VOICE ONSET TIME IN CHILDREN

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The present study reports VOT for stop consonants \p\, \t\ and \k\ in children. 100 male and female children belonging to 5 age groups, ranging from 4-12 years were used to elicit 3 sentences as responses to 3 picture cards. The sentences elicited as responses consisted of the consonants /p/ and \k\ in initial position and /t/ in medial position of the words. These were analyzed using High Resolution Signal Analyzer (B and K 2033) to obtain VOT. The results showed that there was no significant difference in VOT between males and females. Between different age groups of the same sex, except for the children of 4-5 years, no other group had shown significantly different VOT values.

" Today we are able to measure the acoustic or audible aspects of voice with sophisticated equipment. The voice analyzer, sonograph, airflow meter, pressure recorder and the computerized models of the vocal tract enable investigations to confirm earlier empirical findings and unearth new aspects of vocal sound characterization. The physiological aspects of sound production such as breathing pattern, vocal attack, vocal fold vibration, and some resonance qualities can be revealed by acoustic means" (Bunch, 1982).

The literature concerned with development of speech in children have provided much information on grammatical, contextual and syntactic aspects, however, less on phonetic aspects (Irwin, 1943, 1945) of speech development. Phonetic studies, particularly since the introduction of the sound spectrograph in 1946, have clarified certain acoustical characteristics of speech sounds (Joos, 1948; Basu, 1979; Ravishankar, 1981 ; Indira, 1982).

" The past two decades have been witness to an increasing applications of acoustic analysis to the study of speech development in children (Kent, 1976). However, it can be observed that acoustic data have been collected in three major areas :

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(1) Vocal fundamental frequency,

(2) Static formant patterns of vocalic sounds and

(3) Temporal properties such as Voice onset lime, rates of formant movement, and segment duration.

Sometimes the physiologic and phonetic interpretation of acoustic data are uncertain, but acoustic analysis is appropriate to test certain hypothesis about developmental changes in anatomy, motor control and phonological function.

Such acoustic analysis have been considered to be useful in knowing more about the developmental disorders and thus in the treatment of developmental disorders of speech.

Voice onset time (VOT) is one of the parameters among the temporal features of speech. VOT may be defined as 'the duration between the release of a complete articulatory constriction or burst transient and the onset of phonation' (Lisker and Abramson, 1964, 1967).

VOT has been found to be affected by several variables such at age, articulatory position and language. VOT has >ecn found to be more during early childhood upto certain age (Kewly-Port and Preston 1974). It has been stated that the changes in the VOT distributions that occur during the first six years of life appears to be fairly systematic 'Kent 1976).

The nature of the sound,i. *e., whetther it is voiced* or voiceless is determined by the voice onset time. When the voice onset occurs after the articulatory rtlease, the sound will be unvoiced, while qwhen the voice onset occurs before or simultaneously with the relealese of the articulators, the sound will be considered as voiced. The term voice ouset refers to initiation of vocal cord vibration.

Menyuk and Klatt (1975) in their study on VOT in consonant cluster production by children and adults report that overall timing characteristics were similar for children and adults. VOT generally increased from labial to dental to velar clusters. Children's VOT averages were generally, but not Significantly, longer than adults in all context and the co-ari.iculation constraints affected the accuracy with which children produced the stops and liquid portion of a particular cluster. Kent (1976) noted fairly systamatic changes in the VOT distributions during the first six years of life. The majority of stops in the early years of the child are characterized by the occurrence of a short delay between articulatory

release and the onset of vocal fold vibration. Shortly thereafter, the VOt distributions of children begin to assume a form which is similar to that of adult speakers. By the age of six the ranges of VOT values for voiced and voiceless stops overlap to a greater degree than for adults. Voicing lead (negative values of VOT, for which voicing precedes articulatory release) becomes more common with maturation, especially for bilabials. In addition, the variability of VOT decreases so that adult like stability of production is noted at about eighth year of life.

The unstable and infrequent occurrences of lead in the production of voiced stops and long lag in the production of voiceless stops during the early period of life is attributed to lack of consistent control over the timing of laryngeal and supraglottal articulatory events.

Kent (1976) Eguchi and Hirsh (1969) have opined that the distinctive acoustic cue, VOT is helpful to assess the general process of motor skill acquisition, since VOT production distributions appropriate to the child's language are acquired during the period of speech sound learning. Morley (1965) reports that as the child acquires productive control over voicing VOT values will change concomitantly.

VOT has been found to vary between stutterers and non-stutterers, *i.e.*, stutterers have been found to have longer VOT than normals (Agnellos and Wingate, 1972 ; Hitman and Gilbert, 1977 ; Basu 1979).

Thus the review indicates that the VOT is determined by the anatomical and the neurophysiological condition of the speech mechanism. Therefore any deviations in VOT would indicate the possible abnormalities in neurophysiological and/or anatomical maturation. As the VOT has been found to vary between stutterers and non-stutterers, measurement of VOT may become a useful tool in differential diagnosis of stuttering and may be used to evaluate various stuttering therapies.

Method

One hundred children (age ranging from 4-12 years), both males and females, with Kannada as mother-tongue were considered for the study. All the subjects were normal in terms of speech language and hearing and were attending normal schools.

Three sentences in Kannada which could be picturised were selected. They were :

1. Idu papu (this is baby) ಇದು ಪಾಪು
2. Idu koti (this is monkey) ಇದು ಕೋತಿ
3. Idu kempu banna (this is red colour) ಇದು ಕೆಂಪು ಬಣ್ಣ

These sentences were selected as they were found to be within the vocabulary of the children, age ranging 4-12 years- Further, it was found to be easy to elicit spontaneous speech (as answers to the question what is this, by showing the picture cards).

The stop consonants /p/, /t/, /k were extracted from the word papu, koti and kempu for the purpose of measurement of VOT.

Each subject was instructed as follows in Kannada : "I will show you three picture cards and I want you to tell me what you see in the picture".

Whenever the expected answer was not elicited the child was provided with the answer and it was used as a trial, for example, some children did not use the word papu or koti; such children were provided with the words which the investigator wanted them to say.

Each subject was presented the stimulus cards randomly and the investigator asked them to say what they saw in the picture by asking the question "what is this ? ".

The responses were recorded using National Panasonic Tape Recorder (Model RQ. 2175) and Sony CHF-90 cassette in the Speech Laboratory of All India Institute of Speech and Hearing.

Of the nine sentences spoken by eaeh subject, three responses representing three different sentences were selected on she basis of presence of loss interfering noise, absence of a discrete observable plosive release, and/or in appropriate productions (for example, shouted, whispered or grossly exaggerated responses). These utterances of the subjects were transferred from the cassettes to a spool tape using Uher (Model SG 630 Logic) tape recorder. Line recording technique was used for selecting and transferring the speech samples from the cassettes to the spool tape. Measurements of VOT were done using High Resolution Signal Analyzer (B and K 2033) (HRSA.)

No literature was available to the investigator regarding the use of HRSA for the measurement of VOT.

A pilot study was carried out to evaluate the reliability and validity of **HRSA** in the measurement of **VOT** by comparing **VOT** values measured by spectrographic analysis. It was found that the VOT measured using HRSA was valid.

To find out the VOT of the stop consonants / p / from Papu, / k / from Koti and Kempu and / 1 / from Koti the necessary settings were made on the **HRSA.** The signal was fed from a tape recorder. As soon as the required word appeared on the display screen, the ' Stop ' Key was applied. The cursor was moved to the point on the horizontal line to the last dot as it was considered as the representation of the end of the stop burst. This gave the initial reading in milliseconds, *i.e.,* the end of the release of stop consonant and then the cursor was moved to the point where the regular vertical striations appeared on the display screen, as this was considered as corresponding to the beginning of the vowel. The time reading at this point was noted and the difference between this reading and initial one was considered as VOT for that particular consonant. Using this procedure **VOT** for all the four stop consonants, from the three test sentences, were determined.

Results and Discussion

The stop consonants / p /, /1 / and / k/ were taken from the words of the test sentences.

TABLE I. Showing the Mean duration and standard deviation of stop consonants in males and females

	Males				Females			
	/k/empu	/k/oti	ko/t/i	/p/apu	kem/p/u	/k/oti	ko/t/i	/p/apu
4-5	27.9 4.61	28.24 5.61	35 3.37	18.9 4.28	20 4.62	20.6 6.52	26.6 8.85	15.3 3.27
5-6	22 7.8	19.86 8.24	26.1 7.81	13.77 4.65	18-28 5.07	20.6 4.09	24 5.21	14.88 2.75
7-8	20.94 5.11	17.93 4.01	23.21 4.07	15.66 3.07	20.13 6.64	32.1 3.78	27.5 6.63	15.5 2.76
9-10	22.3 6.06	20.4 5.10	23.8 3.81	15.9 3.28	28.05 3.67	27.9 6.87	35.7 8.23	18.3 8.65
11-12	23.7 10.65	20.7 4.42	25.2 6.83	13.9 2.28	23.5 5.25	22.2 5. 70	28.5 6.98	14.6 2.72

Table I shows the results of comparison of mean VOT value of all the four consonants of different age groups of both males and females. The males of 4-5 years of age have differed significantly from all other age groups presenting higher VOT values for all the consonants. No other age group has shown any significant variations with other age groups. The females have shown, as can be made out from Table I, inconsistent variations. Group 9-10 years has shown significant difference in VOT than all other age groups and has presented greater VOT values than the other groups. Hence there is no significant change in VOT of the stop consonants with increase in age. both in males and females.

In conslusion it can be stated that /t/ occuring in the medial position in the word- Koti has consistently shown higher VOT values, next being /k / occurring bath in Kempu and Koti and finally /p/, occurring in Papu, showed the least values in both males and females.

According to the study by Kavishankar (1981) /k/ had the highest mean VOT, /p/ had lowest VOT and. /t/ occuring in between in both males and females, age ranging from 4-10 years. This study has considered, the consonants in isolation. Table II' shows a comparison of mean VOT values, as reported by different investigators.

The comparison of the VOT values of the present study with the previous studies on Indian population using Kannada shows that there is not much difference in the VOT values of / p / both in males and females in the age ranges studied. The VOT values of / p /, in the present study, have been higher than the adult VOT values given by Basu (1979). This may be because of the fact that Basu had studied the VOT values of voiceless stop consonants in reading, in isolation whereas in the present study, VOT of the voiceless consonants have been taken from spoken words. Similarly /t/ has shown higher values than in the previous studies. But surprisingly the VOT values for /k/ in the present study have been lower than that of previous studies. These differences may be attributed to the kind of sample studied and the place of consonant in the word.

Many investigators (Lisker and Abramson, 1964 ; Hillman and Gilbert 1977 ; Basu 1979 ; Ravishankar 1980) have reported that there was a consistent increase in VOT with respect to position of articulatory constriction (as it moved backward in the oral cavity) However, in the present study this has been found to be not true, as /t/ has shown higher VOT values than /k/. This may be because of the fact that, the VOT values had been measured using /t/ occurring in the medial position of the word /Koti/.

While discussing the results of then study with respect to VOT Eguchi and Hirsh (1969) state that "the mean time interval as measured here does not change systematically with age, and also that, there is wide variation among individuals pronouncing the same phonetic sequence . These two observations are in accord

TABLE II. Showing the comparison of mean VOT values obtained by various studies with present study

Years	p		t		k	
	R.S.	P..S.	R.S.	P.S.	R.S.	P.S.
Males						
4-5	18.40	18.90	22.40	35.00	41.00	28.07
5-6	18.00	13.77	18.40	26.10	42.40	20.93
7-8	18.40	15.66	17.40	23.21	38.60	19.43
9-10	16.00	15.90	23.00	23 • 80	40.00	21.30
Females						
4-5	14.20	15.30	18.00	26.60	27.00	20.30
5-6	20.20	14.88	20.40	24.00	42.00	19.44
7-8	10.20	15.50	11.80	27.50	24.80	21.61
9-10	20.00	18.30	22.60	35.70	45.00	27.97
Adult Males	10 •06.*		13•93*		30. 96*	

R.S. = Ravishankar (1981)
P.S. = Present study
* = Babul Basu (1979)

with... .other investigators, with respect to VOT". Similar findings have been observed in the present study, for example VOT of / k / by the same group of subjects in two different words have shown variations.

Earlier studies have indicated that there was no significant difference in VOT values for voiceless stops with increase in age in both males and females (Ravishankar, 1981). The present study has also indicated that there was no significant difference in the VOT values with increase in age both in case of males and females. Further this study has also shown that there was no significant difference in the VOT values shown between males and females of the same age group. Similar findings have been reported by Ravishankar (1981).

Kent (1976) in his tutorial on Anatomical and Neuromuscular maturation of the speech mechanism : Evidence from acoustic studies states that the measurement of formant frequencies and VOT, have applications to the identification and diagnosis of developmental disorders.

As VOT reflects the ability of an individual to control the, neuromuscular system of speech, the study of VOT may contribute to the understanding of various speech pathologies (Kent. 1976: Eguchi and Hirsh, 1969; Basu. 1979; Ravishankar, 1981).

The present study provides in formation regarding the changes in VOT with age, differences in VOT between males and Females and norms for the age range 4-12 years, for both males and females, which can be used to note the variation in VOT in clinical population.

Thus, the results of present study will be useful in identification, diagnosis and treatment of various speech and voice disorders.

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