>10</b>	<b>79</b>	<b>4</b>

Table 3. Mean Frequency of occurrence of diphthongs and its types

<sup>3</sup>OD-Opening diphthongs, CD-Closing diphthongs, HHD-Height Harmonic Diphthongs, CNTD-Centering Diphthongs

As seen in Table 1, there was an inverse relationship between frequency of singleton vowels and age. For an alpha level of 0.05 these patterns are significant. The 720 vowels in the vowel corpus were primarily singleton occurrences. The singleton vowels were majorly produced by the 4 to 6 month age band compared to the older groups; this could be attributed to predominant vowel productions in the early phonetic repertoire. This finding is consistent with the reports which have supported the idea of a predominance of mandibular over lingual movement (MacNeilage & Davis, 1995) during the early phases of babbling. It was observed that as age increased the frequency of occurrence of singleton vowels reduced; this finding also relates to the appearance of more complex syllabic patterns of vocalizations towards the later stages of babbling (Reeny & Sreedevi, 2013).

Table 1 also shows the singleton vowels based on the tongue height dimensions categorized as high (/i, i:, u, u:/), mid (/e, e:, o, o:/) and low (/æ, æ:, a, a:/) vowels from 4 to 12 months old infants. The finding indicates, the mid and low vowels were abundant in the early phonetic repertoire compared to the high vowels /i/ and /u/. This can be related to the anatomical changes in the vocal tract of “pure dynamics frame” (Davis et al., 1990) resulting in low to mid front or vice-versa and front to mid vowel productions with increase in age and may possibly be an indication of its low frequency of occurrence in the ambient language. The overall results indicated that occurrence of singleton vowels decreased in frequency as age increased. The reduction in the singleton vowels towards the latter age range indicated the emergence of more complex syllabic patterns and reduced use of isolated vowels in babbling (Reeny & Sreedevi, 2013).

The data for high, mid and low vowels were subjected to non parametric tests. Kruskal Wallis test for overall group comparison for high, mid and low vowels was significant for mid vowels at  $p < 0.05$ . No significance was present for high and low vowels. Mann Whitney test for pair wise comparison was significant for groups 1 and 4 for high, mid and low vowels and groups 2 and 4 for mid vowels at  $p < 0.05$ . Friedman test for within group for high, mid and low vowels was significant for all groups at  $p < 0.05$ . Wilcoxon Signed Rank test was significant for mid-high and high-low vowels for groups 1 and 2 but no significance was obtained for low-mid vowels at 0.05 level of significance. No such significance was present for group 3. Group 4 was significant at  $p < 0.05$  for mid-high vowels and not for low-mid vowels and high-low vowels.

Overall, mid and low vowels were the most frequent phones in all the infants across the age groups; this supports the findings of infants of English speaking families (Davis et al., 2002). The observation of early vowels such as mid and low vowels are also consistent with the reports of its appearance located in the lower left quadrant of the vowel space (Bhur, 1980; Lieberman, 1980; Bickly, 1983; Kent & Bauer, 1985; Davis & Mac Neilage, 1990; Stoel-Gammon & Harrington, 1990).

Based on tongue advancement, the vowels were front (/i, i:, e, e:/), back (/u, u:, o, o:/) and centre (/a, a:, ə, ə:/) in infants from 4 to 12 months as seen in Table 2. The results indicated that front vowel /e/ was high in occurrence compared to all the other vowels. However, the front vowel /i/ did not have a significant production in all the age groups. This may be



related to the late mastery of the front vowel /i/ and its low frequency of occurrence in the adult language in Malayalam (Sreedevi & Irfana, 2013).

Non parametric Kruskal Wallis test for overall group comparison of front, back and centre vowels, indicated significance only for centre vowels at  $p < 0.05$ . Mann Whitney test for pair wise comparison was significant for groups 1 and 4 for centre vowels at  $p < 0.05$ . No significance was present for front, back and centre vowels between the other age groups. Friedman test for within group for front, back and centre vowels was significant for all groups at  $p < 0.05$ . Wilcoxon Signed Rank test was significant for front-centre vowels for all four groups at 0.05 level of significance. Back vowels were not considered due to their negligible occurrence across age groups.

Hence the findings suggest that the front vowels (/e/) were majorly produced by all infants in all age groups followed by the central vowels and the back vowels. This finding is consistent to the data on English and Brazilian Portuguese in which infants at 10 months and above show predominance of front vowels followed by central and back vowels (Teixeira & Davis., 2002).

The results are also equivalent to the study of coronal vowels being produced at the earliest (Wong 2001) which supports Bhur's study (1980), that claimed the musculature of lips, jaw and frontal portion of the tongue develop at a faster rate compared to the lowering of the larynx and rear portion of the tongue. Back vowels were the least produced in this study as the rear portion of the oral cavity develops at a slower rate and the coronal and dorsal contrasts develop at a later stage.

With reference to the diphthongs, they were classified in terms of Opening diphthongs (OD), Closing diphthong (CD), Height – Harmonic diphthongs (HHD) and central diphthongs (CNTD). Opening diphthongs have the second vowel more open than the first i.e. tongue ends lower in the mouth. Closing diphthongs have the second vowel more closed than the first i.e. the tongue ends higher in the mouth. Central diphthongs have both the vowel elements that are more centre in the mouth. The Height Harmonic Diphthongs have both the elements which are either the open vowels or the close vowels. [http://slbltsu.hull.ac.uk/awe/index.php?title=Different\\_classifications\\_of\\_diphthong](http://slbltsu.hull.ac.uk/awe/index.php?title=Different_classifications_of_diphthong)

Non parametric Kruskal Wallis test for overall group comparison for OD, CD, HHD and CNTD showed significance for OD at  $p < 0.05$ . No significance was present for CD, HHD and CNTD. Mann Whitney test for pair wise comparison was significant for groups 1 and 2 for OD at  $p < 0.05$ . No significance was present for CD, HHD and CNTD between any of the groups. Friedman test for within group for OD, CD, HHD and CNTD was significant for groups 2, 3 and 4 at  $p < 0.05$ . Wilcoxon Signed Rank test was significant for Group 2 at  $p < 0.05$  for OD-HHD, CD-HHD and CNTD-HHD. Group 3 was significant at  $p < 0.05$  for CD-HHD and HHD-CNTD. Group 4 was significant was not significant.

There is a general consensus in literature that diphthongs are dynamic entities, even more than monophthongs (Harrington & Cassidy, 1994). A total of 106 diphthongs were obtained in the phonetic repertoire of the infants studied. The overall diphthongs decreased as age increased which provides as insight on the complexity of utterances during the babbling

period. The findings in the present study reveal the interaction of the constituent vowels based on tongue height, advancement and lip rounding dimensions which are attributed to Frame dominance (MacNeilage et al., 1997). It is observed that the Opening diphthongs, Closing diphthongs, Height Harmonic diphthongs, Central diphthongs are present in the early pre-linguistic period which marks Lings (1989) statement that diphthongs frequently occur in children's early repertoire. Infants easily attain the sequence of production of OD, CD, HHD and CTND by mandibular movement as assumed in the Frame dominance account (MacNeilage et al., 1997) which involve tongue height, for the constituent vowels of the diphthong. HHD demands more of the co-ordination of lip rounding and tongue movement. As age increases it is observed that the OD, CD and CNTD decrease and the vowels constitute a more prominent HHD. The decrease in the other types of diphthongs suggest the emergence of various syllabic patterns towards the advanced stages of babbling.

**Note: Utilization of Language Proficiency Questionnaire (LEAP-Q)**

*The sample recordings of the infants were carried out in native speaking Malayalam families. The Language Proficiency Questionnaire-LEAPQ (RamyaMaitreyee & Goswami, 2009) was utilized to assess the native language proficiency of the parent/s in Malayalam. According to the rating, the language proficiency of the parent/s was "perfect" native speakers of Malayalam. Hence the trend of developing speech sounds could be attributed to the influence of the ambient language since the parents of the participants communicated in their native language with them. Hence, it could be suggested that the infants were reared in a monolingual speaking environment and the exposure to the ambient language could be attributed to the nature and emergence of such vocalizations.*

**4. Conclusions**

Typically developing infants produce a rich variety of vocalizations during the prelinguistic developmental stages. The infant experiences a continuous change in the structures of the vocal tract, which modifies vocalizations and supports future development (Kent & Miolo, 1995). The present study provides an insight on the nature of vowels and diphthongs that are seldom explored in early babbling period. The appearance of a more common phoneme indicated its emergence towards the target language and the vocal tract articulatory dimensions that suggest shaping speech acquisition. The study also reveals the presence of a boost of singleton vowels and diphthongs in the lower age range of the prelinguistic period and as age increased there was a reduction in singleton phonemes indicative of an emergence in the complexity of syllabic patterns.

*4.1. Implications of the study*

The study would help to appreciate the nature of phonological development during the pre-linguistic period in Malayalam. There is limited number of studies exploring the emergence of vowels and diphthongs in early infancy in Indian languages. This is one of the first attempts to explore the nature of vowels and diphthongs in infants. Findings obtained will be greatly



applicable in clinical practices of communication disorders. In the recent years, speech language pathologists are required to evaluate the vocal acquisition of increasing number of children even less than one year of age. A major difficulty in carrying out these assessments is the lack of norms for typically developing children at this early stage. The challenges of providing services to a linguistic and cultural diverse population like India is compounded by the increased awareness and education of the parents and their increased sensitivity to the child's early speech development. The findings of pre-linguistic vocalizations also support the fact that babbling is a predictor of language complexity as well as an indicator of language delay. Studies on infant vocalizations report that early laryngeal vocalizations such as vegetative and reflexive sounds are differentiated from "speech like" vocalizations after the first trimester in life. Findings also suggest that infants gain increasing control over speech mechanism resulting in increased vocal play from 3-4 months onwards which continues beyond the first year of life. Hence, the present study serves as a benchmark for the nature of vocalizations of infants from 4 – 12 months of age which is a significant phase of the pre-linguistic period and contributes to later language learning.

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