# EFFECT OF NEIGHBORHOOD DENSITY ON SPEECH SOUND ACQUISITION IN TYPICALLY DEVELOPING MALAYALAM SPEAKING CHILDREN AGED 1-3 YEARS

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**Abstract**

*Speech sound production is an important aspect of the children's language. Children produce words by combining speech sounds with contrasting distinctive features. Acquisition of speech sound combinations in typically developing children is limited in the field of child phonology. The present study aimed to analyze and compare the acquisition pattern of selected target sounds and their neighboring speech sounds in Malayalam speaking typically developing children between 1 to 3 years of age with respect to: (a) Place of articulation (b) Manner of articulation. Twenty typically developing children participated in the study. They were categorized into four age groups with five children in each age group. The spontaneous or elicited speech samples of the children were audio video-recorded during unstructured free play interaction. The speech sample was phonetically transcribed in IPA by two of the investigators. All the speech sounds of Malayalam language that emerged in participants were chosen as target sounds and speech sounds occurring in their neighborhood were transcribed and analyzed for frequency of occurrence and pattern of distribution (density). Various neighborhood density and patterns were evident in the age groups studied. The neighborhood pattern in different age groups paralleled the speech sound acquisition. The results are discussed in the backdrop of acquisition of speech motor control in the spatial and temporal dimensions in the emerging articulatory control. The trend observed suggests that transcription based procedure for identifying the emerging speech sound profile of a child in terms of its neighborhood could be used as a simple, yet potential clinical tool in commenting on the maturing articulatory mechanism.*

***Key words**: Neighborhood density, Spatial coordinate, Temporal coordinate*

Children speaking any language in the world speak their own language in the beginning (Francescato, 1968). Acquisition of speech sounds of a language acts as building blocks for words and in turn for language acquisition. Studies have shown that children produce words by combining speech sounds with contrasting distinctive features. According to Jackobson & Halle (1956), the development of sound system in children is not only a gradual approximation of the adult phonemes one by one but includes acquisition of successive contrasts between distinctive features of maximum difference and generality. The combination of various sounds and the way in which these sound combinations are acquired in children helps in understanding the phonology of child language.

The phonological development in young children is significant in the ages of 1; 6 to 4; 0 years. The ability improves gradually with the acquisition of adult like sounds of complex phonological structures (Ingram, 1976c). During the process of acquisition of speech sounds, when a child replaces one sound with another, there is generally a system in the sound substitutions of children. These sound laws are referred to as phonological processes (Stampe, 1969). Phonological development according to Stampe (1969) is the gradual loss of these simplifying processes until the children's words finally match their adult models. The organization of sounds in the stage of development is not only dependent on the phonological processes but also on children's active organization of the representation of words.

Netsell (1981) proposed stages of motor control for speech that takes place during the normal development of children. First, the child develops motor control for spatial aspects, then spatial- temporal coordination and finally adult-like timing of motor control, including the anticipatory movement gestures of coarticulation. Netsell (1981) suggested that the most sensitive period for acquisition of speech motor control is from 3 months to 12 months suggesting that fundamental movement routines for speech in children are established early.

Children often show phonetic variability in the pronunciation of words. According to Bynon (1968), in baby talk, a simple consonant-vowel (CV) syllable structure predominates. When this is combined with consonant harmony or assimilation, it results in more reduplicated structures like /dzidzi/ for 'horse'. Thus, the early phonological development in children is

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influenced by acquisition of sound combinations and the density of speech sounds in the neighborhood.

The literature on vowel development in majority of the languages suggests that the acquisition of vowels is earlier than consonants (Templin, 1957). Many investigators report that majority of consonants are acquired by English speaking children by 6 years of age (Templin 1957; Olmsted, 1971; Prather, Hedrick & Kern, 1975; Arlt & Goodban, 1976; Fudala & Reynolds, 1986; Mowrer & Burger, 1991). In English speaking children, Templin (1957) observed that by the age of 4 years, initial position clusters and only fewer final position clusters were produced, but three member clusters and clusters containing fricatives continued to be mastered till the age of 8 years. Wellman (1931) and Snow (1963) expressed that a particular sound is not mastered in all the three positions at the same age. For example, medial /j/ is mastered by 3 years but this sound is not mastered in final position until 6 years. Children exposed to other languages were also reported to show similar although not identical sound repertoires (Locke & Pearson, 1992).

Acquisition of speech sounds by children is reported by many studies in Indian languages (Kumudavalli, 1973; Banu, 1977 and Prathima, 2009 in Kannada language; Usha, 1986 in Tamil; Padmaja, 1989 in Telugu; Banik, 1988 in Bengali and Maya, 1990 in Malayalam). All these studies reported a similarity in the acquisition of speech sounds by children speaking these Indian languages with that of English. However, most of the sounds were reported to be acquired earlier when compared to English.

Maya (1990) studied 240 Malayalam speaking children in the age range of 3-7 years. She reported that they acquire /s/, /r/, /l/, /f/, /tʃ/, /j/ and un-aspirated stops at an earlier age of 3-3.6 year and aspirated stops are acquired as late as 6.0 - 6.6 years. She also reported that 18 different consonants (m, n, p, ŋ, f, j, k, ḍ, v, b, ʈ, g, l, ṭ, tʃ, h, ɲ) and all vowels are developed by children speaking Malayalam language by 3 years of age. There are however, no studies in Malayalam language on the speech sound acquisition before 3 years of age. The present study aims to address issues related to the acquisition of various target speech sounds and the speech sounds in the neighborhood of target sounds before the age of 3 years in Malayalam speaking typically developing children.

'Speech sound neighborhood' is a concept which defines the set of speech sounds that occur in the immediate neighborhood of a target speech sound. The investigation of speech sound neighborhood in children has important theoretical implications. It is interesting to know whether children organize speech sound neighborhoods the same way as adults. Speech sound neighborhoods in adult's lexicon are constructed based on phonemic contrasts. The core question is whether or not children, like adults have phonetic representation for words in the lexicon. It is important to study how the speech sound neighborhoods in children gradually develop into the form of adults' speech sound neighborhoods.

Studies in the field of child phonology till date have dealt with the acquisition of isolated speech sounds in different languages. There are very few studies which address the acquisition of phonemes in relation with its phoneme neighborhood, especially so in Indian languages. Such information is especially crucial in understanding the acquisition of speech sounds with the neighborhood sounds in the speech of young children. This will in turn help in taking appropriate decisions in selecting the target sound stimuli during the assessment and intervention in children with speech production errors. A comparison with the neighborhood density of phonemes in typically developing children can be instrumental in detecting early deviancies and risk for phonological disorders. In the context of motor programming disorders, where the sequencing of sounds to form words is affected, the knowledge of acquisition of speech sound combinations remain crucial for early identification and intervention. The study aims to analyze the neighborhood density of selected target speech sounds (consonants) in Malayalam language. Due to restricted data available in Malayalam language below the age of 3 years, the study considered the most frequently occurring sounds in the speech sample of the children, keeping Maya's (1990) data on acquisition of speech sounds as a reference. Since most of the speech sounds are acquired before the age of 3 years in Malayalam language (Maya 1990), this study considered four age groups between 1 to 3 years. Acquisition of sound combinations in this age group would have an implication in early identification of atypical speech productions.

**Aims of the study:**

To analyze and compare the acquisition pattern of the neighboring speech sounds (preceding and following positions) of selected target sounds in Malayalam speaking typically developing children between 1 to 3 years ( in 4 age groups of 6 months interval) in terms of:

a) Spatial coordinate

b) Temporal coordinate

## Method

### Participants

A total of 20 typically developing children with native language as Malayalam, were included in this study. They were categorized into four age groups- 1.0 - 1.5 years (2F & 3 M); 1.6-2.0 years (3F & 2M); 2.1-2.5 years (4F & 1 M); 2.6-3.0 years (3F & 2 M), with five children in each age group.

The participants were selected based on the following criteria:

- None of the participants had any history of otological /neurological and / or any motoric dysfunction.
- All were native speakers of Malayalam language and were not exposed to any other language.
- They had no delay or deviancies in speech and language as on screening tests. The language development was screened using Receptive Expressive Emergent Language Scale (REELS) (Bzoch & League, 1972).

### Instrument & Material:

The speech sample of the participants was audio – video recorded. A high quality digital video camera (Nikon coolpix P1) was used for video recording. Age appropriate toys were used to elicit the speech samples from the participants (Toy models of fruits, vehicles, kitchen items).

### Procedure:

The children were audio video-recorded in their respective homes in individual setting during half-hour unstructured free play interaction. The child was initially desensitized for the presence of camera. While recording the speech sample, the recorder was kept away from the child's sight. A quiet room away from the traffic and other environmental noises was chosen for recording. It was ensured that the recording of speech samples was carried out during the active period of the child's activities and did not interfere with the sleeping and feeding schedules of the child. The sample was elicited from children within a span of 4-5 sessions. The first session aimed at rapport building and the successive sessions aimed at collecting spontaneous speech. Spontaneous or elicited speech samples and interactions of the participants with the family members were also video recorded. The recording of the samples continued till a representative sample of client's speech was obtained.

### Analysis:

The numbers of words selected for analysis were dependent on the total meaningful vocabulary of the child. A vocabulary of approximately 50 words was expected from children in the age range of 1-2 years and vocabulary of 50-300 from children in the age range of 2-3 years. A total number of 50 intelligible words were selected for transcription (IPA- Broad Transcription) and analysis in 1 to 2 year old children and 100 intelligible words was selected for transcription (IPA- Broad Transcription) and analysis in 2 to 3 year old children. While selecting these words, it was taken into cognizance that the words were within the vocabulary of the given child. Gender was not considered for analysis since most of the studies have not reported a gender bias in terms of phonological acquisition of speech sounds. The speech sample was phonetically transcribed in IPA (Broad transcription) by two of the investigators, which was later verified for agreement in notations between the two investigators. The inter judge agreement was above 85% for all transcribed samples. Transcriptions that were not agreed upon by the two investigators were verified from literature and by consulting an experienced linguist. The contextual reference in which the utterances were made was also noted down for later reference. The words analyzed from the transcribed samples consisted of true words within the vocabulary of the child. From these words all the speech sounds in Malayalam language that emerged in each group of participants were chosen as target sounds. While doing so, attention was paid to see that the chosen utterances were produced correctly by the children and were within the order of acquisition of speech sounds in Malayalam language. By 3 years of age, all vowels and few consonants are reported to be acquired in Malayalam language (Maya 1990). Hence these sounds (m, n, p, ŋ, f, j, k, ḍ, v, b, ṯ, g, l, ṭ, tʃ, h, ɲ) were selected as target sounds for all the groups. These sounds were grouped based on place and manner of articulation as shown in Table 1. The place of occurrence of the target sound, viz., initial, medial and / or final positions were noted. In this study, the neighborhood sounds were defined as those speech sounds which preceded and / or followed the target sounds. If there were two target syllables in a given intelligible word utterance, both were considered. The neighborhood of the target syllables were obtained and were compared across the age groups. Scatter plots were plotted based on frequency of occurrence of neighborhood combinations. A 35% cut off criteria was selected for the same as this was found to be the most common point for all neighborhood combinations.

Table 1: *Sounds selected for analysis of neighborhood density*

| *Place of articulation* | *Manner of articulation* |
|---|---|
| Bilabials-m, p, b | Stops- p, b, t̪ ,ɖ , k, g, ʈ |
| Labiodentals-v, f | Fricatives- f, h |
| Dentals- t̪ | Affricates- tʃ |
| Alveolars- n, l, | Nasals-m, n,ŋ,ɲ |
| Palatal – j, tʃ, ɲ | Glides-v, j |
| Retroflex – ʈ ,ɖ | Laterals-l |
| Velar – k, g, ŋ | |
| Glottal – h | |

## Results and Discussion

The results are discussed under the following sections:

**1. Neighborhood density in spatial coordinate.**

Table 2 and Figures 1 to 4 show the frequency of occurrence of different target sounds and their neighborhood sounds across age groups according to their place of articulation (spatial co ordinate). In the age range of 1-1.5 years, it is found that the frequency of occurrence of combinations of phonemes is greater for palatals than for bilabials (Fig 1). The pattern in the linear plot suggests that similar sounds with same place of articulation are mostly combined to form meaningful words in the early stages. Visible phonemes present more neighborhood combinations as compared to non visible phonemes. For example, bilabials and labiodentals have a larger number of neighborhood phonemes when compared to velars and alveolars. This could be due to the hierarchy of acquisition of sounds in a given language, wherein, the back consonants are acquired much later owing to the neuro-motor maturation of the tongue.

Many studies have reported early acquisition of bilabials, since they are the easiest and more visible sounds. Neighborhood density is higher for palatals suggesting that tongue -palate motor executions in the space-time dimension seem to be explored more by children in this age group. The findings in Fig 1-4 suggests similarity in terms of place of articulation as a crucial factor that probably dictates the pattern of neighborhood density. Indirectly it may be suggesting that while children are acquiring more than one sound at a time, there is an evolving motor program for sounds that are similar in their place of articulation. This is evident from rich neighborhood density in pre and post positions for bilabials and labiodentals compared to the velar sounds.

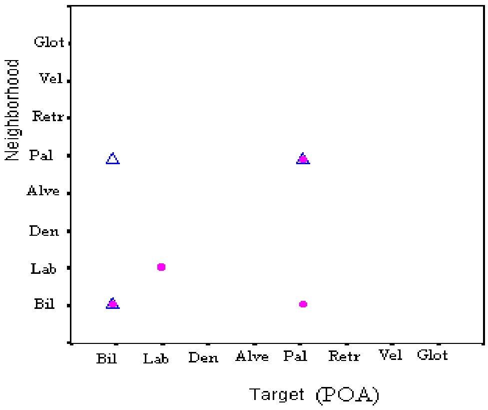


Figure 1 : Neighbourhood density in 1- 1.5yrs.

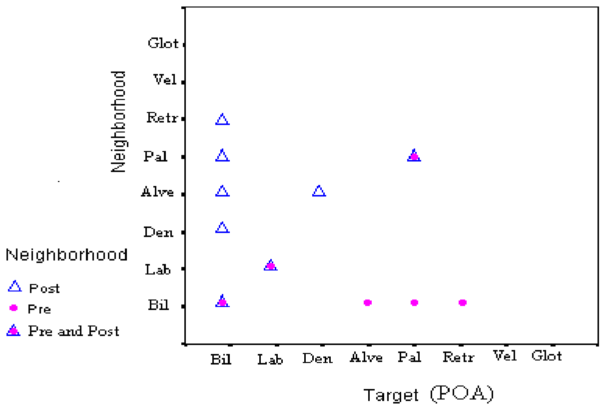


Figure 2 : Neighbourhood density in 1.6-2yrs

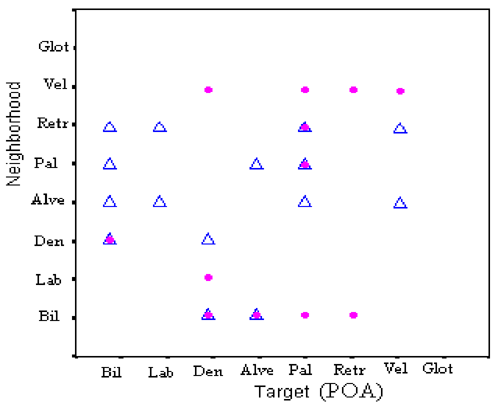


Figure 3: Neighbourhood density in 2-2.5 years

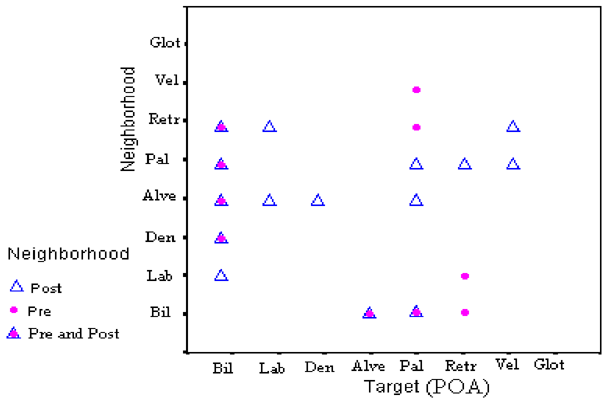


Figure 4: Neighbourhood density in 2.6-3 years

Table 2: *Frequency of occurrence of target sounds and their neighborhood according to place of articulation (spatial coordinate) across all the four age groups*

| Place of articulat-ion | Age (years) | Bilabial | | LabioDental | | Dental | | Alveolar | | Palatal | | Retroflex | | Velar | | Glottal | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post |
| Bilabial | 1.0-1.5 | 13 | 13 | 2 | 3 | 0 | 0 | 0 | 0 | 2 | 11 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1.6-2.0 | 19 | 21 | 0 | 0 | 5 | 6 | 18 | 7 | 24 | 4 | 12 | 1 | 3 | 9 | 0 | 0 |
| | 2.1-2.5 | 8 | 8 | 5 | 8 | 14 | 22 | 8 | 20 | 4 | 32 | 6 | 20 | 3 | 6 | 0 | 0 |
| | 2.6-3.0 | 3 | 3 | 3 | 25 | 10 | 12 | 29 | 19 | 23 | 27 | 11 | 20 | 7 | 4 | 0 | 0 |
| Labio Dentals | 1.0-1.5 | 2 | 2 | 12 | 12 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1.6-2.0 | 1 | 3 | 16 | 13 | 2 | 0 | 1 | 0 | 0 | 2 | 3 | 0 | 0 | 1 | 0 | 0 |
| | 2.1-2.5 | 5 | 3 | 5 | 5 | 7 | 2 | 0 | 10 | 4 | 4 | 3 | 15 | 0 | 2 | 0 | 0 |
| | 2.6-3.0 | 6 | 3 | 3 | 3 | 4 | 1 | 4 | 11 | 3 | 3 | 4 | 18 | 2 | 4 | 0 | 0 |
| Dental | 1.0-1.5 | 0 | 0 | 0 | 0 | 8 | 8 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1.6-2.0 | 6 | 12 | 1 | 0 | 7 | 8 | 1 | 2 | 5 | 2 | 3 | 3 | 2 | 4 | 0 | 0 |
| | 2.1-2.5 | 27 | 13 | 10 | 0 | 9 | 10 | 6 | 6 | 5 | 5 | 9 | 2 | 12 | 0 | 0 | 0 |
| | 2.6-3.0 | 6 | 5 | 1 | 2 | 3 | 6 | 2 | 12 | 2 | 2 | 5 | 8 | 0 | 1 | 0 | 0 |
| Alveolar | 1.0-1.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1.6-2.0 | 8 | 23 | 0 | 1 | 0 | 14 | 8 | 7 | 2 | 6 | 0 | 3 | 3 | 0 | 0 | 1 |
| | 2.1-2.5 | 16 | 12 | 8 | 0 | 6 | 5 | 4 | 5 | 7 | 11 | 3 | 3 | 7 | 8 | 0 | 0 |
| | 2.6-3.0 | 13 | 10 | 8 | 0 | 4 | 1 | 6 | 7 | 21 | 5 | 6 | 3 | 5 | 4 | 0 | 1 |
| Palatal | 1.0-1.5 | 11 | 2 | 1 | 0 | 0 | 5 | 0 | 0 | 10 | 10 | 0 | 0 | 0 | 2 | 0 | 0 |
| | 1.6-2.0 | 5 | 26 | 0 | 0 | 1 | 3 | 4 | 1 | 28 | 27 | 1 | 2 | 0 | 3 | 0 | 0 |
| | 2.1-2.5 | 27 | 4 | 3 | 4 | 5 | 7 | 8 | 10 | 11 | 11 | 10 | 13 | 15 | 4 | 0 | 0 |
| | 2.6-3.0 | 22 | 19 | 4 | 5 | 4 | 2 | 7 | 27 | 9 | 11 | 11 | 6 | 15 | 4 | 0 | 0 |
| Retroflex | 1.0-1.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| | 1.6-2.0 | 4 | 13 | 0 | 2 | 1 | 2 | 0 | 3 | 2 | 2 | 3 | 0 | 0 | 2 | 0 | 0 |
| | 2.1-2.5 | 18 | 4 | 8 | 1 | 4 | 5 | 0 | 6 | 5 | 8 | 2 | 1 | 13 | 4 | 0 | 0 |
| | 2.6-3.0 | 15 | 8 | 15 | 3 | 4 | 3 | 1 | 7 | 8 | 11 | 3 | 3 | 8 | 6 | 0 | 0 |
| Velar | 1.0-1.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| | 1.6-2.0 | 2 | 3 | 0 | 0 | 1 | 2 | 4 | 2 | 5 | 3 | 3 | 0 | 5 | 5 | 0 | 0 |
| | 2.1-2.5 | 3 | 5 | 1 | 0 | 3 | 7 | 6 | 13 | 5 | 14 | 4 | 26 | 10 | 8 | 0 | 0 |
| | 2.6-3.0 | 4 | 6 | 0 | 1 | 0 | 0 | 6 | 8 | 3 | 19 | 2 | 20 | 3 | 3 | 0 | 0 |
| Glottal | 1.0-1.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1.6-2.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2.1-2.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2.6-3.0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

As an extended thought it may also be reasoned that the motor programs are probably operating on the dimensions of visibility and proximity in terms of placement of articulators. As compared to 1.0-1.5 year old children, in 1.6-2.0 old children, the neighborhood density clearly point to a shift from palatals to alveolar combinations. In the spatial coordinate, palatal region was dominant in 1.0-1.5 year old children and there is a shift to alveolar region in the 1.6-2.0 age group. The change in the dimensions of the oral cavity itself as a part of growth may also be a contributing factor in this shift. In the 2.1-2.5 years group, there seems to be a scatter in terms of the neighborhood density as all possible combinations are programmed and executed in speech. The only exceptions seen in this figure is the programming of labiodentals with dentals and velars. Glottal sounds as neighborhood sounds are denser in 2.6- 3.0 year age group.

Overall, initially more homogenous sound combinations are observed while in the later age groups, a variety of sound combinations emerge.

**2. Neighborhood density in temporal coordinate**

The manner of articulation (time coordinate) has a linear, less dense neighborhood compared to the place of articulation as is evident from Tables & Figures 5-8. Stops have a denser neighborhood compared to other sounds. In the younger age groups, fricatives and laterals have not occurred with any target sounds as neighbors. This finding is consistent with those reported in literature (Templin, 1957) where children are reported to acquire these phonemes at a later age. In 1.6-2.0 year old children, dense neighborhood patterns are observed for stops and laterals. All combinations of sounds in terms of manner (time coordinate) were observed in this group except that of trills.

Table 3: *Frequency of occurrence of target sounds and their neighborhood according to manner of articulation (temporal coordinate) across all the four age groups*

| Manner of articulation | Age (years) | Stops | | Fricatives | | Affricates | | Glides | | Nasals | | Laterals | | Trills | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post |
| Stops | 1.0-1.5 | 18 | 13 | 2 | 3 | 1 | 11 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1.6-2.0 | 35 | 47 | 5 | 4 | 3 | 4 | 0 | 23 | 20 | 26 | 3 | 19 | 0 | 0 |
| | 2.1-2.5 | 94 | 89 | 13 | 13 | 11 | 12 | 4 | 28 | 30 | 45 | 3 | 22 | 0 | 3 |
| | 2.6-3.0 | 42 | 49 | 28 | 39 | 15 | 20 | 1 | 18 | 18 | 45 | 5 | 37 | 3 | 9 |
| Fricatives | 1.0-1.5 | 2 | 2 | 12 | 12 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1.6-2.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| | 2.1-2.5 | 15 | 19 | 5 | 5 | 0 | 0 | 1 | 3 | 3 | 11 | 0 | 3 | 0 | 0 |
| | 2.6-3.0 | 14 | 20 | 3 | 5 | 2 | 1 | 0 | 2 | 5 | 8 | 2 | 6 | 1 | 2 |
| Affricates | 1.0-1.5 | 11 | 1 | 0 | 0 | 10 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1.6-2.0 | 6 | 3 | 0 | 0 | 26 | 26 | 0 | 0 | 5 | 1 | 1 | 4 | 0 | 0 |
| | 2.1-2.5 | 14 | 14 | 0 | 0 | 5 | 5 | 1 | 2 | 1 | 3 | 2 | 3 | 0 | 0 |
| | 2.6-3.0 | 21 | 9 | 2 | 1 | 7 | 7 | 1 | 3 | 1 | 21 | 0 | 1 | 0 | 0 |
| Glides | 1.0-1.5 | 0 | 8 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1.6-2.0 | 27 | 3 | 13 | 13 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 0 |
| | 2.1-2.5 | 28 | 7 | 2 | 1 | 2 | 1 | 1 | 1 | 3 | 4 | 5 | 1 | 0 | 0 |
| | 2.6-3.0 | 19 | 2 | 2 | 1 | 0 | 2 | 0 | 0 | 5 | 11 | 4 | 4 | 0 | 0 |
| Nasals | 1.0-1.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 5 | 0 | 0 | 0 | 0 |
| | 1.6-2.0 | 20 | 25 | 0 | 2 | 1 | 4 | 0 | 0 | 16 | 18 | 4 | 7 | 0 | 0 |
| | 2.1-2.5 | 32 | 32 | 14 | 7 | 1 | 6 | 3 | 6 | 21 | 24 | 1 | 13 | 1 | 0 |
| | 2.6-3.0 | 39 | 16 | 6 | 5 | 21 | 3 | 9 | 5 | 20 | 33 | 10 | 9 | 1 | 4 |
| Laterals | 1.0-1.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1.6-2.0 | 14 | 2 | 1 | 4 | 0 | 0 | 0 | 0 | 6 | 6 | 2 | 3 | 0 | 0 |
| | 2.1-2.5 | 10 | 4 | 2 | 0 | 2 | 3 | 1 | 5 | 5 | 1 | 0 | 1 | 0 | 0 |
| | 2.6-3.0 | 13 | 2 | 5 | 1 | 1 | 0 | 3 | 3 | 5 | 2 | 5 | 3 | 0 | 2 |

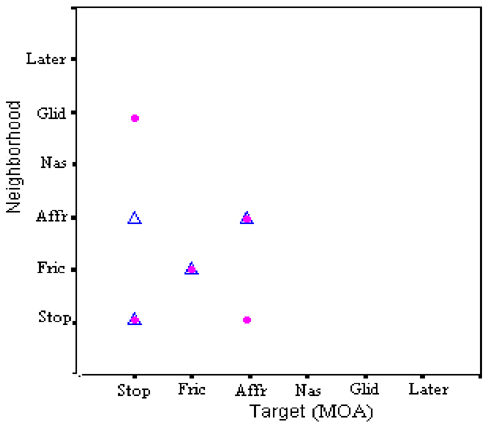


Figure 5 Neighboorhood density in 1-1.5yrs

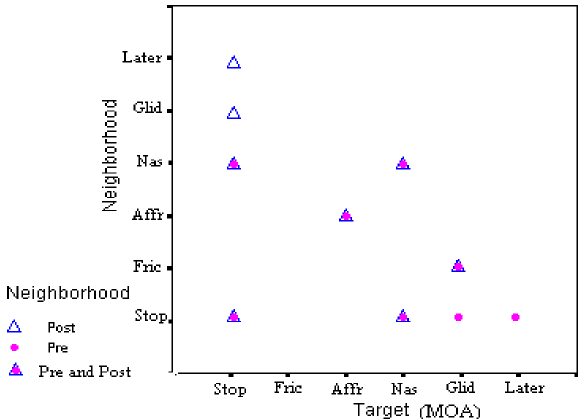


Figure 6: Neighboorhood density in 1.6-2yrs

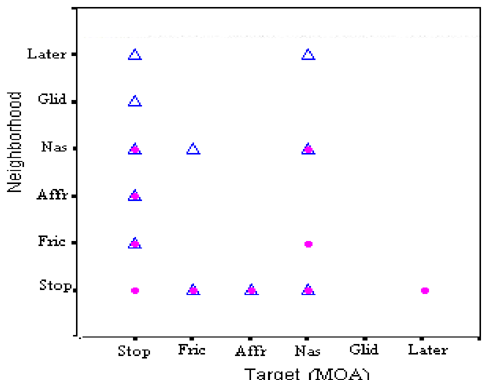


Figure 7: Neighborhood density in 2-2.5yrs

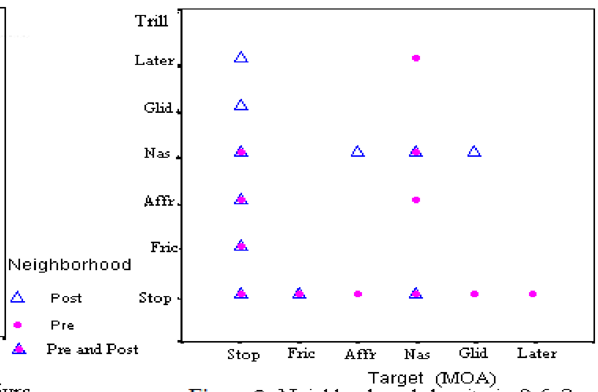


Figure 8: Neighborhood density in 2.6-3yrs

All the target sounds in the temporal coordinate (manner) except fricatives showed reduplicated combinations. The neighborhood density for sounds in the temporal coordinate (manner of articulation) showed an increase with age, as may be seen from Figures 3 and 4. Temporal neighborhood for fricative sounds seems to emerge beyond the age of 2.1-2.5 years. In 2.6-3.0 year old children, fricatives are placed in the neighborhood of stops and nasals as the initial combinations. The results point strongly to the fact that the last occurring neighborhood in 2.6-3.0 year old children seems to be that of fricatives, whereas all other target phonemes are acquired in pre and post neighborhood positions in the spatial coordinate by this age.

**3. Neighborhood density of geminates**

Table 4: *Target geminate sounds*

| Bilabials | Alveolar | Dentals | Palatals | Retroflex | Velar |
|---|---|---|---|---|---|
| pp, mm, bb | nn, ll, tt, ss, nt | t̪t̪ , nt̪ | ɲdz, ɲɲ | ʈʈ, ɭɭ, ɳʈ, ɳɳ | kk, ŋk |

The above table represents the geminate sounds which were selected as targets in this study based on the findings of Maya (1990). The results of analysis of neighborhood density for geminates for the four age groups are represented in the Figures 9 – 12. From the figures it is evident that, the only geminate in the age group of 1.0-1.5 is a combination of palatal and bilabial sounds. This pattern of acquisition is not similar to that observed in the place and manner of articulation. Though neighborhood increases with increase in age, a clear linear acquisition of combinations like that seen in the case of place (spatial) and manner (temporal) of articulation is not seen. The pattern seen in geminates, seem to be more horizontal than linear. That is, a phoneme is combined with all possible combinations as it is acquired irrespective of similarity. Thus as a bilabial is acquired, it is geminated with all possible other phonemes to make geminate sounds of that particular language irrespective of the place of articulation. In the backdrop of the results observed in the space-time coordinates in figures 1 to 8, the pattern in geminates suggests that the geminate neighborhoods were mostly in the succeeding position of the targets than preceding the targets. This could be because of simple syllabic structures acquired by children in which geminates occur rarely in the initial positions. Another point of interest is that at the age of 3 years, few combinations were still not present probably because of the evolving pattern in the development of articulation sounds.

**4. Comparison of results across age groups**

The results across age groups are represented in the figures 13 and 14. The combinations seen at the age range of 1-1.5 years are seen even at the age of 3 years, but with a lesser frequency of occurrence. The target groups showed a gradually increasing pattern of combinations with increase in age in both place and manner (space and time coordinates).All neighborhood combinations were achieved by 3 years of age both with respect to place and manner of articulation as seen in the figures 1 to 8. The results also show a dense group of combinations emerging as age advances in terms of place of articulation. The same is not evident in the manner of articulation. Hence the neighborhood density closely matches with what is reported for acquisition of speech sounds in typically developing Malayalam speaking children (Maya, 1990), more in terms of place of articulation than in terms of manner of articulation.

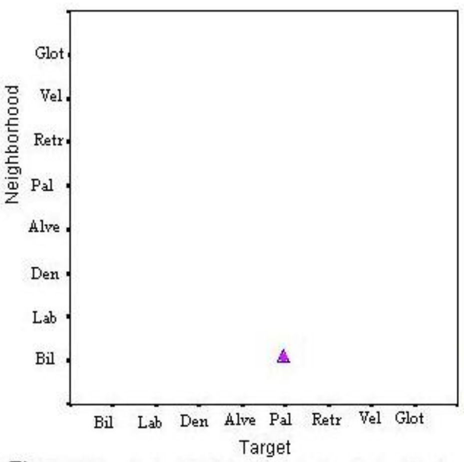

Figure 9:Geminate Neighbourhood density in 1-1.5 years

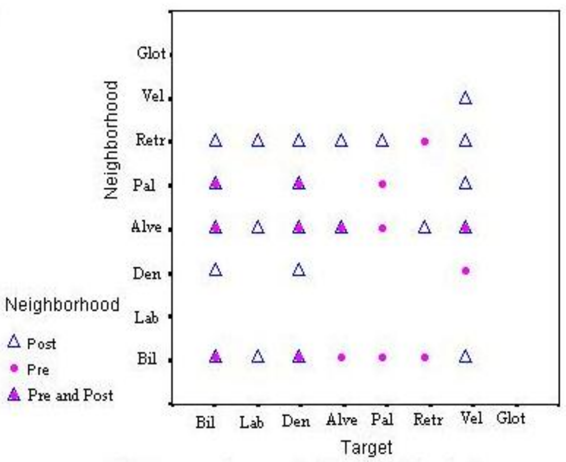

Figure 10:Geminate Neighbourhood density in 1.6-2 years

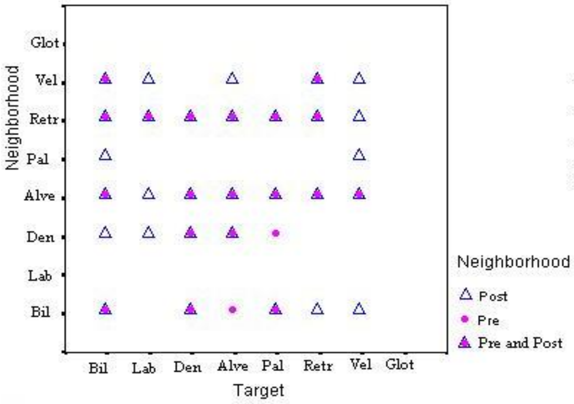


Figure 11 : Geminate Neighbourhood density in 2-2.5years

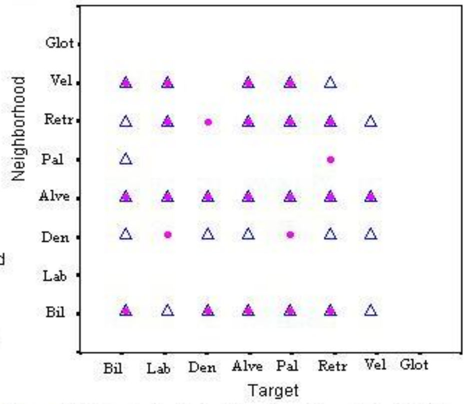


Figure 12 :Geminate Neighbourhood density in 2.6-3 years

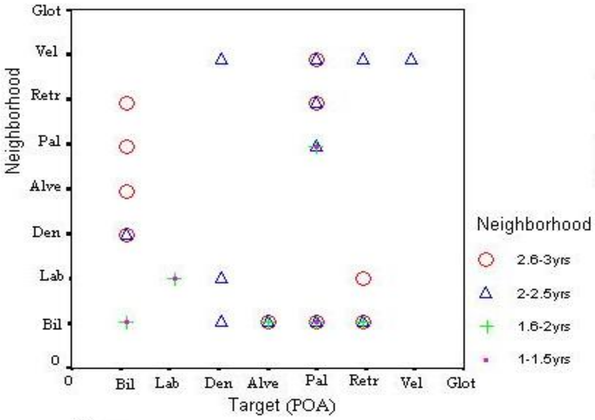


Figure 13: Preceding neighborhood combinations

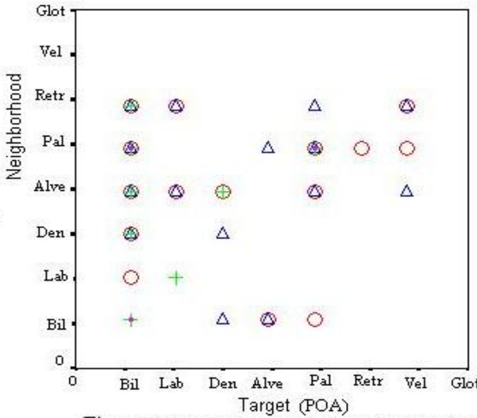


Figure 14: Succeeding neighborhood combinations

It is of interest then to see whether the development of articulation as recorded by the previous study (Maya, 1990) in Malayalam speaking children was favored more towards the place of articulation as a criterion rather than manner of articulation. The spatial dimensions (place of articulation) seem to mature before the temporal dimension (manner of articulation). Many studies have supported similar observations based on the use of sophisticated experimental paradigms using Kinematic traces (Easton, 1972; Kuehn & Moll, 1976; Fowler, 1980; Saltzman & Kelso, 1987; Guenther, 1992; 1994).

The 1.0-3.0 year old children acquire a considerable amount of phonological skills (Ingram, 1976c). Speech sounds are acquired in combinations than as individual sounds. There are specific combinations of sounds that are acquired first rather than acquisition of individual sounds such as bilabials with bilabials /palatals and stops with stops /affricates etc. Various neighborhood patterns appear with advancement in age. The neighborhood in different age groups studied pointed to a clear parallel to that of speech sound acquisition pattern. For example, with respect to the place of articulation, bilabials being the earliest achieved sounds, also appeared as the major neighborhood for the target groups in that particular age group. An emerging pattern was evident in terms of acquisition of sound combinations also. Sounds seemed to be combined more based on the similarity of place of articulation than the manner of articulation. Amongst the spatial neighborhood, palatals showed a denser neighborhood than any other class of phonemes even from a very young age of 1.0-1.5 years. This is probably suggestive of the ability of children as young as 1.0-1.5 year to select a reference in the spatial coordinate system of oral cavity. Initially the reference seems to be concentrated in the palatal area. The initial coordinate in the articulatory system seems to be the palatal sounds, to which other sounds are anchored to create new neighbors. In this process of neighborhood choice, two factors, viz., similarity and visibility seem to play a crucial role in deciding the type of neighborhood sounds. Sounds that are more visible and those that are similar were combined initially, suggesting that may be these are easily acquired by children because of the dual mode advantage. That is, children not only get auditory and visual feedback for visible front consonants (bilabials and labiodentals) compared to back consonants, they also seem to be maturing more in the spatial dimension due to a correlatory maturation of the proprioceptive (somato sensory) channel (Fry, 1968; Locke, 1986; Vihman, 1993; Browman & Goldstein, 1992; Kent, 1992; Menn, Markey, Mozer & Lewis,1993).

Coady and Aslin (2003) and Storkel (2004), suggested that words with higher frequency of occurrence were acquired first compared to less frequently occurring sounds. The neighborhood patterns that emerged in this study needs to be compared with the frequency of occurrence of sounds in children in Malayalam language in order to study the relationship if any between the factors of neighborhood density and frequency of occurrence of sounds in children in Malayalam language. This can be taken up as an extension of this study as it is beyond the scope of this study. The findings are in agreement with other studies which support that there is a specific sound law operating in children's speech (Jespersen, 1922), early acquired combinat-ions are retained although newer combinations appear in later ages (Bynon, 1968), a high degree of reduplicated combinations are seen, which can be attributed to the consonant harmony or assimilation (Bynon, 1968) and the sound combinations are richer in terms of place rather than the manner (Logan, 1992). Intriguingly, the trill sounds as neighborhood sounds even in the age range of 2.1–2.5 years points to the need for introspection and verification of articulatory acquisition data reported in the literature (Maya, 1990).

## Summary and Conclusion

Speech sound production is an important aspect of the children's language and it refers primarily to the gradual mastery of speech sound form within a given language. The present study aimed to investigate the acquisition of neighborhood of speech sounds in Malayalam speaking children aged 1-3 years. The results obtained revealed that the acquisition of speech sounds follow a specific pattern which parallels the individual speech sound acquisition as reported in Malayalam language. Similarity in place and manner of articulation plays an important role in speech sound acquisition and its phonology. Thus to conclude, the neighborhood of the various speech sounds are influenced by the developing speech motor control. Children from 1-3 years, speaking Malayalam language did not show arbitrary phonological combinations but followed a specific pattern in terms of neighborhood density of consonants.

## Implications

The trend observed in the study clearly points to the fact that a transcription based procedure of identifying the emerging sound profile of a child in terms of its neighborhood could be used as a simple, yet potential clinical tool in measuring/ commenting on the maturing articulatory mechanism in terms of the space and time coordinates. This probably can serve as a window to the understanding of the exact nature of speech motor control in the articulatory mechanism in space and time dimension.

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