

Effect of Age on Vowel Duration in Kannada

N. Sreedevi

Abstract

The present study investigated the developmental changes in vowel duration in Kannada (Mysore dialect) in normal subjects. Audio recordings of 73 bisyllabic words (CVCV) incorporating one of the 10 vowels of Kannada in a carrier phrase served as the material. Ten subjects each in the age groups of 7-8 years; 14-15 years and 20-30 years participated in the study. Using the software package SSL (VSS, Bangalore) vowel duration was extracted. The results indicated a decrease in vowel duration from children to adults. Also, this developmental trend was more evident in short vowels compared to long vowels. The data can be used for vowel synthesis and recognition. The data can also be used as norms in the assessment and therapeutic aspects of speech disorders.

Key words: Vowel duration, Kannada, Children, Adolescents, Adults

Vowel duration is the time duration from the onset to the offset of the vowel (Gopal, 1987). Many have investigated the duration of these vowels in English (Peterson & Lehiste, 1960) and other western languages like German (Zwirner, 1959), Danish (Fischer-Jorgensen, 1955) and Swedish (Engstrand & Krull, 1994). However, there are only few studies in the Indian languages. These include studies in Telugu (Majumder, Datta & Ganguli, 1978; Nagamma Reddy, 1988) Tamil (Balasubramanian, 1981) Malayalam (Velayudhan, 1975 and Sasidharan, 1995) Hindi (Aggarwal, 1988) and Kannada (Rajapurohit, 1982; Savithri, 1986, 1989 and Venkatesh, 1995). Since acoustic phonetic techniques reached a relatively high level in English speaking countries earlier than elsewhere, English has been most extensively studied, and there has been a tendency to assume that what holds for English is true in general.

Vowel duration is an important parameter which provides information on the prosodic as well as linguistic aspects of speech. Vowel duration can be used to signal the stressed syllable, mark the word boundaries, identify the syntactic units, and distinguish between similar phonetic segments. Duration data is of immense use in applied research, viz., automatic generation of speech for a reading machine for the blind and the automatic recognition of speech from the acoustic waveforms. Thus it is essential to study vowel duration to understand the speech production, perception and the language structure.

There are several studies comparing the temporal parameters of children with adults. Mc Neill (1974) reported speaking rates of slightly over three words /sec for adults, about 2.5 words/sec for children above two. Not surprisingly, then the duration of individual segments are longer in children's speech (Smith, 1978; Kent & Forner, 1980). Kent & Forner (1980) measured duration of phrases and short sentences and found them to be 8% longer for 12 year olds and 16% longer for 6 year olds than for adults. Children's speech differed from adult speech in terms of its variability also. When children make the same utterance several times, the duration of individual segments vary more than for adults (Eguchi & Hirsh, 1969; Tingley & Allen, 1975; Kent & Forner, 1980). This difference in reliability of production may be an index of the child's linguistic and neuromotor immaturity. In general, a young child's speech patterns were less controlled than the adult's and there was evidence that the control continues to improve until the child reaches puberty (Kent, 1976).

Extensive research on various aspects of vowel duration has been done. Di Simoni (1974 c) studied the developmental changes in vowel duration in child speakers (3-, 6- and 9 year old). It was observed that average durations of segments decreased with age, as did the variation in subject productions. In the Indian context, Rashmi (1985) studied vowel duration in children from 4-15 years old and reported that both males and females show a consistent decrease in vowel duration as a function of age.

Earlier research on vowel duration in Indian languages has unraveled interesting findings which are contrary to English language. Language differences exist because of various reasons. The efforts put forth in this area are scanty and more systematic study in different Indian languages is warranted. In this context the present study investigated the developmental changes in vowel duration across three age groups in Kannada language. Specifically, the study investigated the effect of age on vowel duration.

Method

Subjects: Ten subjects with normal speech and hearing, each in three age groups of 7-8 years (children), 14-15 years (adolescents) and 20-30 years (adults) participated in the study. Each group had five male and five female subjects. All the 30 subjects in the three groups had Kannada (Mysore dialect) as their dominant language. Kannada is a Dravidian language spoken by around 20,000,000 people in Karnataka, a state of South India (Nayak, 1967).

Test Material: There are ten vowels in Kannada according to Upadhyaya (1972) Schiffman (1979) and Andronov (1982). These 10 vowels are as follows:

/a/ : Short low central vowel	/a:/ : Long low central vowel
/i/ : Short high front unrounded vowel	/i:/ : Long high front unrounded vowel
/u/ : Short high back rounded vowel	/u:/ : Long high back rounded vowel
/e/ : Short mid front unrounded vowel	/e:/ : Long mid front unrounded vowel
/o/ : Short mid back rounded vowel	/o:/ : Long mid back rounded vowel

In the present study, these 10 vowels were embedded in meaningful bisyllabic words. Totally there were 73 test words. These 73 test words were embedded in the medial position of a three word carrier phrase. The carrier phrase used was “/l: pada _____ a:gide/” (This word is _____). These 73 sentences formed the test material.

Procedure: The subjects were seated comfortably in the sound treated room of the Speech Science Lab at AIISH and were tested one at a time. Subjects were instructed to read the test sentences, each printed on a card, three times into the Cardioid dynamic microphone (AKG D-222). All these were audio-recorded using a Sony deck. The best of the three trials were considered for acoustic analysis. The reading samples were digitized at a sampling frequency of 16 kHz. The program “DISPLAY” of the software SSL (VSS) was used to extract the vowel duration. Vowel duration was measured as the time difference between the onset to the offset of voicing of the vowel V_1 in the word $/C_1V_1C_2V_2/$.

Results

The purpose of the study was to measure the vowel duration in the ten vowels of Kannada in children, adolescents and adults and to compare the duration values across the three groups. The results are discussed under the following four objectives of the study.

- To estimate the mean and standard deviation of vowel duration in the three age groups
- To compare the vowel duration across age
- To compare the vowel duration across gender
- To delineate short VS long vowel ratio in the three groups

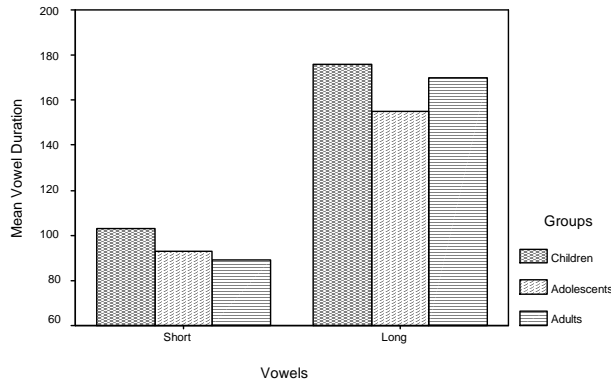
Mean and Standard Deviation of Vowel Duration

Using Descriptive statistics of the SPSS Statistical package, mean and standard deviation were calculated for all the ten vowels of Kannada in the three age groups studied. The results indicated that vowel /u/ was the shortest and vowel /o/ was the longest among short vowels. Also, vowel /u:/ was the shortest and /a:/ was the longest among long vowels. This was observed in both genders and all three age groups studied. Standard deviation reduced from children to adults. Table 1 depicts the Mean and Standard Deviation of vowel Duration in m sec for short and long vowels of Kannada in children, adolescents and adults for males and females.

	Children			Adolescents			Adults		
	M	F	Average	M	F	Average	M	F	Average
a	101(28)	112 (38)	107 (33)	87 (16)	107 (20)	97 (18)	83 (17)	104 (24)	94 (21)
i	103 (29)	100 (23)	102 (26)	82 (16)	100 (25)	91 (21)	82(20)	95 (23)	89 (22)
u	97 (35)	88 (27)	93 (31)	75 (14)	88 (23)	82 (19)	71(17)	81(22)	76 (20)
e	102 (30)	105 (23)	104 (27)	86 (18)	101(24)	94 (21)	83(21)	99 (25)	91 (23)
o	110 (36)	107 (31)	109 (34)	94 (22)	110 (30)	102 (26)	84(20)	104 (31)	94 (26)
Avg	103 (32)	102(28.4)	103(30.2)	84.8(17.2)	101.2(24.4)	93.2(21)	80.6(19)	96.6(25)	88.8(22.4)
a:	190 (31)	208 (45)	199 (38)	159 (26)	196 (27)	178 (27)	162 (26)	206 (44)	184 (35)
i:	157 (37)	175 (37)	166 (37)	142 (33)	157 (37)	150 (35)	146 (26)	179 (43)	163 (35)
u:	148 (38)	173 (35)	161(37)	124 (25)	154 (33)	139 (29)	146 (25)	174 (46)	160 (36)
e:	176 (35)	193 (33)	185 (34)	142 (21)	173 (31)	158 (26)	157 (25)	195 (41)	176 (23)
o:	160 (29)	177 (30)	169 (30)	132 (19)	166 (28)	149 (24)	153 (25)	185 (35)	169 (30)
Avg	166.2(34)	185.2(36)	176(35.2)	139.8(24.8)	169.2(31.2)	154.8(28.2)	152.8(25.4)	187.8(41.8)	170.4(31.8)

Table 1: Mean and Standard Deviation (in parenthesis) of Vowel Duration (in m sec) for short and long vowels of Kannada in children, adolescents and adults for males and females

It was observed that the standard deviation and range reduced from children to adults. The overall average duration of short and long vowels in Kannada for children, adolescents and adults is shown in Graph 1



Graph 1: Mean duration of short & long vowels in Kannada for children, adolescents & adults

Comparison across age: Scaling was done for comparing the vowel across the three groups as a function of age and sex. Earlier scaling was made by Kent (1976) for comparing the formant frequencies of adults and children. On scaling of vowel duration in the present study, the following observations were made:

Scaling across age it was found that in males a) short vowels were longer in children compared to adults by 21 % and compared to adolescents by 17% b) Adolescents had longer short vowel duration than adults by 5%. In females, a) children had longer short vowel duration than adults and adolescents by 6% and 1% respectively b) Similarly adolescents had longer short vowel duration than adults by 5% (Table 2).

In case of long vowels, children had longer duration than adolescents and adults by 16% and 8% and in females they were 9% and 1% respectively. However in long vowels for both males and females, adults had longer duration than adolescents by 9% and 11% respectively (Table2). Hence even though there was a decrease in vowel duration as age increased, it was not linear in case of long vowels. That is vowel duration decreased from children to adolescents markedly and later again increased gradually to adults in both males and females.

Vowel duration	Ch vs Ad		Ch vs Ado		Ado vs Ad	
	M	F	M	F	M	F
Short Vowel	21 %	6 %	17 %	1 %	5 %	5 %
Long Vowel	8 %	1%	16%	9%	- 9 %	- 11 %

Table 2: Shows the percentage by which vowel duration is longer in children Ch) than in adolescents (Ado) & adults (Ad) and longer vowel duration in adolescents compared to adults

On statistical analysis using ANOVA it was observed that there was significant difference in vowel duration across the three age groups for all the vowels in male subjects. The F values are shown for all the 10 vowels in Table 3 ($p < 0.05$). The F values indicate that the main effect across the three groups of males was age. The vowel duration was longest in child males followed by adolescent males and adult males respectively. However there was an exception for long vowels as adolescent males had significantly longer vowel duration compared adult males for the vowels /e:/, /a:/, /u:/ and /o:/.

Short vowels	F value	Long Vowels	F Value
/a/	32.89*	/a:/	19.5*
/i/	21.0*	/i:/	28.30*
/u/	21.13*	/u:/	28.06*
/e/	20.16*	/e:/	19.81*
/o/	20.09*	/o:/	29.11*

* indicates $p < 0.05$

Table 3: F values at degrees of freedom (2,12) across male subjects

Using Duncan's test, pair wise differences were tested across the three groups of males at 5% level of significance and the results are given in Table 4. It is seen that there was significant difference in vowel duration for nine out of ten vowels between children and adolescent/adult males and for six vowels across adolescent and adult males. A linear decrease in vowel duration was observed for short vowels as age increased in male subjects.

Males	/i/	/i:/	/e/	/e:/	/a/	/a:/	/u/	/u:/	/o/	/o:/	Total
Ch Vs Ado	P	P	P	P	P	P	P	P	A	P	9/10
Ch Vs Ad	P	P	P	P	P	P	P	A	P	P	9/10
Ado Vs Ad	A	A	A	P	P	P	P	P	A	P	6/10

(Ch- Children, Ado- Adolescents, Ad- Adults) P- Significant difference present A- Significant difference absent

Table 4: Shows the significance of difference across the three age groups of males for short vowel duration in Kannada at 0.05 level

Similarly using ANOVA, it was observed that there was significant difference in vowel duration across the three groups of female subjects for all the vowels except for the short vowel /u/. The F values are shown for all the 10 vowels in Table 5 below ($p < 0.05$). The F values indicate that the main effect across the three groups of females was age. The results indicated that children had longer vowel duration than adolescents and adolescents had longer vowel duration than adults in the female groups also. Nevertheless, as seen in males here also there was an exception in the case of all the five long vowels which had significantly longer duration in adult females compared to the adolescent females.

Short Vowels	F value	Long Vowels	F Value
/a/	28.37*	/a:/	25.15*
/i/	19.8*	/i:/	22.35*
/u/	10.2	/u:/	29.93*
/e/	21.19*	/e:/	19.99*
/o/	30.13*	/o:/	19.89*

* indicates $p < 0.05$

Table 5: F values at degrees of freedom (2, 12) across female subjects

Using Duncan's test, pair wise differences were tested across the three age groups of females at 5% level of significance and the results are given in Table 6. It is seen that in female subjects, there was significant difference in vowel duration between children and adolescents (6/10) rather than between children and adults (2/10). Comparing adolescents and adults, the vowel duration was significantly longer in adults for five out of ten vowels.

Females	/i/	/i:/	/e/	/e:/	/a/	/a:/	/u/	/u:/	/o/	/o:/	Total
ChVs Ado	A	P	A	P	P	P	A	P	A	P	6/10
Ch Vs Ad	A	A	A	A	P	A	A	A	P	A	2/10
Ado Vs Ad	P	P	A	P	A	P	A	P	A	P	5/10

Ch- Children, Ado- Adolescents, Ad- Adults P- Significant difference present A- Significant difference absent

Table 6: Shows the significance of difference for the three age groups of females for vowel duration in Kannada at 0.05 level

Comparison across gender: On scaling across gender, in children, males and females had almost equal short vowel duration. In adolescents and adults, short vowels in females were longer by 16% and 17% respectively compared to their male counterparts (Table 7).

On scaling across sex for long vowels, in children, females had longer duration by 10%. In adolescents and adults also females showed longer vowel duration than males by 17% and 19% respectively (Table 7).

Vowel	Children	Adolescents	Adults
Short	0%	16%	17%
Long	10%	17%	19%

Table 7:Percentage by which the female subjects had longer vowel durations compared to their male counterparts in different age groups.

On statistical analysis using t test, it was observed that there was significant difference in vowel duration across gender in all the three groups for all the vowels except for /e/ and /o/ in children. The F values are shown for all the 10 vowels in Table 8 below (p<0.05).

M vs F	/i/	/i:/	/e/	/e:/	/a/	/a:/	/u/	/u:/	/o/	/o:/
Ch	3.13	2.41	1.92	2.92	2.90	2.95	2.51	2.88	1.63	2.82
Ado	4.19	2.59	2.92	3.53	3.19	2.73	2.83	3.63	3.92	3.8
Ad	4.45	3.03	2.86	3.01	4.04	4.09	4.09	4.13	4.11	4.2

* indicates p < 0.05, Ch- Children, Ado- Adolescents, Ad- Adults

Table 8: Shows the F values at degrees of freedom (2, 12) across males & females subjects

Table 9 shows the presence and absence of significant difference in short and long vowel duration across the different age groups of males and females separately.

M vs F	/i/	/i:/	/e/	/e:/	/a/	/a:/	/u/	/u:/	/o/	/o:/	Total
Ch	P	P	A	P	P	P	P	P	A	P	8/10
Ado	P	P	P	P	P	P	P	P	P	P	10/10
Ad	P	P	P	P	P	P	P	P	P	P	10/10

Ch - Children, Ado- Adolescents, Ad- Adults, P- Significant difference present A- Significant difference absent

Table 9: Shows the significance of difference between males and females for vowel duration in Kannada at 0.05 level

Short vs. Long vowel ratio: On calculation of short versus long vowel ratios, it was observed that the ratio increased from children to adults. In adult males and females the long vowels were almost twice the length of the short vowel. But in children and adolescents the difference in short/long vowel duration was less distinct compared to adults. Table 10 shows these ratios in males and females for different age groups.

	Children (M)	Children (F)	Avg	Adolescents (M)	Adolescent (F)	Avg	Adults (M)	Adults (F)	Avg
Ratio	1:1.6	1:1.8	1:1.7	1:1.6	1:1.7	1:1.65	1:1.9	1:1.9	1:1.9

Table 10: Short Vs long vowel ratios in children, adolescents and adults for males and females.

Discussion

The initial part of the study dealt with the mean values and standard deviation of vowels in the three groups. The study showed that the high vowels /u/ and /u:/ among the short and long vowel categories were shortest in all the three age groups studied. This is exactly in consonance with the earlier study in Kannada on adult vowel duration by Venkatesh (1995). Also the mid vowel /o/ and low vowel /a:/ were longest in all the age groups in the present study. Data of Venkatesh (1995) also revealed that /e/ and /a:/ in males and /e:/ in females were the longest which are again mid and low vowels. These findings indicate that as the tongue height increased, the duration of the vowel decreased. The shorter duration of high vowels may be due to the requirement of greater effort to produce them. This finding is also in agreement with Savithri (1984) in Sanskrit and Savithri (1986) in Kannada.

It was also observed that the variability and range of vowel duration decreased from children to adults. These findings are also in support of earlier studies, where in they report that temporal variability decreased as children get older (Eguchi & Hirsh, 1969, Tingley & Allen, 1975; Kent, 1976; Smith, Sugarman & Lang, 1983).

The second part of the study focuses on comparison of vowel duration across age. It was seen that vowel duration in Kannada decreased from children to adults. The findings are in support of earlier studies by Smith (1978) and Kent & Forner (1980) where they have reported that children's speech segments are frequently longer in duration than those of adults. As the young children's speech segment duration are often longer than those of adults, Smith and Gartenberg (1984) hypothesized that at least two factors could be responsible for the temporal differences which have been observed in acoustic measurements of children's and adult's speech. They state that "it is possible that physical characteristics of children's less mature speech mechanisms might limit the rate at which they perform articulatory movements due to factors such as development of the nervous system and/or growth of the orofacial region (Crelin, 1973).

The second factor for children's longer vowel durations could be a result of not yet having learned to anticipate and plan sequences of speech gestures in the same manner as adults do (Kent & Forner, 1980). Smith and Gartenberg (1984) suggested that the longer acoustic durations on children's versus adult's speech seemed to involve both physical level and organizational level factors. Rashmi (1985) reported that both males and females show a consistent decrease in vowel duration as a function of age from 4 to 15 years. Elizabeth (1998) has reported longer vowel duration in children aged between 7-8 years than in adults of Malayalam language. She attributed the reduction in vowel duration to neuromuscular maturation and progress in speech motor control.

There seems to be no obvious reason for the longer duration observed in the adult group compared to the adolescent group in the present study. It is possible that a more homogenous group was selected in the 14-15 year group compared to the adults whose age range varied from 20-30 years and moreover the rate of speech was not controlled during the recording procedure. Most previous studies have examined the acoustic differences between children and adults. As acoustic data on 14-15 year group is limited, further research should help clarify this finding.

The next part considered in the study was the comparison of vowel duration across sex. The study revealed that females had longer vowel duration than males which is also in consonance with several earlier reports. Zue and Lafferiere (1979) observed that longer vowel duration characterized female speech. Rashmi (1985) has reported longer vowel duration in female subjects compared to males in the age range of 4 to 15 years. Savithri

(1984) in Sanskrit and Savithri (1986) and Venkatesh (1995) in Kannada, observed that the vowels produced by female speakers had longer duration than the male speakers. Similar results were reported by Elizabeth (1998) in Malayalam for both children and adults. The longer vowel duration in females may be related to the higher fundamental frequency used by them. Further the vowel duration decreased as a function of age in both males and females which may possibly be due to the decrease in fundamental frequency with age. Study by Nataraja and Jagadish (1984) has also shown a relationship between the vowel duration and fundamental frequency, that is the duration of vowels /i/ and /u/ at high and low frequencies were significantly longer than at the normal fundamental frequency in case of males and females.

The fourth objective of the present study was to establish the short versus long vowel ratios. It was observed that the ratio of short versus long vowel duration increased from children to adults. In adult males and females the long vowels were almost twice the length of short vowels as reported earlier by Savithri (1989) in Sanskrit and Venkatesh (1995) in Kannada. Shalev, Ladefoged, & Bhaskararao, (1993) found that in Toda language, the mean duration of short vowels was 68 ms and that of long vowels, 139 ms. The short-long ratio was therefore 1:2.04. sasidharan (1995) reported that in Malayalam, the short-long vowel ratio was 1:1.89. Engstrand and Krull (1994) studied vowels in Swedish, Finnish and Estonian languages and found short and long vowel contrasts, similar to the earlier studies. Therefore the relationship between short and long vowels must be language dependent. In some languages, it may be invariant across contextual influences, whereas in other languages it may vary as a function of various other factors. In languages like Kannada, which have distinct duration differences, duration also acts as a cue for stress.

Conclusion

The findings of this study are that, in Kannada, mean vowel duration its variability and range decreased from children to adults. The developmental trend was more evident for the short vowels than for the long vowels of Kannada. In all the three groups studied, female subjects had longer vowel duration compared to their male counter parts. And the durational ratio of short versus long vowels increased from children to adults. This study provides vowel duration data in children, adolescents and adults where as most of the literature reports confine to either children or adults. The data obtained is useful in synthesizing Kannada vowels and recognition of the same. This information can be used in the assessment of speech deviations in patients with hearing impairment, stuttering, dysarthria etc. It can also aid in post therapy validation of such cases.

References

- Aggarwal, S.S. (1988): Acoustic-phonetic studies and speech data base for Hindi. In Rao, P.V.S. & Aggarwal, S.S. (Ed.), Proceedings: Second International Workshop in speech Processing. Bombay: Tata Institute of Fundamental Research.
- Andronov, M.S. (1982): The Navakarnataka Publishing House. Central Department of Oriented Literature (II Edn.), Moscow.
- Balasubramanian, T. (1981): Duration of vowels in Tamil. *Journal of phonetics*, 9, 151-161.
- Crelin, E.S. (1973): *Functional anatomy of the newborn* (Yale U.P., New Haven).
- Di Simoni, F.G. (1974c): Influence of utterance length upon bilabial closure for /p/ in 3-6 and 9 year old children, *Journal of Acoustical Society of America*, 55, 1353-1354.
- Gopal, H.S. (1987): Temporal aspects of tense and lax vowels in American English: Effects of speaking rate and post vocalic consonant voicing. Un published Doctoral Dissertation, Dallas, University of Texas.
- Engstrand, O. & Krull, D. (1994): Durational correlates of quantity in Swedish, Finnish & Estonian: Cross-language evidence for theory of adaptive dispersion. *Phonetica*, 51, 80-91.
- Eguchi, S. & Hirsh. I.J. (1969): Development of speech sounds in children, *Acta Otolaryngologica*, Suppl, 257.

- Elizebeth (1998): Analysis of speech of Malayalam speakers. Research at AIISH, Dissertation Abstracts, Vol IV, 2003
- Fischer – Jorgensen, E. (1955): Om vokallaengde I danskrigsmal, nordisk tidsskrift for tale og stemme. In Lehiste, I. (1970), *Suprasegmentals*, Cambridge: MIT Press, p33-56.
- Kent, R.D. (1976): Anatomical & Neuromuscular maturation of the speech mechanism : Evidence from acoustic studies. *Journal of speech and hearing research*, 19, 421-447.
- Kent, R.D. & Forner, L.L. (1980): Speech segment durations in sentence recitations by children and adults, *Journal of Phonetics*, 8,157-168.
- Majumdar, D.D., Datta, A.K. & Ganguli, N. R. (1978): Some studies on acoustic – phonetic features of Telugu vowels. *Acoustica*, 41, 2, 55-64.
- Nagamma Reddy, K. (1988): The duration of Telugu speech sounds: an acoustic study. *Special issue of JIETE on speech processing*, 57-63.
- Nataraja, N.P. & Jagadish, A. (1984): Vowel duration and fundamental frequency. *Journal of All India Institute of Speech and Hearing*, 15, 57-64
- Nayak, H.M. (1967). *Kannada literacy and colloquel: A study of two styles*. Mysore: Rao & Raghavan.
- Rajapurohit, B.B. (1982): *Acoustic characteristics of Kannada*. Mysore: Central Institute of Indian Languages. Occasional Neurograph Series.
- Rashmi, M. (1985): Acoustic aspects of speech of children. Research at AIISH, Dissertation Abstracts, Vol II, 2002
- Savithri, S.R. (1981): Speech production: Indian perspective. *Journal of All India Institute of Speech and Hearing*, 63-68.
- Savithri, S.R. (1984): Relationship between the fundamental frequency and duration. Unpublished research, conducted at All India Institute of Speech and Hearing, Mysore
- Savithri, S.R. (1986): Durational analysis of Kannada vowels. *Journal of Acoustical Society of India*, 14 (2), 34-41.
- Savithri, S.R. (1989): Acoustic and psychological correlates of speech. *Journal of Acoustical Society of India*, 17, (3, 4), 41-48.
- Sasidharan, P. (1995): Vowel duration in Malayalam language. Research at AIISH, Dissertation Abstracts, Vol III, 2002
- Schiffman, H. (1979): Reference grammar of spoken Kannada. Final report, OE, 0100-78-01, 861, Sept. 79, US Department of Health, Education and Welfare, Washington.
- Shalev, M., Ladefoged, P. & Bhaskara Rao, P. (1993): Phonetics of Toda. *UCLA Working papers in phonetics*. 84, 89-126.
- Smith, B.L. (1978): Temporal aspects of English speech production: A developmental perspective, *Journal of Phonetics*, 6, 37-67.
- Smith, B. L., Sugarman & Lang, (1983): Cited in Smith B.L., (1994), Effects of experimental manipulations and intrinsic contrasts on relationships between durations and temporal variability in children's and adult speech, *Journal of Phonetics*, 22,155-175.
- Smith, B. L. & Gartenberg, T. (1984): Initial observations concerning developmental characteristics of labiomandibular kinematics. *Journal of Acoustical Society of America*. 75, 1599-1605.
- Tingley, B.M. & Allen, G.D. (1975): Development of speech timing control in children, *Child development*, 46, 186-194.
- Upadhyaya, U.P. (1972): *Kannada phonetic reader*. Mysore, Central Institute of Indian Languages.
- Velayudhan, S. (1975): *Vowel duration in Malayalam; an acoustic phonetic study*. Trivandrum: Dravidian Linguistic Association of India.

Venkatesh (1995): Acoustic analysis of Kannada speech sounds (vowels). Unpublished Doctoral Thesis, University of Mysore

Zue, V.W. & Lafferiere, M. (1979): Acoustical study of /t/, /d/, in American English. *Journal of Acoustical Society of America*, 66, 1039.

Zwirner (1959): Phonometrische Isophonan der Quantitat der deutschan Mundarten, *Phonetica*, 4 (Suppl), 93-125.

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