

## Original Article

### Contrastive analysis of vowel production in Hindi and Malayalam learning infants

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#### **Abstract**

*Infants begin to vocalize as early as they are born. Speech like vocalizations such as gurgles, shrieks are also accompanied. Parent and caregiver interaction during this period are vital for early pre linguistic vocalizations. Early vocalizations are usually vowel like forms. The researcher's previous studies focused on vowel production in Hindi and Malayalam learning children. However, in this locus, it is exciting to compare and contrast the early vowel productions in both these language learning infants. The present paper focusses on analyzing the contrastive features of vowel production in 4 to 12 month -old infants in Hindi and Malayalam language. The participants consisted of 80 typically developing native speaking Hindi and Malayalam infants. The audio recordings were carried out and transcribed. The transcribed data was analyzed in IPA to acquire the frequency of the vowel productions.*

**Keywords:** Pre-linguistic, Early vowel productions, Malayalam, Hindi

## Introduction

Considering the fact that there were substantial differences among the early phonetic studies across languages, studies emerged on cross linguistic comparisons in this area. Many researchers were in favor of Slobin's (1986) opinion that cross linguistic study is necessary to explore and verify the basis of speech development and the strategies that operate to construct a concrete language. According to Maddieson (1984) on data –driven study of phonological complexity, segment inventories of consonants and vowels in 317 languages were obtained. In spite of the differences across these languages studied, the most typical vowel inventory was [i, e, a, o and u].

Cross linguistic studies on babbling behavior have shown dissimilarities for early vowel patterns. Oller and Eilers (1982) conducted a cross cultural study of babbling on infants reared in English –Spanish speaking environments in Miami. Vowels belonging to the sound inventory of Spanish were more frequent in the Spanish speaking group while the vowels in English were more frequent in the English speaking group. They found that vowel [æ] in particular had a frequency of 22.4% in English but only 13.5% in Spanish children. This study indicated that phonotactic patterns are necessary for cross linguistic comparisons.

Early phonetic behavior on vowel patterns were also studied using spectral analysis. De Boysson-Bardies et al. (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, 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.

An additional spectral analysis study by De Boysson –Bardies and her colleagues (1989) on vowels in preverbal infants of four different languages were carried out. The four languages were English, French, Swedish, and Japanese. They found that the infants matched vowel patterns of their own ambient language. These reports indicate that there are definite influences of the ambient language on the babbling behavior.

An acoustic study was carried out by Mattock, Rvachew, Alhaidary and Polka (2008) on the emergence of corner vowels [i, a, and u] in infants and the influence of ambient language on babbling. Formants F1-F2 were obtained from 51 Canadian infants (English learning infants [n=24] and French learning infants [n=27]) from 8 to 18 months. The listener judgments confirmed the peripheral expansion of infant vowel space towards diffuse and grave corners with age. A higher proportion of [u] in the English sample was observed throughout the age range suggesting the influence of ambient language at a young age.

A recent spectral study by Benner and Grenon (2011) examines the relationship between vowel quality and laryngeal constriction on Bai and English infants. Five infants (3 females, 2 males) were taken from English speaking families and 2 males and 3 females were taken from Bai (Tibeto-Burman) speaking families. They found Bai infants produced sounds with greater degree of constriction than English infants throughout the phonetic development signifying the ambient language effect.

In the Indian context, a cross sectional study carried out by Shyamala and Basanthi (2003) reported that vowels 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.

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 (2013) was conducted in Kannada. They observed seven vowels [I, e, æ, a, u, o, ɔ] 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.

In the Indian scenario, there are relatively few studies on the emergence of syllable shapes. 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. Vowels were one among the various syllable shapes found in the samples analysed. Vowels gradually increased in frequency of occurrence between 0-18 months.

## **Method**

The researchers in the present study have included older research findings as there is a dearth of recent Indian studies in this particular area of research on vowels and their types in children below 12 months. The older references have findings on children in the higher age ranges and have also included them in this study as it's a preliminary study.

### ***Participants***

The participants included 40 native Malayalam and 40 native Hindi learning infants. 10 participants were included in Group I (4 – 6 months), Group II (6 – 8 months), Group III (8 – 10 months) and in Group IV (10 -12 months) in both the language groups. A written consent was obtained by the parents for the participation of the infants.

The participants were screened on the Developmental Screening Checklist (Swapna, Jayaram, Prema & Geetha, 2010). It was ensured that both the parents were educated upto a minimum of 10<sup>th</sup> grade and were from middle socio-economic status. 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 Maitreyee and Goswami (2009). A score of “5” would indicate the parent/caregiver to be a “perfect” native speaker.

### ***Data collection***

Audio recordings were carried out in a quiet room in the homes of the participants. Parents or caregivers were requested to interact with the infants naturally. Each infant was recorded using a hand held MZ-55 digital voice recorder with an integrated microphone placed at a reasonable distance so as not to cause any distraction. Samples obtained were then transferred to a computer that had a VLC media player software for analysis. No additional play materials were used in the environment so that infants’ utterances would reflect their typical productions in familiar surroundings.

The researcher then classified the utterances into vowels and their types. Two Speech Language Pathologists and the 1<sup>st</sup> author served as judges for determining inter-subject reliability for the language. 10% of each of the subject sample was transcribed by each of the three judges. The researcher transcribed 10% of each of the subject sample for intra judge

reliability. Cronbach's alpha co-efficient was consistent and found to be 0.70 and 0.75 for inter and intra transcriber reliability respectively.

### ***Data analysis***

The study consists of a small number of participants with fewer production of vowels, hence non parametric tests were carried out. Descriptive statistics for median percentage and Inter-quartile range was determined. A 60% criteria was utilized in the study i.e the frequency and type of the early words produced by 6 out of the 10 participants.

### **Results and Discussion**

#### **I. To compare the pre-linguistic vocalizations and phonetic repertoire across age within the languages Hindi and Malayalam.**

##### ***a. Comparison of vowels across age in Hindi participants***

A total corpus of 4713 phonetic behaviors in Hindi produced by 40 participants consisted of 1072 singleton vowels. Among these, 269 vowels were produced by Group I (4-6 months), 324 vowels by Group II (6-8 months), 227 vowels by Group III (8-10 months) and 252 vowels by the oldest group of participants of Group IV (10-12 months). It was seen that there were relatively less number of singleton vowels in the older two groups from 8 to 12 months. The vowels are presented in front, central and back dimensions. Singleton vowels such as /i, i:, u, u:,ɔ and ɔ:/ were produced by few participants in all the 4 age groups, hence were not included for statistical analysis. However, relatively more productions of these infrequent vowels were seen in the older age groups.

The vowels are described with reference to their tongue height and tongue advancement dimensions. Table 1, describes the median (*Mdn*) percent and inter-quartile range (*IQR*) for the combined scores of boys and girls for front, central and back vowels in Hindi.

Table 1  
Descriptive statistics (Median percent and inter quartile range) of vowels in Hindi

Vowels	Hindi							
	Age range (in months)							
	4:0 to ≤ 6:0 Group I		>6;0 to ≤ 8:0 Group II		>8;0 to ≤ 10:0 Group III		>10;0 to ≤ 12:0 Group IV	
N= 10	Md	IQR	Md	IQR	Md	IQR	Mdn	IQR
	n		n		n			
<b>FRONT VOWEL S</b>	30.7	24.63 - 55.18	30.3	14.9 - 51.14	45.0	36.46- 61.47	53.21	35.91 - 75.83
<b>CENTRAL VOWEL S</b>	70.0	47.55- 75.73	69.6	48.86 - 85.03	60.0	44.39- 64.58	53.57	26.38 - 66.64
<b>BACK VOWEL S</b>	0.00	0.00-0.51	0.00	0.00-0.42	1.61	0.00-4.76	0.00	0.00-6.79

Front and central vowels emerged (considering 60% criteria for the phonetic behavior as emerging) early as 4 months and continued to be present till 12 months. From Table 1, it is seen that there is a linear progression of front vowels and reduction in central vowels with advance in age. Back vowels remained to be the least occurring in all the age groups. The median percent scores are higher for central vowels compared to front vowels in all the 4 age groups in Hindi. This is because among the vocalizations of the eight frequent vowels, the mid central vowel [ə] and its longer counterpart [ə:] exhibited relatively high production across the four age groups. Central vowel [a] also had a linear progression in its production with advance in age, a finding consistent with Oller and Eilers (1982) in English-learning infants and Lee et.al (2010) in Korean-learning infants, who produced an extremely high frequency of central vowels with advance in age. Its longer counterpart [a:] was vocalized by participants in the older group of 8 to 10 months; this may be because infants are physiologically predisposed to laryngeal constriction especially for a low vowel which is retracted and produced more frequently during the babbling period (Benner & Grenon, 2011).

Findings of pre-linguistic production of central and front vowels is in support of reviewed studies in babbling in Kannada (Sreedevi & Jyothi, 2014), English (Kent & Bauer, 1985; Lieberman, 1980, McNeilage & Davis, 1990), French (Boysson-Bardies et al., 1989) and Spanish (Oller & Eilers, 1982) language environments. All these studies found a tendency for front and central vowels to be preferred across languages. This pattern has been designated as a preference for ‘lower left quadrant’ vowels (Bickly, 1983; Bhur, 1980 Kent & Bauer, 1985; Lieberman, 1980; Stoel-Gammon & Harrington, 1990). The lower left quadrant preference was confirmed in the analysis of a large database of 15,719 vowels produced by six English-learning infants in babbling (Davis & MacNeilage, 1995).

Fig. 1 depicts the developmental trend for central, front and back vowels in Hindi participants. It could be seen that among the types of vowel dimensions, central vowels were higher than front vowels and emerged as early as 4 months and reduced in production as age advanced and vice-versa for the front vowels. Hence, among the central vowels [ ə, ə, a, a:], it was observed that there was a high occurrence of vowel [ə] which can also be related with the acoustic study of vowels by Boysson-Bardies et al., (1989) in the babbling utterances of Arabic, Chinese, English and French infants at age 10 months, reflecting relatively more central vowels for French and Arabic.

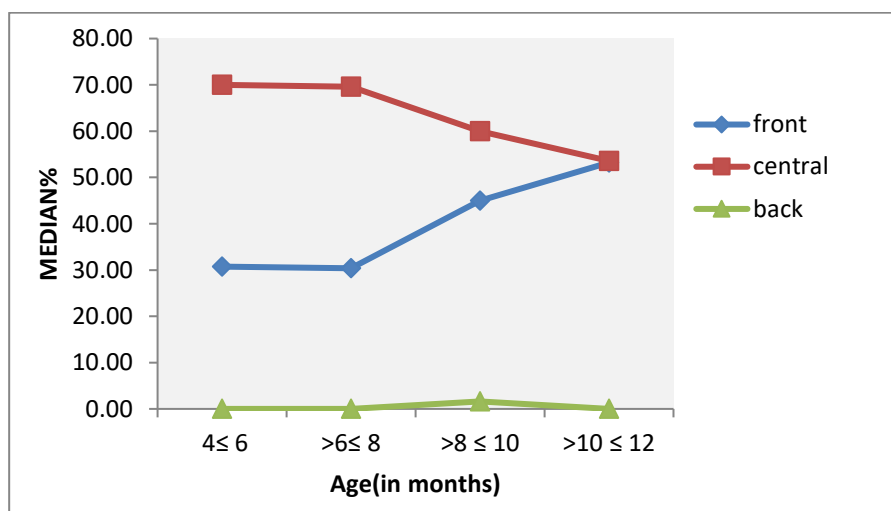


Figure 1 Shows central, front and back vowels in Hindi



For a qualitative analysis of the vowels produced by Hindi participants, an attempt was made to superimpose the same on the adult vowel quadrilateral as depicted in Fig. 2

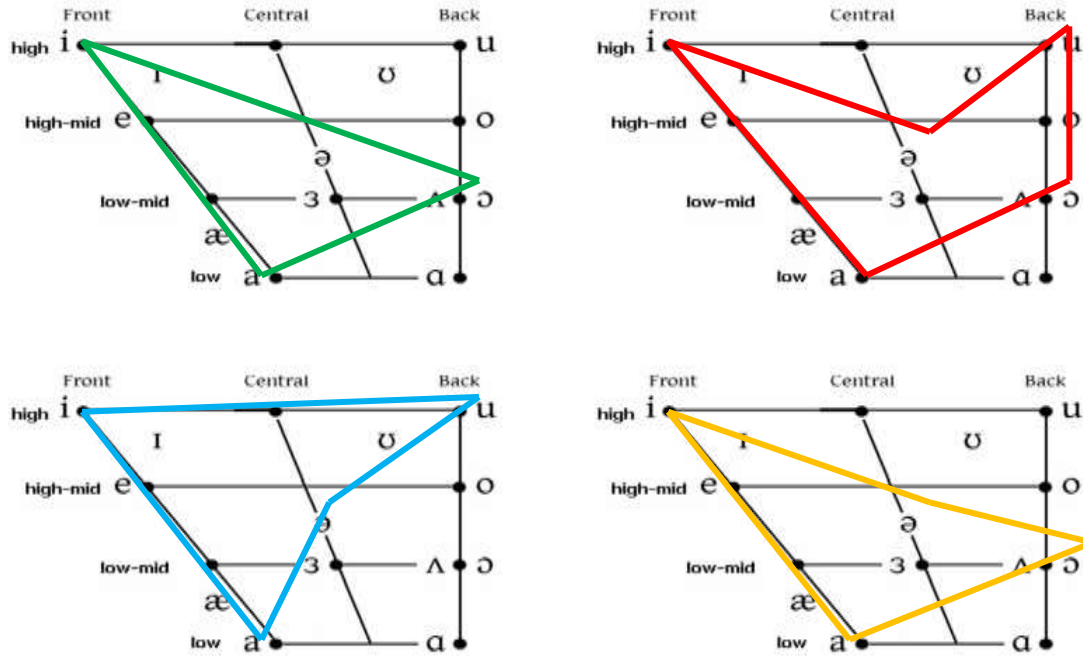


Figure 2 Comparison of vowel repertoire of Hindi participants with a vowel quadrilateral

Note: █ 4 to  $\geq 6$  months, █  $\leq 6$  to  $\geq 8$  months, █  $\leq 8$  to  $\geq 10$  months and █  $\leq 10$  to  $\geq 12$  months

From Fig. 2, it can be observed that, the mid central vowels /ə/, low front vowels /æ/ and mid front vowels /e/ were frequently produced and back vowels /u/, /ɔ/ were the least occurring vowels in all the age groups. This may be because infants show more involuntary mouth openings for this vowel based on visual salience of imitation (Khul & Meltzoff, 1982, 1996) as well as open jaw movements along with co-ordination of the laryngeal air stream (Bowman, 2009). It could be observed from Fig 2, that participants in Group II (6 to 8 months) show vowel plots that relatively resemble the adult vowel quadrilateral, indicating articulatory development for vowel productions. As observed, the other age groups show vowel productions mainly confined to low and mid in terms of tongue height, and front and central in terms of tongue advancement dimensions. This is in support of the babbling data on five

languages (English, Arabic, French, Romanian and Spanish analyzed by Kern and Davis (2014) that depicted mid- front, low-front and mid-central vowels to be exceeding back and high vowels.

Other more complex vowels such as the high front vowels [i] and [i:], high back vowels [u] and [u:] and mid back vowels [ɔ] and [ɔ:] were produced by very few participants in all four age groups. These findings are similar to studies as reported by Lieberman's (1980) spectrographic analysis for children aged about 3 to 14 months in English revealed back-rounded [o] and [u] to be least frequent in production. On crosslinguistic comparisons, Rvachew et al. (2008) reported that their French-learning infants produced a lesser frequency of high front vowels and high back vowels relative to English learning infants. In Kannada learning infants of 4 to 12 months, Sreedevi and Jyothi (2013) reported that /i/, /i:/, /u/, /u:/ and /o:/ were less frequent in production and occurring in less than 50 % of the subjects studied.

Among the relatively infrequent vowels, the occurrence of front vowels [i, i:] were higher compared to back vowels [u, u:] in all the age groups. The present finding draws parallels with studies of Anjana and Sreedevi (2008) in Kannada; Liberman (1980) and Boysson-Bardies et al., (1989) in English, that front vowels were more frequent from 8 months onwards until 12 months compared to back vowels. However, the less frequent back vowels [ɔ] and [ɔ:] also appeared at 4 to 6 months and continued until 10 to 12 months. This similarity across languages can be inferred as the universal nature in babbling.

To determine the overall significant difference in the occurrence of vowels in Hindi, Kruskal -Wallis test was carried out across the four age groups. The test revealed no significant effect of age for front vowels [ $\chi^2(3) = 4.810, p = .186$ ], central vowels [ $\chi^2(3) = 4.225, p = .235$ ] and back vowels [ $\chi^2(3) = 4.748, p = .191$ ]. Thus, the hypothesis, that there is

*no significant difference in the phonetic behavior of singleton vowels across age in Hindi is accepted.*

***b. Comparison of vowels across age in Malayalam participants***

A total corpus of 4788 phonetic behaviors produced by 40 participants comprised of 1378 singleton vowels in the babbling samples of infants aged 4 to 12 months of age. Out of 1378 vowels, Group I (4 to 6 months), Group II (6 to 8 months), Group III (8 to 10 months) and Group IV (10 to 12 months) produced 405, 360, 314 and 299 vowels respectively. Median (*Mdn*) percent scores and inter-quartile ranges (*IQR*) for the combined scores of boys and girls for vowels in Malayalam are presented in Table 2. Similar to the Hindi learning infants, the Malayalam group also displayed the same eight frequent types of vowels (mid central vowels [ə], [ə:], mid front vowels [e], [e:] low front vowels [æ], [æ:], and low back vowels [a], [a:]). High front vowels [i], [I], high back vowels [U], [u], and mid back vowels [ɔ], [ɔ:] occurred sparingly in all four age groups and hence were not included for statistical analysis.

Table 2  
*Descriptive statistics (Median percent and inter quartile range) of vowels in Malayalam*

Vowels N = 10	Malayalam							
	Age range (in months)							
	4:0 to ≤ 6:0 Group I		>6;0 to ≤ 8:0 Group II		>8;0 to ≤ 10:0 Group III		>10;0 to ≤ 12:0 Group IV	
	Mdn	IQR	Mdn	IQR	Mdn	IQR	Mdn	IQR
<b>FRONT VOWEL S</b>	72.86	36.91 - 84.18	87.8	48.71 - 92.99	74.8	41.67-87.55	77.1	58.57-88.34
<b>CENTR AL VOWEL S</b>	27.14	15.82 - 63.09	12.1	7.01 - 51.29	26.3	15.94 - 61.11	22.9	11.66 - 41.43
<b>BACK VOWEL S</b>	0.00	0.00- 0.81	0.00	0.00-0.00	1.09	0.00-4.44	0.00	0.00 - 4.17

The vowels produced are described with reference to dimensions of tongue height and tongue advancement. Based on the 60% criteria, it was observed that front vowels emerged from the youngest age group and continued to be present in the 3 older age groups. However, central vowels also showed emergence as early as 4 months but reduced in production with advance in age. The back vowels were produced by less than 60% of the participants in all the 4 age groups. As observed from Table 2, the front vowels showed a higher production than central vowels in all the four age groups. This is similar to the findings by Sreedevi and Jyothi (2013) who reported vowel [e] to be predominant in its frequency of occurrence in a longitudinal study of babbling in Kannada learning infants. The predominance of this vowel can be related to the high frequency of occurrence of vowel [e] in adult Malayalam speakers (Sreedevi & Irfana, 2013). Longer counterpart [e:] was relatively high in the older age groups compared to the younger age groups. The predominance of this vowel can be related to other language studies by Lee et.al., (2010) in Korean and French infant learning groups. Both showed relatively high frequencies of vowels in the mid-front dimensions of the vowel space. Lieberman (1980) reported that vowel [e] was heard most frequently of all the vowels transcribed in the phonetic repertoire of English infants of 3 to 14 months. This can also be explained by the investigations of Bardies and her colleagues (1989), who interpreted that infants begin to position their lips and tongue specific to the sound production of their language environment with increase in age.

Similar to [e], front vowel [æ] and its long counterpart [æ:] were high in occurrence in the younger two age groups and subsequently reduced in the older age groups. This is in consonance with the reports of Anjana and Sreedevi (2008) that vowel [æ] gradually diminished with increase in age. Reports of Shyamala and Basanthi (2003) also revealed that vowel [æ] frequently occurred in the samples of younger subjects of 6 months compared to older infants of 12 months in Hindi and Kannada. This finding is also similar to the cross

cultural study by Oller and Eilers (1982) on babbling in infants from 6 to 12 months reared in English –Spanish speaking environment and vowel [æ] in particular was predominant in the younger English group than in Spanish children. Hence the strong similarities in vowel vocalization preferences across the different languages suggest a universal basis of babbling in the early linguistic period. These observations suggest that they are probably because of the manipulation for jaw development at early infancy (Lindblom & Sundberg, 1969, Davis & Mc Neilage, 1990).

Central vowels [ə] and [ə:] were high in occurrence in the youngest and oldest age groups respectively. Similar findings have been observed in the Hindi learning infants also, where a high occurrence of vowel [ə] was present in the younger age groups with a reduction in the older age groups. This could suggest that these infants hear and visualize open mouth sounds and respond to early vocal imitation (Khul & MeltZoff, 1982, 1996). It was observed that the production of low central vowel [a] was high in the mid age groups and long low central vowel [a:] were low in production in the 6 to 8 months and the 10 to 12 months groups. The gradual reduction of singleton [a] in the oldest age group also may be because it occurs in combination with other well developed utterances (Green, Moore, & Reiley, 2002).

Fig 4 depicts the developmental trend for central and front vowels in Malayalam infants. Overall, it could be seen that front vowels were higher than central vowels and emerged as early as 4 months. From Figure 4, it can be seen that front vowels were the highest in production at 6 to 8 months and relatively reduced in the older age groups and vice versa for the central vowels. Back vowels were the least in occurrence.

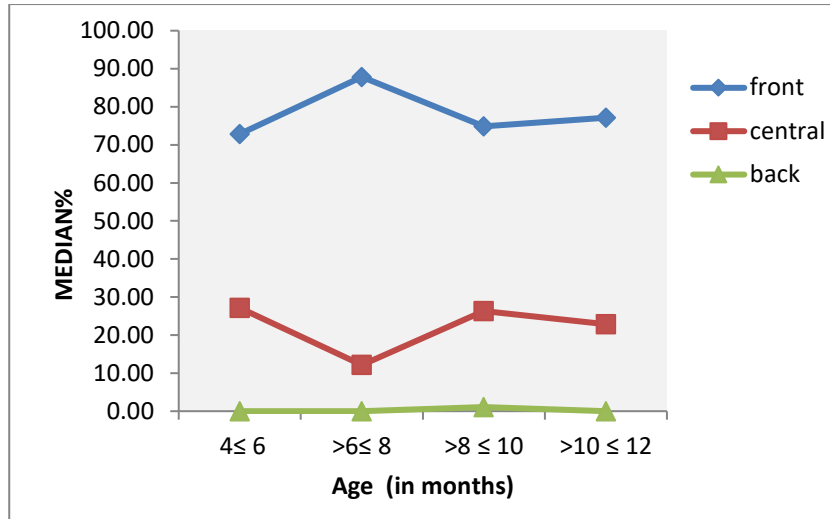


Figure 4. Shows central, front and back vowels in Malayalam

Fig. 5. shows a representation of the vowels produced by infants of all Malayalam groups from the most to the least occurring singletons. The vowels that emerged during each of the 4 age groups are superimposed on the adult vowel quadrilateral as shown in Fig.5.

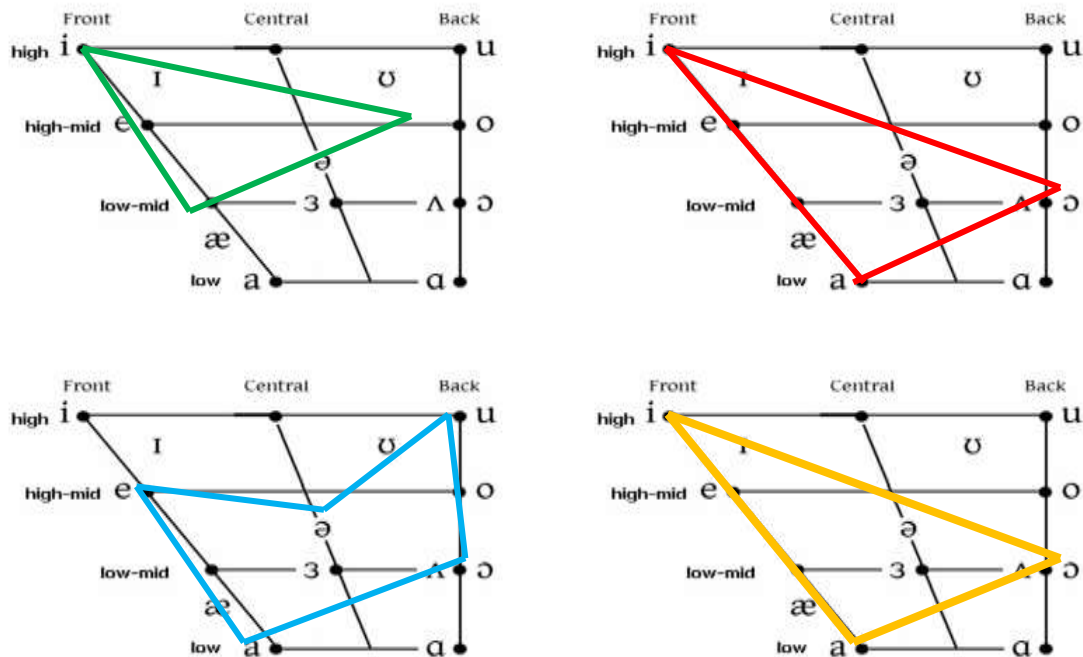


Figure 5 Comparison of vowel repertoire of Malayalam participants with vowel quadrilateral

Note: ■ 4 to  $\geq 6$  months, ■  $\leq 6$  to  $\geq 8$  months, ■  $\geq 8$  to  $\geq 10$  months and ■  $\geq 10$  to  $\geq 12$  months

It can be observed from Fig. 5, that vowel plots mainly confined to front and central vowels and back vowels were the least in production. As age advanced participants in Group III (8 to 10 months) showed slight resemblance of the adult quadrilateral, indicating exploration of the oral cavity for back sounds. In the present study, high front vowels [i] [i:], high back vowels [u], [u:] and mid back vowels [ɔ] [ɔ:] were the least occurring vowel types that made their appearances from 4 months to 12 months in the Malayalam group. Anjana and Sreedevi (2008); Shyamala and Basanthi (2003) also found the occurrence of these vowels to be relatively low in Kannada learning infants of 6 to 12 months. In a crosslinguistic study, Rvachew, Alhaidary, Mattock and Polka (2008) reported that French-learning infants produced less frequent high-back vowels than English-learning infants through the age range of 0;8 to 1;6 years, thus, implying the productions of these less frequent vowels as a universal nature in the babbling period.

To examine the significant difference in the occurrence of vowels across all the four age groups in Malayalam, non parametric Kruskal-Wallis test was carried out. The test revealed no significant effect of age for front vowels [ $\chi^2(3) = 2.090, p = .554$ ], central vowels [ $\chi^2(3) = 2.860, p = .414$ ] and back vowels [ $\chi^2(3) = 3.204, p = .361$ ]. *Thus, the hypothesis that there is no significant difference in the phonetic behavior of singleton vowels across age in Malayalam is accepted.*

## **II. To compare the early production of vowels in infants between the two languages studied (Hindi and Malayalam).**

### **1. Comparison of vowels between the languages Hindi and Malayalam**

It was observed in the previous section of the second objective, that although both Hindi and Malayalam participants shared the same vowel segments i.e the most occurring central

and front vowels [ə, ə:, a, a:, æ, æ:, e, e:] and the least occurring back vowels [i, u and ɔ] including their longer counter parts, which made up to 14 vowels in all, they differed in frequency and emergence for the type of vowel dimensions. Front, central and back vowels were different in their frequency of occurrence in all the four age groups across the languages. This is similar to the reports of Levitt and Utman (1992) in English and French learning infants, as for vowels, both group of infants produced the same vowels (11 in all), though with different frequencies of occurrence. Roug, Landberg and Lundberg (1988) studied vowels in English learning infants of 1 to 20 months of age and found that the vast majority of the vowels were front and central vowels /a, æ, e, u and i/ and their longer counterparts. Because languages share many of the same segments, it is not clear whether the infants' productions are similar because of the similar sounds to which they were exposed, or because, as Locke (1983) would argue, certain sound patterns are particularly common in the languages of the world because they reflect the child's and the adult's natural phonetic proclivities.

On comparing the data, among the most occurring vowels across Hindi and Malayalam it can be inferred that, in Group I, Group II, Group III and Group IV, central vowels ( [ə] ) showed the highest percent median score in the Hindi group. For the Malayalam learning group, the front vowels ( [e and e:] ) exhibited the highest percent median score.

Irwin (1948) reported mid central vowel [ə] and mid front vowel [e] to account for 70% of the vowel production during the first years in 95 English speaking infants studied. Mid-central and mid front vowels [ə, e] often used in babbling before 10 months were also reported in Mandarin speaking infants ( Jeng, 1979; Yue- Hashimoto,1980). On similar lines, in a study by De-Boysson et. al (1999), 10 month old infant vowel productions were drawn from four linguistic communities of Arabic, Chinese, English and French, found that categories of mid front vowels accounted for the vast majority of vowels, which is similar to the findings of the present study again, indicating a universal phenomenon for vowel emergence in babbling.



Considering the 60% criteria, the Hindi group depicted the emergence of front and central vowels by 4 to 6 months and continued to be present till 10 to 12 months. In the Malayalam group, it was observed that front vowels emerged from the youngest age group and continued to be present with advance in age. However, central vowels also emerged by 4 to 6 months. The back vowels were produced minimally by fewer participants in all the 4 age groups in both languages.

The occurrence of vowels showed a wide variability which 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 wide individual variability in the use of vowels. In the present study, overall, the vowel repertoire found in the babbling samples of the infants from the age range of 4 to 12 months were [æ, ə, a, e, i, u, o]. The findings are also in par with the studies by Shyamala and Basanti (2003) and Anjana and Sreedevi (2008) in Kannada which revealed that the cardinal vowels /i/, /e/, /a/ /æ/, /ə/, /u/ and /o/ also made their appearance by 6-12 months of age in infants. The findings of the present study are similar to these reports indicating the universal nature in vowel production. Vowel production has been examined largely within Indo-European languages such as English, French and Spanish. It is not certain whether the lower left quadrant vowel space is a universal characteristic in infant vowel production patterning. Moreover, studies on infant patterns have not been compared to native language sound patterns consistently. No comparison with native language frequencies is available in the large infant databases as reported by Kern and Davis (2007) for five Indo-European languages or in the English database analyzed by Davis and MacNeilage (1995). It is difficult to argue conclusively that infant speech patterns are based only on production limitations without comparison with adult input frequencies.

In the current study, the high front vowels [i], [i:], high back vowels [u], [u:], and low mid vowels [ɔ], [ɔ:] occurred sporadically in both Hindi and Malayalam language learning groups. However, made their appearance as age increased. This could be related to the acoustic study by Rvachew et al., (2008) on Canadian English and Canadian French learning infants who showed increased occurrence of corner vowels [i] and [u] at 12 months onwards, reflecting maturational changes in speech motor control along with language exposure (Englund & Behne, 2006; Khul et al., 1997). Overall, 43% of the entire phonetic repertoire constituted the singleton vowels in Hindi group whereas 57% in the Malayalam learning group. The findings elucidated indicate a lot of similarities and differences across the two languages studied. Statistical analysis using Mann-Whitney U test was carried out to exemplify the significant difference of vowels for each age group across the two languages as shown in Table 3.

Table 3  
*Comparison of vowels between Hindi and Malayalam participants*

Vowels	4:0 to ≤ 6:0 months		>6;0 to ≤ 8:0 Months		8;0 to ≤ 10:0 months		>10;0 to ≤ 12:0 months	
	Z	p	Z	p	Z	p	Z	p
<b>Front</b>	1.814	.070	<b>2.609*</b>	.009	1.437	.151	1.436	.151
<b>Central</b>	<b>2.368*</b>	.018	<b>2.609*</b>	.009	1.679	.093	1.960	.050
<b>Back</b>	0.108	.914	0.486	.627	0.121	.904	0.559	.576

\*Significant at  $p < .05$

In Group I (4 to 6 months), central vowels showed significant difference ( $|Z| = 2.368$ ;  $p = .018$ ) between Hindi ( $Mdn = 70.00$ ) and Malayalam ( $Mdn = 27.14$ ) with a higher occurrence in the Hindi group. In Group II (6 to 8 months) also, central vowels ( $|Z| = 2.609$ ;  $p = .009$ ) was significantly higher in the Hindi group ( $Mdn = 69.62$ ) in comparison with the Malayalam group ( $Mdn = 12.14$ ). However front vowels ( $|Z| = 2.609$ ;  $p = .009$ ) showed significantly

higher occurrence in the Malayalam group ( $Mdn= 87.86$ ) compared with the Hindi group ( $Mdn =30.38$ ). For Group III (8 to 10 months) and Group IV (10 to 12 months) there was no significant difference for any of the vowels in both languages. Therefore, it was observed that though the types of vowels are same in both the languages, the frequency of their occurrence varied across languages. *Thus, the hypothesis that there is no significant difference of vowels between the languages Hindi and Malayalam is rejected.*

To summarize, the infants in the Hindi and Malayalam groups shared the same vowel patterns though they were different in their frequency of occurrence in all the four age groups. The results also revealed that central vowels dominated across the four age groups in Hindi, whereas front vowels were predominant in Malayalam, both emerging as early as 4 months. Both the groups also exhibited the least occurring vowels as [i, i:, ə, ə:,u and u:]. As these vowels were less present in other studies as well, these findings of the present study leaned towards the universal nature of babbling. It was also observed that as age increased, the production of singleton vowels decreased indicating emergence of linguistically advanced utterances or word forms.

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