COMPARISION OF TIME, SPACE AND WHOLE WORD PATTERNS IN PHONOLOGICAL PROCESSES OF 2 TO 7 YEAR OLD TYPICALLY DEVELOPING KANNADA SPEAKING CHILDREN

[1]Shailaja Shukla, [2]Manjula R, & [3]Praveen H R

Abstract

Phonological processes can be grouped to with respect to timing, articulatory space and whole word patterns (Velleman, 2003.) No study has been conducted addressing the hierarchy of appearance or disappearance of these patterns in typically developing children in Indian languages. The aim of the study is to analyze and compare the time, space and whole word patterns in conversational speech of 2 to 7 years old Kannada speaking typically developing children. The present study included 50 typically developing children in the age range of 2 to 7 year, sub-grouped into 10 groups with 5 children in each group divided in 6 months range. Conversational speech sample was collected from each of the participant. 100 intelligible utterances were selected and transcribed using IPA by the first investigator. Mean percentage of occurrence of timing, space and whole word patterns were calculated. Statistically significant differences and a decreasing trend in the occurrence of total patterns with age were observed. Timing features stabilized first by 4 years of age followed by space and whole word patterns (which prevailed even after 7 years of age), which is in line with other reported studies which are based on kinematic analysis.

Key Words: *Phonological processes, timing pattern, articulatory space pattern, whole word pattern.*

All children embark on the development of their phonological systems from the same beginnings (Stampe, 1979). Children possess a full understanding of the underlying representation of the adult phoneme system. They however have difficulties with the peripheral motor realization of the phonetic surface form which are perceived as articulation errors.

When children's speech is analyzed, clear systematic patterns are found in their erroneous approximations to adult target words (Yavas, 1998). These error patterns are uniform across children and languages. One of the most common ways of describing these error patterns that has been used since a very long time is with reference to phonological processes. Phonological processes are regularly occurring deviations from the adult speech patterns; may occur across a class of sound, a syllable shape or syllable sequence (Hodson & Paden, 1983). All the phonological processes operate to simplify adult targets. The phonological processes have been categorized into 3 groups for ease of analysis. These include; syllable structure, substitution and assimilation processes. This classification system acts as a comprehensive device for identification of the relationship between the adult target and the child's erroneous productions. Studies addressing on the normal use and suppression of phonological processes indicates that most children regardless of the language being learnt use a set of common processes early in the development of sound system. Process such as denasalization is suppressed by 2 years of age whereas epenthesis and cluster reduction prevail even after 7 years of age (Smit, 1993; Lowe, 1996).

One more way of grouping the phonological processes is according to the fundamental patterns that underlies each one: timing, articulatory space and whole word patterns (Velleman, 2003). This method has been recommended for the description of phonological errors in persons with childhood apraxia of speech. Velleman (2003) classified the articulatory errors into space, timing and whole word errors in order to comment on the contribution of these patterns to praxis control.

This way of classifying processes is especially useful for apraxia because

- They have difficulty with sequencing; thus timing is an important issue for them
- Awareness of where the articulators are in space, self-monitoring of movement, so that they will often exhibit place processes
- They have more persistent whole-word (phonotactic, harmony) processes than other children

The specific features analyzed under timing, space and whole Word patterns according to Velleman (2003) are shown in Table1. This method of grouping the phonological processes has been incorporated in several studies for the purpose of studying phonological development, especially in children with apraxia of speech (Rupella, 2008; Bhanumathy, 2008). Significant variations are reported in a child's speech when compared to that of adults (Chermark &

[1]Student, All India Institute of Speech and Hearing (AIISH), Mysore-06, E-mail:mail_shukla@yahoo.com, [2]Prof. in Speech Pathology, AIISH, E-mail: rmanjula08@gmail.com, & [3]Research Officer, AIISH, Mysore-06, E-mail: pheonixnash@gmail.com

Schneiderman, 1986; Kent & Forner, 1980; Sharkey & Folkins, 1985; Smith & Goffman 1998). Variability in performance is a hallmark of early learning process for any complex motor skill (Schmidt & Lee, 1999). Greater variability in the developing motor system is an adaptive and essential feature of a system acquiring new patterns of behavior (Thelen & Smith, 1994). The transition from prelinguistic vocalizations to adult speech represents the mastery of multiple sub-systems. The remarkable behavioral accomplishment emerges in the context of rapid changes in musculoskeletal growth and neuromotor development (Kent, 1976, 1984; Kent & Vorperian, 1995; Smith, Goffman & Stark, 1995). Motor processes of speech are shaped by multiple intrinsic factors such as cognitive/linguistic and sensorimotor maturation and extrinsic factors such as auditory, visualstimulation and perceptual saliency (Green, Moore, Higushikawa & Steeve, 2000).

Amongst others, one of the variations seen in the early speech development is that of phonological processes in the speech of young children. As and when children achieve greater control over the speech sub-systems, some processes disappear and some continue to prevail. For example, denasalization as a process is said to disappear by 2 years of age whereas cluster reduction and epenthesis prevails even after 7 years (Smit, 1993; Lowe, 1996). Addressing the issue of phonological processes in typically developing children helps in the identification of a trend if any regarding the appearance and persistence of various processes, and thus facilitates comparison of children with disordered phonology.

Table 1: *Features under timing, space and whole word patterns (Velleman, 2003)*

Timing patterns	Space/ accuracy patterns	Whole-word patterns
• Voicing errors • Affrication • Deaffrication • Nasalization • Denasalization	• Fronting • Backing • Vowel deviations • (Including vowel prolongation, vowel centralization and monophthongization)	•Cluster reduction •Reduplication •Consonant harmony •Migration •Metathesis •Epenthesis •Consonant deletion •Syllable deletion

There is no study that addresses the hierarchy in which the timing, space and whole- word patterns appear or disappear in typically developing children in any of the Indian languages. It has been suggested that perhaps children achieve control of temporal parameters of speech first before the movement amplitudes are adult like, because the subtle changes in timing can significantly affect the perception of acoustic signals (Levelt, 1989; Walsh & Diehl, 1991). On the contrary, Smith & McLean- Muse (1986) argued that physical growth as well as higher order processes involving the formulation and planning of speech movement sequences, delays the acquisition of temporal control like that of adults in speech. In line with this observation, Walsh & Smith (2002) also suggested that children achieve temporal before spatial goals in speech. The spatial and temporal variability of the articulatory movements thus has an important bearing in understanding the speech motor control in the developing speech system. The observation as to which of the two dimensions, viz., temporal or spatial of articulatory system is acquired first has been addressed using kinematic data by majority of the studies (Smith & McLean- Muse, 1986; Smith & Walsh, 2002). No study has attempted to analyze the feature of time or space errors within the developing articulatory (phonological) process in children using a behavioral paradigm. This study explores and attempts to analyze the patterns of time, space and whole word errors in the speech of Kannada speaking typically developing children aged 2-7 years, based on the classification of phonological processes elaborated by Velleman (2003). Kannada is a major Indian language spoken by people in Karnataka which is one of the southern states of India. Such an attempt helps determine which of the three types of phonological features that is, timing, space and whole word patterns are acquired and / or diminish in the age range of 2 to 7 years in Kannada speaking children. The outcome of the study will help to:

- Understand the trend seen in the developing nature of timing, space and whole word patterns in the phonological processes of typically developing Kannada speaking children.
- Verify the possibilities of using a simple clinical behavioral analysis tool such as the phonological process analysis in understanding the trend in time and space motor control in the articulatory system of speech, as a substitute method instead of the most sophisticated instrumentation procedures such as kinematic analysis.
- Adopt a similar method in comparing the trend in acquisition of time-space dimensions in the phonological patterns of other Indian languages.
- Compare and verify if the trend is same in the speech of children with phonological impairment.

Hence, the specific objectives of the study were to analyze and compare the phonological processes in conversational speech of 2 to 7 years Kannada speaking typically developing children (in 6 months interval) in terms of:

a) timing patterns
b) space patterns
c) whole word patterns

Also to identify the similarities and / or differences in these patterns if any, in the selected age groups across the patterns.

Method

Subjects: 50 typically developing Kannada speaking children in the age range of 2 to 7 years were included in the study. They were divided into 10 groups with 5 children in each group divided in 6 months interval as shown in Table 2. The children were screened for age appropriate speech and language skills based on history, clinical observation and assessment tools (Kannada Language Test- RRTC, Madras & AYJNIHH, Bombay, 1990- UNICEF funded project)

All the subjects were also screened for the following:

- Sensory impairment (hearing and visual impairment) based on clinical observation
- Deviant oral structures (oral mechanism examination).
- Oro-motor deficit (test for diadochokinetic rate)
- Cognitive- linguistic deficits (clinical psychological evaluation)
- Other developmental disabilities (based on clinical observation)
- Severe behavioral problems (based on clinical observation)

All subjects belonged to middle socio-economic status and their parents had minimum educational qualification up to 12^{th} grade. All participants were native speakers of Kannada. They were exposed to Kannada language at home and Kannada as well as English in the school.

Procedure: An informed consent was obtained in writing from the parents/ caregivers of all the subjects. Conversational speech samples were collected from each child in a quiet room at their home/school situation. Interaction with the child involved asking questions to the child regarding his/ her daily activities, narrating stories and indulging in general conversation using toys and pictures appropriate to their mental age. A pilot study was carried out on 2 children in order to assess the duration of speech sample to be recorded so as to elicit minimum of 100 fluent utterances from each child.

Table 2: *Distribution of subjects across age groups*

Age group	Age range	Male	Female	Total No. of Subjects
1	2-2.6	2	3	5
2	2.6-3	2	3	5
3	3-3.6	3	2	5
4	3.6-4	3	2	5
5	4-4.6	3	2	5
6	4.6-5	2	3	5
7	5-5.6	4	1	5
8	5.6-6	3	2	5
9	6-6.6	3	2	5
10	6.6-7	2	3	5

The outcome of the pilot study showed that a speech sample of 12-15 minutes was sufficient to elicit approximately 100 utterances. Hence, the speech sample of 15-30 minutes was collected from each child. Speech was recorded using a Sony-MZ-55 digital recorder with an external microphone and were stored in a compact disk. For the purpose of analysis, approximately one minute sample from the initial and final portion of the speech samples were not included to rule out initiation speech errors/ hesitations and fatigue effects in speech. From the selected portion of the speech sample 100 intelligible utterances per child were chosen and transcribed using broad transcription IPA (International Phonetic Alphabet). These were further subjected to analysis.

Analysis: From the transcribed speech sample, different phonological processes in the **s**peech were analyzed and classified into space, timing and whole word errors based on the criterion proposed by Velleman (2003). The following method was used to calculate the mean percentage occurrence of different phonological processes across the age groups: The different patterns in the speech sample observed were computed for individual & mean scored for each age group.

$$\text{Mean percentage of occurrence} = \frac{\text{Total no. of patterns in the age group}}{\text{Number of subjects in the age group}} \times 100$$

$$\text{Mean percentage of occurrence of a particular pattern} = \frac{\text{Total no. of particular patterns in the age group}}{\text{no. of subjects in the age group}} \times 100$$

Results and Discussion

The speech samples collected from 50 children grouped into 10 different age groups (5 subjects per age group) with 6 month age interval from 2-7 years were transcribed by the investigator and the phonological patterns analyzed. Reliability measures were carried out which included both intrajudge and interjudge reliability. For the intrajudge reliability, the investigator selected 10% of the total sample and repeated the procedure of transcription after a week. Also to check the reliability of the transcription, interjudge reliability measures were carried which included an experienced Speech Language Pathologist transcribing 10% of the whole sample. Reliability measures were calculated based on point to point percentage of agreement. Intrajudge and interjudge reliability was found to be more than 85%.

The frequency of occurrence of the patterns across age groups were compared to identify the developmental trend if any in the frequency of occurrence of time, space and whole word patterns across age groups. The data was statistically verified using various tests. As the distribution of male and female children in different age groups were small in number, the data was not analyzed for differences in patterns across the gender. The mean scores and standard deviation of the total patterns observed in the speech samples of children in different age groups are given in the Table 3 and Figure 1.

Table 3: *Mean scores and standard deviation of the total patterns (time, space and whole word) in different age groups.*

Age group	Age range	No. of subjects	Total patterns	
			Mean	SD
1	2.0-2.6	5	68.80	1.92
2	2.6-3.0	5	61.60	4.39
3	3.0-3.6	5	52.00	3.80
4	3.6-4.0	5	43.20	1.30
5	4.0-4.6	5	31.20	2.16
6	4.6-5.0	5	26.40	1.51
7	5.0-5.6	5	20.60	2.07
8	5.6-6.0	5	14.00	1.58
9	6.0-6.6	5	12.80	1.48
10	6.6-7.0	5	10.80	1.64

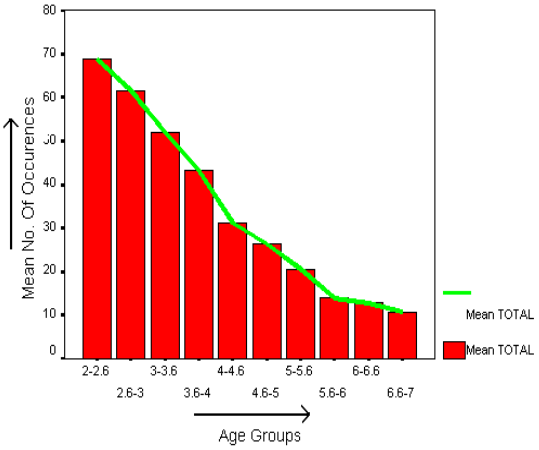

Figure 1: *Mean occurrences of total patterns (time, space and whole word) in different age groups*

Kruskal-Wallis non parametric test revealed a statistically significant difference across the age groups (χ^2 (9) =47.926, p <0.001). Further, non parametric test for 2 independent sample t- test (Mann- Whitney U test) was applied across the age groups to check whether the difference among the groups were statistically significant. The results revealed a statistically significant difference across all the age groups at p <0.05, except across the age groups 5.6-6.0 & 6.0-6.6 and 6.0-6.6 & 6.6-7.0. From table 3 and Fig 1, it is evident that the patterns show a decreasing trend with age. Such a trend is also supported by other studies in children speaking English language (Smit, 1993; Lowe, 1996). The less significant differences in the total mean occurrences of patterns in the older age groups (5.6-6.0 & 6.0-6.6 and 6.0-6.6 & 6.6-7.0) may probably be due to a gradual decline in the occurrences of the patterns. Major decline of the occurrences of processes is seen from 2 to 5 years of age, after which, the rate of decline is gradual. Overall, the variability in speech which is revealed in terms of the time, space and whole word patterns reduced drastically from 2-7 years and this signifies a gradual approximation to adult like speech, as also reported by Thelen & Smith (1994).

An attempt was made to identify the developmental trend specifically with respect to frequency of occurrence of time, space and whole word patterns across age groups. The mean and standard deviations of the three patterns are given in the table 4 and Figure 2.

Table 4: *Mean and Standard Deviations for timing, space and whole word patterns across age groups.*

Age group	Age range	N	Timing patterns		Space patterns		Whole word patterns	
			Mean	SD	Mean	SD	Mean	SD
1	2.0-2.6	5	13.00	1.87	18.40	0.54	37.40	2.40
2	2.6-3.0	5	11.00	2.91	18.60	0.89	32.00	2.54
3	3.0-3.6	5	8.60	1.67	17.40	1.81	26.00	1.58
4	3.6-4.0	5	5.20	1.30	13.80	1.48	24.40	0.54
5	4.0-4.6	5	1.20	0.83	8.60	1.14	21.00	2.00
6	4.6-5.0	5	1.20	0.44	7.20	1.30	18.00	1.00
7	5.0-5.6	5	0.00	0.00	6.60	0.89	14.00	1.41
8	5.6-6.0	5	0.00	0.00	4.60	0.54	9.40	1.14
9	6.0-6.6	5	0.00	0.00	3.60	0.54	9.20	1.30
10	6.6-7.0	5	0.00	0.00	2.40	0.54	8.40	1.51

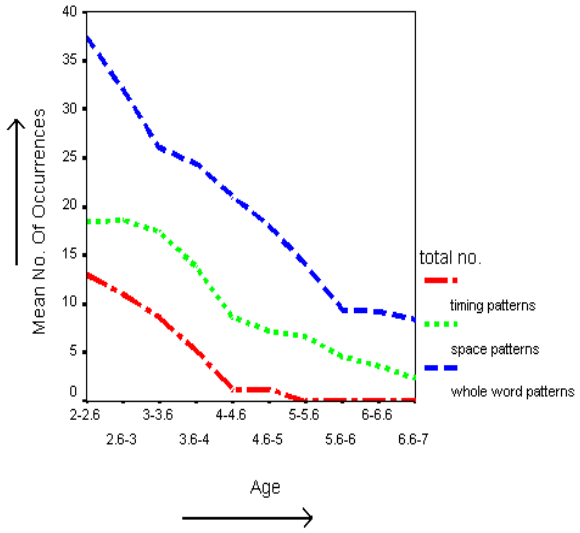

Figure 2: *Mean score of timing, space whole word pattern across age*

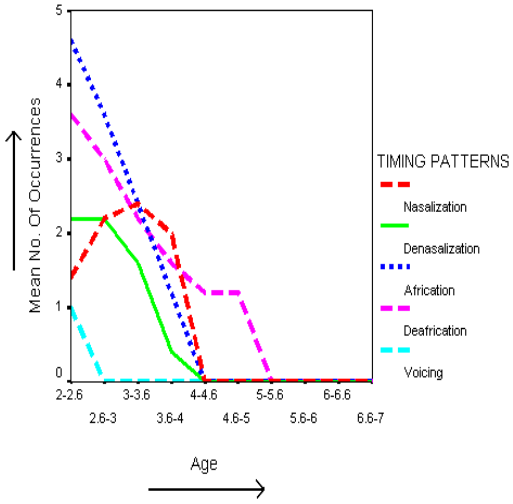

Figure 3: *Occurrences of various and patterns in timing*

a) Timing patterns: The timing patterns were observed upto 4.6-5.0 years of age. Kruskal-Wallis non parametric test was employed to check if the difference in the frequency of occurrence of timing patterns across age groups were statistically significant. The results revealed a statistically significant difference across the age groups (χ^2 (9) = 46.959, p <0.001). Hence a non parametric test for 2 independent sample t test (Mann- Whitney U test) was applied across the age groups to check whether the difference among the groups were statistically significant. The results revealed a statistically significant difference across all the age groups (p <0.05) except across the age groups (2.0-2.6 & 2.6-3.0; 2.6-3.0 & 3.0-3.6 and 4.0-4.6 & 4.6-5.0). The non significant differences for the occurrence of the timing patterns across the successive age groups reveal that the rates of decline of the time patterns show a slow developmental trend. Timing patterns were stabilized and hence not observed after 5 years of age.

Among the timing patterns, the various prominent patterns observed included nasalization, denasalization, affrication, deaffrication and voicing patterns. The developmental patterns with respect to the frequency of occurrences across age groups for these timing patterns are shown in the Figure 3. The developmental pattern of various features in timing varied across the age groups. The nasalization feature is observed from 2.0-2.6 years of age to 3.0-3.6 years of age after which it is stable at the age of 4.6 years. The reduced frequency in the initial years can probably be due to non acquisition of nasal sounds as one of the initial sound classes. The increase in the

occurrence after this age group could probably be attributed to individual differences among the subjects considered for the study. Denasalization feature showed a gradual decline from 2.0 years to 4.0-4.6 years of age. However the simultaneous stabilization of nasalization and denasalization feature by 4-4.6years of age is an important feature observed and can be attributed to the neuromotor control of the velo-pharyngeal structures and the maturation of the voluntary coupling of oral and nasal structures. The occurrence of affrication as a pattern appeared at 2 years of age, and then decreased steeply before stabilizing at approximately 4.0-4.6 years. On the other hand, deaffrication pattern is evident from 2.0-2.6 years of age, gradually declining and stabilizing by 5.0-5.6 years. As seen from the Fig 3, deaffrication is the only feature among the timing patterns to disappear at a later age. The relatively late disappearance of affrication and deaffrication patterns can probably be accounted to the much later development of motor control of tongue movements which is essential in the production of frication. The coordinative organization of the tongue and jaw which are required for the acquisition of frication are reported to exhibit changes until the age of 8–11 years and continue to undergo refinement into late adolescence (Cheng, Murdoch, Goozee & Scott, 2007). The occurrence of the voicing pattern is also reported to stabilize by 3 years of age by Bowen (1998). Jaw which matures much earlier than the tongue contributes to most of the consonant production (Green, Moore, Higushikawa & Steeve, 2000).

b) Space patterns: As evident from the table 4 and figure 2, the mean values show that the space patterns show a developing trend, i.e. the patterns exhibited by younger age group gradually reduces with age. Kruskal- Wallis non parametric test was carried out to check if the difference in the frequency of occurrence of space patterns observed across age groups were statistically significant. The results revealed a statistically significant difference across the age groups (χ^2 (9) =46.747, p <0.001). Hence a non parametric test for 2 independent sample t-test (Mann-Whitney U test) was applied across the age groups to check whether the difference among the groups were statistically significant. The results revealed a statistically significant difference across the age groups ($p < 0.05$) except 2.0-2.6 & 2.6-3.0; 2.6-3.0 & 3-3.6; 4.0-4.6 & 4.6-5.0; 4.6-5.0 & 5.0-5.6; and 5.6-6.0 & 6.0-6.6. No significant difference between 2.0 to 3.6 yrs reveals that the space patterns remain consistent with respect to number of occurrences at the initial months as is evident in Fig 2. No statistically significant difference across the successive age groups like (4.0-4.6 & 4.6-5.0), (4.6-5 & 5-5.6) and (5.6-6 & 6-6.6), indicate a slow rate of decline in the mean number of occurrence at the later stages.

Within space patterns, the predominant features that were observed in the subjects were fronting, backing and vowel deviation. The same is depicted in figure 4. As it is evident from the figure 4, fronting was the most predominant pattern amongst the other space patterns. Fronting pattern remains consistent with respect to number of occurrences from 2 to 4 years of age, then shows a steady decline and continues to prevail even after 7 years of age. The predominance of the fronting pattern can be attributed to early acquisition of the front sounds (e.g. /p/, /b/, /m/, etc.) in children (Jacobson & Halle, 1956). Backing features are prevalent till 4yrs of age and shows a less and sporadic occurrence compared to fronting feature. Vowel deviations as a pattern were lesser in frequency and disappeared by 4 years of age. This may be due to early acquisition of vowels and the vowels differ from each other in terms of placement and position of articulators in the oral structures. Various studies have reported that vowels and diphthongs are acquired by 3 years of age (Rupella & Manjula, 2006).

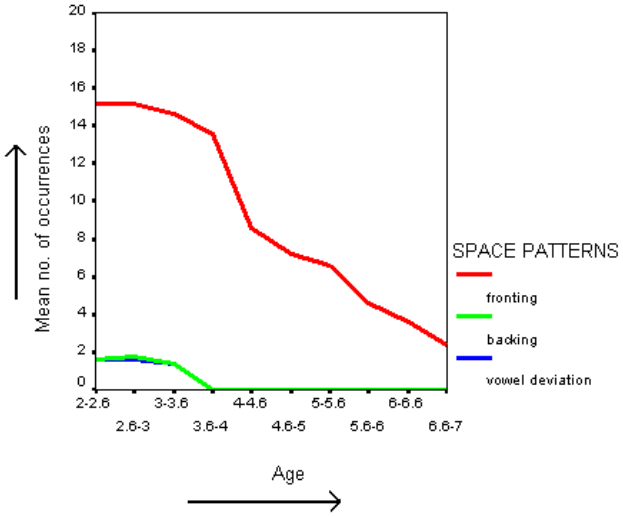

Figure 4*: Occurrence of various features under space patterns*

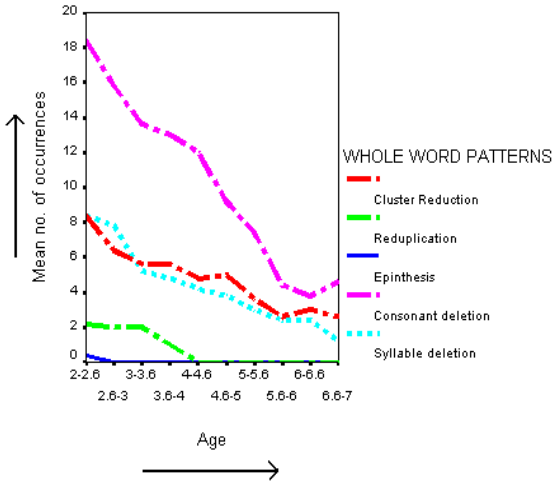

Figure 5: *Occurrence of various features under whole word patterns.*

c) Whole word patterns: As evident from the mean scores in table 4 and figure 2, the occurrence of whole word patterns show a decreasing trend from 2 to 7 years. Unlike the timing patterns, these patterns prevail even after 7 years of age. This observation is in order with the findings by Smit (1993) and Lowe (1996). Kruskal- Wallis non parametric test was carried out to check if the difference in the frequency of occurrence of whole word patterns observed across age groups were statistically significant. The results revealed a statistically significant difference across the age groups (χ^2 (9) =47.218, p <0.001). Hence a non parametric test for 2 independent sample t- test (Mann- Whitney U test) was applied across the age groups to check whether the difference of scores among the groups were statistically significant. The results revealed a statistically significant difference across all the age groups (p <0.05) except across the age groups 3.0-3.6 & 3.6-4.0; 5.6-6.0 & 6.0-6.6; 6.0-6.6 & 6.6-7.0. Occurrence of the whole word patterns decreased drastically up to 5.0-5.6 years of age. The drastic decrease in the number of occurrences till 6 years of age may be accounted to the development of the oral motor control. This observation is in line with that of Green, Moore, Higushikawa & Steeve (2000) who investigated lip and jaw co-ordination and found that the movement synchrony of articulators steadily increases with age.

The features that were observed within whole word patterns were cluster reduction, reduplication, epenthesis, consonant deletion and syllable deletion (figure 5). The developmental pattern of the various features among the whole word patterns observed reveal that the consonant deletion dominated across all age groups followed by cluster reduction, syllable deletion, reduplication and epenthesis. Consonant deletion was seen maximally at 2 years of age, reduced drastically up to 6 years of age and later showed a sustained occurrence. For syllable deletion and cluster reduction were similar (the frequency of occurrence and rate of decrease across age groups). Reduplication was seen up to 4.0-4.6 years of age and stabilized thereafter. Occurrence of epenthesis was sporadic and did not show any growth trend like that seen for before 3years of age.

It is evident that timing patterns are stabilized first, followed by space and whole word patterns. The findings of the present study parallel the findings by Levelt (1989) and Walsh & Diehl (1991), who observed that children achieve control of temporal parameters of speech first before the movement amplitudes are adult like, because the subtle changes in timing can significantly affect perception of the acoustic signal. Smith & Walsh (2002) also suggested that children reach temporal goals before spatial goals. However Smith & McLean –Muse (1986) reported that higher order processes involving the formulation and planning of speech movement sequences delays the development of adult like duration of speech output.

Conclusions

The study revealed distinct pattern of development of various patterns such as time, space & whole word patterns and also various features within these patterns. When the data was compared across the various age groups, the frequency of occurrence showed a decreasing trend. The results revealed stabilization of the patterns wherein, the timing patterns were the first one to stabilize by 4 years of age where as space and whole word patterns prevailed even after 7 years. The order among the various timing patterns emerged as voicing, denasalization, nasalization, affrication and deaffrication. Fronting feature dominated among the space patterns across all age groups. The order of acquisition of features among the whole word patterns were epenthesis, reduplication, syllable deletion, cluster reduction and consonant deletion. In typically developing children, control of temporal parameters of speech is achieved earlier followed by space and whole word patterns.

Implications of the study

The studies which are carried out so far addressing the development of temporal and spatial dimensions of speech motor control are based on kinematic analysis. The present study is first among its kind which has considered

behavioral measures like phonological processes to imply on the speech motor control in typically developing children. Also there has been no study in any of the Indian languages that addresses the order of acquisition of time, space and whole word patterns in the phonological processes and their developmental trend in typically developing Kannada speaking children aged 2 – 7 years.

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