Voice Onset Time for
Stutterers and Nonstutterers

BABUL BASU

A Dissertation submitted in part fulfilment for the Degree of
Master of Science (Speech & Hearing)
University of Mysore
1979

To my Parents

CERTIFICATE

This is to certify that the dissertation entitled "VOICE ONSET TIME FOR STUTTERERS AND NON STUTTERERS" is the bonafide work in part fulfilment for IV Semester M.Sc., Speech and Hearing, carrying 100 marks, of the student with Register No. 1.

(N.RATHNA)
Director in-Charge,
All India Institute of speech & Hearing,
Mysore.

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CERTIFICATE

This is to certify that this dissertation has been prepared under my supervision and guidance.

Guide

18/7/79

DECLARATION

This dissertation is the result of my own study undertaken under the guidance of Mr. N.P.Nataraja and has not been submitted earlier at any university for any ether diploma or degree.

BABUL BASU

Mysore, Register No. 1

Dated

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CHAPTER I

INTRODUCTION

> "stuttering is a baffling disorder for both client and clinician. It is amazing that such an ancient universal, and obvious human problem should defy precise description; despite countless scientific investigations, the basic nature and cause of stuttering remain a mystery"
>
> (Emrick and Hatten, 1974)

The literature of stuttering is a welter of confusions in all the areas like definitions, the nature, the origin and maintenance and the therapy.

> "Stuttering has probably received more attention than any other speech disorder because of the way in which it dramatically exposes many of the unpleasant sides of social living. It is the dark mirror of speech, reflecting man's frustrations in communicating with his fellows. It portrays his fear of social penalties; it reveals his shame for deviancy; it is the hallmark of man's inability to communicate with his fellows"
>
> (Van Riper, 1971)

From the time of Aristotle (384 BC) till today various 'theories' have been put forward to explain the onset, development and maintenance of stuttering. (Cerebral dominance theory by Orton 1927, Travis 1931, and Bryngelson 1935, Conflict theory by Sheehan 1958, Diagnosogenic theory of stuttering by Johnson 1957, Wischner's Anticipatory theory of stuttering 1947, 1950, 1952, Delayed Auditory Feedback theory by Lee & Black 1950, 1951 and other theories).

> "There is something about the sight of an adult in the throes of a severe moment of stuttering which immediately suggests that there must be something organically wrong with him."
>
> (Van Riper, 1971)

Larynx has been thought to be the culprit even in very early days (Avicenna 1037, Hann 1736, Morgagni 1731, Serre d'Alais 1829, Arnott 1829).

Recently the explanation regarding the basic nature, cause and maintenance of stuttering has been given on the basis of laryngeal dysfunction again.

Schwartz (1974) has attempted to explain stuttering behavior on the basis of evidences from various areas like respiratory physiology, speech pathology, speech science and learning psychology. According to his model stuttering is due to "......an inappropriate vigorous contraction of posterior crico-arytenoid in response to the subglottal air pressure required for speech".

Mackenzie (1955) has found a complete reduction in stuttering for stutterers who had used electro larynx. There have been reports that the stutterers who had used esophagial speech did not show stuttering behavior. (Oldray 1953, Irving and webb 1961).

Wingate (1969) has suggested that 'Vocalization is a crucial element in the complex of stuttering'. His suggestion is based on his belief that the 'artificial fluency' during singing, whispered speech, silent reading and rhythmic speech for stutterers is due to the change or absence of vocalization during those speech acts.

Adam and Reis (1971) have reported that stutterers showed remarkably less stuttering when they read a passage containing 'all voiced' sounds than the one which contained 'both voiced and voiceless' sounds.

Wyke (1972) suggested that some categories of stuttering may involve temporal incoordination of activity in one or more of the neurological mechanism controlling laryngeal muscles.

Attempts have been made to reduce stuttering using bio-feedback of laryngeal muscle activity. Hanna et. al. (1975) have found improvement in fluency in stuttering behavior. Guitar (1975) has observed a reduction in stuttering using analogue electromyographic feedback from both laryngeal and lip Sites.

Electramyographic study (Freeman and Ushijima, 1975) of four intrinsic muscles of larynx has shown that there is a tendency for antagonistic muscle to contract simultaneously during stuttering behavior of a stutterer instead of reciprocal contraction, as it happens in case of normal phonation.

Thus the review of literature indicates that larynx plays an important role in stuttering. The "inappropriate vigorous contraction of posterior crico-arytenoid" as suggested by Schwartz (1974) and the simultaneous contraction of intrinsic muscles of larynx as observed by Freeman and Ushijima (1975) during stuttering might result in a change in the temporal aspect of speech with respect to voicing.

Voice onset time (VOT) is one of the parameters among the temporal aspect of speech. VOT has been defined as "The duration between the release of a complete articulatory constriction or burst transient and the onset phonation Lisker and Abramson 1964, 1967).

There have been reports that stutterers vary from normals in terms of VOT measurements. Agnello (1970) has found that the voice onset and voice termination times in 'fluent' speech of the stutterers were longer than that of the non-stutterers. Starkweather et. al. (1976) have observed that stutterers were slower in initiating vocalization. Hillman and Gilbert (1977) have reported that VOT values of stutterers for intervocalic voiceless stop consonants in fluent contextual speech were significantly higher than that of normals.

There have been only two methods reported in the literature for the measurement of VOT, wideband spectrograms and optical oscillograph method.

VOT has been found to be more during early childhood upto a certain age. (Preston, Yeni-Komshian and Stark 1967; winter, Korn, Mac Keilage and Preston 1967; Eimas et.al., 1971; Kewley-Port and Preston 1974; Stark 1972; Trehub and Rubinovitch 1972; Zlatin and Koenigsknecht 1975, 1976).

Language has been found to be another variable. (Lisker and Abramson 1964, Abramson and Lisker 1967, Yeni-Komshian, Preston and Benson 1968). Lisker and Abramson (1964) have studied VOT for many languages including Hindi, Tamil and Marathi. They have found that VOT varies from language to language. There have been no study reported regarding the VOT values in Kannada language.

VOT has been found to be different for different stop consonants depending upon the place of articulation. (Lisker and Abramson 1964, 1967, Hillman and Gilbert 1977).

While producing the syllables with voiceless stop sounds (cv), the release of the complete articulatory constriction precedes the voicing where as for voiced stop-vowel paradigm the voicing is either simultaneous or precedes the articulatory release. Hence, the VOT valves have been found to be positive in case of voiceless stop-vowel paradigms, where as they have been found to be either zero or negative for voiced stop-vowel paradigm. (Lisker and Abramson 1964, 1967).

Brown (1938) Eisenson and Horowitz (1945) and wingate (1967) have shown that speaking pattern of the stutterers are different for 'isolated' 'contextual' speech. So context might play a role for the variations in voice onset time measurements.

Summerfield and and Haggard (1972) have found that VOT varies with speaking rate. Their experiment has shown that VOT decreases with increase in speaking rate.

Thus the present review of literature shows that laryngeal muscle activity of the stutterers is different than that of non stutterers during speech and VOT's for voiceless stop consonants are more for stutterers than non stutterers.

So, it was intended to study the VOT for both voiced and voiceless stop sounds of Kannada language for normal speakers and to compare them with stutterers.

statement of the problem

The problem is to study the voice onset time values for both voiced and voiceless stop sounds of Kannada language in spontaneous reading and syllables in isolation for normal speakers and to compare them with those for stutterers.

Purpose of the study

The purpose of the study is to test the following hypotheses:

1. There will be no difference between stutterers and non stutterers for VOT values of voiceless stop sounds, (a) in

reading (b) in isolation.

2. There will be no difference between stutterers and non stutterers for VOT values of voiced stop sounds, (a) in reading (b) in isolation.

3. (a) There will be no difference between VOT for voiced stop sounds and VOT for voiceless atop sounds in non stutterers.

(b) There will be no difference between VOT for voiced stop sounds and VOT for voiceless stop sounds in stutterers.

4. There will be no difference between the VOT for syllables in isolation and VOT for the same sounds in spontaneous reading, (a) in stutterers (b) in non stutterers.

5. There will be no difference between the VOT for each sounds with respect to the position of articulatory constriction, (a) in stutterers (b) in non stutterers.

6. There will be no difference between the VOT for stop consonants in Kannada and the reported VOT for stop consonants in other languages in non stutterers.

To test the hypotheses,5 stutterers and 5 non stutterers were taken. The two groups of subjects were matched in terms of age, sex and language background. The subjects read a Kannada passage specially designed for the study which contained (p), (t), (t), (k); & (b), (d), (d), (g) sounds. The subjects also read the syllables in isolation of the aforesaid sounds with the vowel (a) (in cv paradigm).

The speech samples were recorded using a cosmic sterio deck cassette recorder in sony cassette. The recording was done in a sound treated roost used for audiometry. The word initial segments and the syllables in isolation which contained (p), (t), (t), (k) and (b), (d), (d), (g) sounds were transferred to another sony cassette with the help of another cosmic sterio deck cassette recorder. The speech samples thus obtained were analyzed with the help of a Kay's Sona-Graph Model 6061 B. VOT measurements were done using the technique followed by Lisker and Abramson (1964).

Limitations of the study

1. Only 5 stutterers and 5 non stutterers were included for the study because of the nonavailability and the cost of spectrogram papers.

2. Differentiation of VOT with reference to various groups of stutterers in terms of severity was not studied.

3. Sex difference for VOT was not studied.

4. VOT's for spontaneous speech and words in isolation were not studied.

5. VOT's for the atop sounds in word medial and word final positions in spontaneous reading were not studied.

Implications of the study

1. The study provides information regarding VOT's among stutterers and normals.

2. The study gives information regarding VOT's of stop sounds classified depending upon the place of articulation.

3. The study also indicates VOT's for isolated stop sounds and that in reading.

4. It may be possible to classify the stutterers as laryngeal stutterers and non laryngeal stutterers on the basis of VOT.

5. VOT data may be useful to develop therapy for stutterers.

6. VOT data of this study i.e., VOT in Kannada language may be useful in comparing them with other languages.

Definitions of some of the kev words used in the study:

Stuttering:

"The term stuttering means: I (a) Disruption in the fluency of verbal expression, which is (b) characterized by involuntary, audible or silent, repetitions or prolongations in the utterance of short speech elements, namely: sounds, syllables, and words of one syllable. These disruptions (c) usually occur frequently or are marked in character and (d) are not readily controllable. II. sometimes the disruptions are (e) accompanied by accessory activities involving the speech apparatus, related or unrelated body structures, or steriotyped speech utterances. These activities give the appearance of being speech-related struggle. III. Also, there are not infrequently (f) indications or report of the presence of an emotional state, ranging from a general condition sf 'excitement' or 'tension' to more specific emotions of a negative nature such as fear, embarrassment, irritation, or the like. (g) The immediate source of stuttering is some incoordination expressed in the peripheral speech mechanism; the ultimate cause is presently unknown and may be complex or compound." (Wingate 1964)

Voice onset time (VOT):

"The duration between the release of a complete articulatory constriction or burst transient and the onset of phonation" (Lisker and Abramson 1964, 1971).

Voiced stop:

A voiced stop is a speech sound produced by (1) a complete oral closure (2) a velic closure and (3) presence of voicing during complete oral closure.

Voiceless stop:

A voiceless stop is a speech sound produced by (1) a complete oral closure (2) a velic closure and (3) absence of voicing during complete oral closure.

CHAPTER II

REVIEW OF LITERATURE

Stuttering is ".... a disturbance of rhythm and fluency of speech by an intermittent blocking, a convulsive repetition, or prolongation of sounds, syllables, words, phrases, or posture of speech organs" (Wood 1971).

> "Stuttering has been called a riddle. . . . . stuttering is more than a riddle. It is at least a complicated, multidimentioned jig-saw puzzle, with many pieces still missing"
>
> "Many good minds have attempted definitions of stuttering, but the variability among them makes clear this complex and variable disorder is hard to delimit"
>
> (Van Riper 1971)

While searching for a standard definition of stuttering wingate has opined: "The definition should be one which (a) identifies and emphasizes discriminative features (b) is amenable to general application and (c) accords with our current state of knowledge of stuttering" (Wingate 1964).

According to Wingate (1964) "The term stuttering means I (a) Disruption in the fluency of verbal expression which is (b) characterized by involuntary audible or silent repetitions or prolongations in the utterance of short speech elements, namely sounds, syllables, and words of one syllable. The disruptions (c) usually occur frequently or one marked in character and (d) are not readily controllable.

II Sometimes the disruptions are (e) accompanied by accessory activities involving the speech apparatus, related or unrelated body structures, or stereotyped speech utterances. These activities give the appearance of being speech-related struggle.

III Also, there are not infrequently (f) indications or report of the presence of an emotional state, ranging from a general condition of 'excitement' or 'tension' to more specific emotions of a negative nature such as 'fear', embarrassment, irritation, or the like (g) The immediate source of stuttering is some lncoordination expressed in the peripheral speech mechanism, the ultimate cause is presently unknown and may be complex or compound".

Van Riper (1971) has felt that when a stutterer stutters a word, "......there is a temporal disruption of the simultaneous and successive programming of music movements required to produce one of the word's integrated sounds, or to emit one of its syllables appropriately or to accomplish the precise linking of sounds and syllables that constitutes its motor pattern".

Several attempts have been made and are going on to locate the causative factor/s of stuttering but none of them have definitely indicated the factor/a which cause the stuttering behavior. Attempts have been made to explain stuttering behavior on the basis of learning theories

(Johnson, 1958; Johnson, Brown, Curtis, Edney and Keaster, 1967; Brutten and Shoemaker, 1967 and other people). Green end wells, 1927 have attributed the cause of stuttering to the difference in constitutional factor such as nervous system. Some other important theories are, Cerebral dominance theory by Orton, 1927, Travis, 1931; Brynglson, 1935; Conflict theory by Sheehan, 1958; Diagnosogence theory of stuttering by Johnson (1957), Wischner's Anticipatory theory of stuttering, 1947, 1950, 1952; Delayed auditory feedback theory by Lee and Black, 1950, 1951 and ether theories.

The causative factors or so called 'theories' which have been attributed to stuttering are too divergent to each other. In this connection Ainsworth (1971) writes:

> "The process of attempting to provide a way of integrating the multiplicity of ideas and facts concerning the nature and sources of stuttering continues to be frustrating and fragmentary".

From the time of Aristotle (384 BC) till today many have attributed stuttering as an organic condition. Aristotle (384 BC), Galen (AD 200), Dechauliac (1336), Mercurialis (1584) and Francis Bacon (1627) thought that some defects in tongue, such as tongue tie, too cold tongue, too wet or too dry tongue cause stuttering. While others considered stuttering is due to the dysfunction of some other articulatory organs like lips or jaw or palate.

Serre d'Alais and Arnott (1829) thought that stuttering is due to glottic spasm. The famous Arabian physician Avicenna (1037) viewed the disorder as a spasm of epiglottis which is due to some brain lesions.

Sir Charles Bell (1832), Becquerel (1847) and Cohen (1875) believed that causative factor of stuttering is some respiratory abnormality and their followers suggested several breathing exercises for improving the speech of the stutterers.

Orton (1927), Travis (1931) and Bryngelson (1935) have advocated the cerebral dominance theory. According to this theory stutterers have been thought to have lower margins of cerebral dominance which could result in desynchronization between the paired structure of speech and leads to stuttering blocks. The basic problem of this theory was that it was untestable except in terms of peripheral laterality. Studies on handedneas do not confirm this theory fully.

West (1945) thought stuttering was either due to a mild form of epilepsy (called Pyknolepsy) or a mild form of Subclinical cerebral palsy.

Kopp (1934) found a difference in biochemical factors for the stutterers than the non stutterers, whereas other studies show that there is no such difference.

The feedback theories have tried to explain the stuttering behavior. Van Riper (1971) believed that "......stutterers posses a defective monitoring system for producing sequential speech". Lee (1951) has found that introduction of delayed auditory feedback in normals disturbs the normal flow of speech. Cherry and Sayers (1956) have reported improvement in fluency among stutterers during elimination of auditory feedback by masking.

> "Rational analysis, clinical investigation and systematic research are lending support to an old suspicion:- many of the abnormal disfluencies judged as stuttering involve problems of smooth coordination of phonation with articulation and respiration". (Travis, 1931)

After reviewing the vast literature of stuttering Van Riper (1971) has concluded that the core of the disorder is a disruption of timing of the motor sequence of sound, syllable and word production. Wingate (1970) has found stutterers to be more fluent when they sing, speak in chorous, whisper, speak under masking noise or adopt a foreign accent. He considers that the fluency achieved by the stutterers during singing, chorous speech, whispered speech, speaking under masking noise or during speaking with a foreign accent may be due to a change in phonatory function during those acts.

According to Van Riper (1971) the marked reduction in stuttering during whispering and its elimination during pantomimed speech could be attributed to the high degree of conscious articulation of slower speeech rates that permits synchronization of phonatory, articulatory and respiratory mechanism.

Rathna and Nataraja (1972) have reported a case where stuttering was found even in whispered and silent reading. This observation is contradictory to that of Wingate (1970) and Van Riper (1971).

Wingate's view, that improved fluency in several conditions, is due to a change in phonatory function has spurred a number of investigations related to phonation in stutterere.

Adams and Reis (1971) have compared the frequency of stuttering and adaptation rate of stutterers while reading 2 passages that were constructed to differ in the number of off/on vocal adjustment. One passage was composed entirely of voiced speech sounds (all voiced passage) the other contained both voiceless and voiced sounds (combined passage). They have found a higher frequency and slower adaptation rate for the passage containing the greater number of off/on adjustments (i.e., for the combined passage). A replication of the study (Adams and Reis, 1974) has confirmed the difference in rate of adaptation, although it has failed to confirm the difference in frequency.

Brenner, Perkins and Soderberg (1972) have compared the effect of rehearsing a passage out loud with those of rehearsing it in whisper. Only the rehearsal that included phonation produced the customary adaptation effect.

Freeman and Ushijima (1975) have investigated the intrinsic muscular activity of the larynx during stuttering and fluent speech of a subject. The electromyographic recording of four intrinsic muscles shows that there is a tendency of the antagonistic muscle to contract simultaneously rather than reciprocally as occurs when normal speakers initiate phonation.

Guiter (1975) has observed reduction in stuttering frequency using analogue electromyographic feedback. He has chosen four areas to provide feedback viz., Laryngeal site, lip site, chin site and frontalis site (as a control). Three stutterers included as subjects for this study demonstrated different responses. One subject showed greater dacrease in stuttering frequency when feedback was associated with lip site. Another subject showed greater reduction in stuttering when feedback was given from laryngeal site. Third subject showed greater reduction when the feedback was from both laryngeal and lip sites.

In an exploratory study of a single stutterer, Hanna, Wilfling and McNeill (1975) have observed a Marked reduction in stuttering. The laryngeal muscle tension of the subject was fed auditorily. Both the amplitude of EMG signal and stuttering blocks were reduced 'dramatically'.

These two studies, as mentiond above, suggest that some kind of stuttering might involve larynx. In this view, Van Riper (1973) also has stated that there are stutterers whose stuttering appears to be focussed at the laryngeal area.

Based on an analysis of recent research studies of the neurological mechanisms controlling laryngeal muscle activity, Wyke (1974) has suggested that some categories of stuttering may involve temporal incoordination of activity in one or more of these neurological systems. He has, further, added "stuttering of laryngeal origin may be a form of phonatory ataxia arising either because of disordered voluntary prephonatory tuning of the vocal fold musculature or from incoordinated reflex modulation of the activity of this musculature during actual utterance".

Mackenzie (1955) has found a complete reduction in stuttering for the stutterers who had used electrolarynx. other reports (Oldray, 1953; Irving & Webb, 1961) have shown that laryngectomized stutterers who had learnt esophageal speech did not show any stuttering.

Except one contradictory finding (Rathna and Nataraja, 1972) all other studies point out that stuttering could be a result of a faultly functioning of the phonatory mechanism.

One of the factors which has been pointed out as an evidence of faulty phonatory function in stutterers during stuttering behavior is the increase in voice onset time (VOT) in stop consonants in stutterers than that of in non stutterers.

Voice onset time (VOT) is defined as the interval of time measured from the release of an initial stop to the onset of vowel periodicity. Lisker and Abramson (1964, 1974) have opined that VOT is the critical acoustic cue underlying voicing distinctions, whereas according to Winitz (1975) aspiration is the primary perceptual cue in the detection of voicing, and VOT operates as a relatively unimportant secondary cue.

Adams and Hayden (1974) have compared the voice onset and voice termination times of stutterers with those of non stutterers as they produced an initial vowel in rapid response to a pure tone stimulus. Their study has tested the hypothesis that stutterers have difficulty initiating and terminating phonation independent of the acts of running speech and stuttering. Ten adult stutterers served as experimental group. They were matched as a group for age and sex with ten normal speakers. Subjects from both the groups were tested individually. They were required to start and stop phonation as quickly as possible upon hearing each number of a series of 1000 Hz pure tones appear and disappear. Subjects' vocalizations were permanently recorded on an optical oscillograph. The results showed that both the groups improved (shortened) their voice initiation and termination times from the beginning to the end of the experiment. Typically, however, the stutterers were significantly slower than the control subjects on most of the temporal measures.

Starkweather et.al.(1976) have measured the latency of vocalization onset for stutterers and non stutterers. The subjects were asked to produce different syllables following a visual stimulus. Responses were filtered to remove supraglottaly produced sounds, and the time between visual stimulus and the onset of vocalization was measured by a voice operated relay and a computer's internal clock. The results have shown that stutterers are slower in initiating vocalization across a wide variety of syllables. They have, further, concluded that '.....either vocal dysfunction or the lack of cerebral dominance may be responsible for these differences".

Agnello and Wingate (1972) have reported that the VOT for stutterers are longer than that of non stutterers in fluent speech. Adams and Reis (1971) have shown that the stutterers experience more difficulty in reading a passage which is filled with voiced and voiceless consonants than that of the one with all voiced consonants.

Brown (1938), Eisenson and Horowitz (1945) and Wingate (1967) have showed that the speech of the stutterers changed depending upon the type of speech sample produced. For example, isolated verses contextual speech.

Hillman and Gilbert (1977) have obtained VOT values for the fluent contextual speech of stutterers and compared with the VOT values of non stutterers. Ten stutterers and ten non stutterers read "The Rainbow Passage". Intervocalic voiceless stop consonant segments were selected and displayed on wide band spectrograms. Results of VOT measurements obtained have indicated that (a) the stutterers displayed longer VOT values than the non stutterers and (b) VOT values increased in duration as the place of articulation moved back in the oral cavity.

Based on these findings and other evidences from respiratory physiology, speech pathology, speech science and learning psychology, schwartz (1974) has attempted to explain "The core of the stuttering block". He believes that "The disorder is essentially an inappropriate, vigorous contraction of the posterior cricoarytenoid in response to the subglottal air pressures required for speech". He further adds that "This response occurs as a result of psychological stress which, in stutterers, substantially reduces the effectiveness of the normal supramedullary inhibitory controls on this muscle". Thus according to Schwartz's model the 'inappropriate vigorous construction of posterior cricoarytenoid' results in increased voice onset time in the stutterers.

Neurophysiologically VCT can be defined as the amount of time required to inhibit the activity of posterior cricoarytenoid during phonation. When a subject is asked to say (pa), "the speaker ia aaked to inhibit the reflexive posterior cricoarytenoid to pressure only for the final vowel (a). The amount of time required to achieve this state is an important physical constraint underlying voice onset time in voiceless-plossive-vowel (cv) paradigms...... VOT appears to involve not only a consideration of the neural control over the adducting muscle of the larynx, but also the control of the neural inhibition of the abductor muscle as well" (Schwartz, 1974). so, when the speaker has the difficulty to inhibit the posterior cricoarytenoid reflex activity his VOT will be more.

There are basically two techniques to measure voice onset time. They aye (a) wide band spectrogram method and (b) Optical oscillograph method. In a series of investigations of VCT Lisker and Abramson (1964), Abramson and Lisker (1974) have used spectrograph to find out VOT in different languages including Hindi, Tamil and Marathi. Malecot (1966) Lubkor and Parris (1969), Han and Weitzman (1970), Stevens and Klatt(1971), Hardcastle (1973) and others have also used wide band spectrograms for the measurement of VOT. Winitz et.al. (1975) have used optical oscillograph for the same purpose.

Lisker and Abramaon (1964) & Abramson and tisker (1974) have suggested that VOT is the critical acoustic cue underiying voicing distinction. That is, the voiced and voiceless sounds are differentiated by the VOT differences. Their conclusions were based on spectrographic measurement of VOT for a large number of languages. Winitz et.al. (1975) have used Oscillograph to determine VOT. Using a 'pause adjustment device' the duration of VOT was systematically altered for English stops. For voiceless stops VOT was reduced to half the distance between the voiced and voiceless cognates, VOT was made equivalent to the voiced cognate and the vocalic portion preceded the release and aspiration segments by 20 m.secs. Changes in VOT far voiced stops involved the inversion of the first two measurements described above. In general, their findings have not indicated that changes in VOT duration far stop-vowel syllables altered appreciably the perception of voicing. The conclusions, that have been drawn from these experiments are that aspiration is the primary perceptual cue in the detection of voicing, and that VOT operates as a relatively unimportant secondary cue.

Thus if the stutterers have different VOT in their fluent speech than that of non stutterers, as that have been found out by Agnello (1975) and Hillman & Gilbert (1977), one cannot perceive voiced sounds as voiceless ones and vice versa with the help of hearing cues.

While finding the phonatic basis for our ability to distinguish between phoneme categories, Linguists often invoke the dimension of voicing to call some categories 'voiced' and others 'voiceless'. In the case of stop consonants it is usual to level as voiced categories characterized by the presence of glottal buzz during the interval of articulatory closure, while absence of buzz during this interval is a mark of voiceless stops. The two kinds of stops art in most cases easily distinguished by reference to their spectrographic patterns, for voiced stops the formentless segment corresponding to the closure interval is traversed by a small number of low frequency harmonic components, while in the case of voiceless stops the closure interval is essentially blank.

Language has been found to be a variable in VOT measurement. Lisker and Abramson (1964) have studied the VOT for a number of languages including Tamil, Hindi, Marathi and English for the stop sounds in word initial positions. The VOT values obtained in their experiment were found to vary from language to language. No study has been reported so far in the same area for Kannada language. They have also reported that VOT values in running speech are less than that of in non-sense syllables. Their findings have been made it clear that presence of voiceless stop in a stressed syllable makes for a greater lag in the onset of voicing. Thus, type of speech sample is another variable for VOT.

Speaker's age is another variable which influencesvoice onset time. Preston et.al. (1967) studied VOT for Labanese and American infants. Zlatin and Koenigsknecht (1976) used VOT to study the development of the vocing contrast in ten two year old children, ten 6 year old children and twenty adults. Both the studies have indicated that VOT is not same for different age groups. There is a considerable need to standardize VOT for various age groups in each language.

Thus the review of literature indicates that stuttering may be due to a faulty functioning of laryngeal mechanism which might reflect in VOT measurement for stutterers. Hence it is proposed to study the VOT for stutterers in reading and in sounds in isolation and to compare them with that of non stutterers.

CHAPTER - III

METHODOLOGY

The study involved five steps.

Step 1: selection of subjects

Step 2: Preparation of materials

Step 3: Recording of the speech samples

Step 4: Selection of the speech segments

step 5: Measurement of VOT

Step 1

Two groups of subjects were included for the study.

Group A

This group consisted of five stutterers. The age range of these subjects was fifteen to twenty years with a mean age of 17 years.

All the subjects were males and their mother-tongue was Kannada.

The severity of stuttering was judged by the qualified speech pathologists of All India Institute of speech and Hearing. The number of stutterers in each severity group is shown in the table below:

severity rating	No. of stutterers
severe stutterer	1
Moderately severe stutterers	2
Moderate stutterers	2

Brief history and speech evaluation reports of the subjects are given in Appendix II.

Group B

This group consisted of five non stutterers. These subjects were matched with the subjects of Group A in terms of age, sex and language background.

Step 2

It was necessary to construct a passage in Kannada for the purpose of the experiment which

1) should be meaningful:
2) should have /p, t, ţ, k/ and / b , d, d, g/ sounds in initial position of the word.

For the purpose of easy isolation of the syllables of the aforesaid sounds from the recorded speech sample,(this was required for spectrographic analysis) it was planned to use these words as the first word of some of the sentences.

So, a passage was constructed with the words Which occurred in the beginning of some of the sentences and having the above mentioned sounds as the initial sounds.

Step 3

The passage and the syllables in isolation were given to the subjects for reading.

The following instructions were given prior to reading.

"You will be given a passage and a few syllables. Please read them.

Are you ready? Now start".

The instructions were in Kannada and given in Appendix I,

Speech samples were recorded in a sound treated room of All India Institute of speech and Hearing which is used for audiometrlc purpose.

A cosmic stereo cassette deck taperecorder (Model No. CO 88 X D) and a Sony C 90 cassette were used for recording purpose.

Step 4

Another cosmic stereo cassette deck tape recorder of same model and another Sony C 90 cassette were used to extract the initial segment of some of the words beginning with /p, t, ţ, k/ and /b, d, d, g/ sounds.

The same segments of the passage (in the same word environment) were separated from the original recorded speech sample of all the subjects of Group A and Group B.

The syllables in isolation for all the aforesaid sounds read by the subjects were also transferred from the previous cassette.

Line recording technique, monitored through a Sonodyne headphone, was used for selecting and transferring the initial segments of some of the words and the syllables in isolation from one cassette to another.

Step 5

The speech samples obtained from step 4 of the experiment were displayed on a wide-band spectrogram using a Sona-Graph (Model No. 6061 B, Kay Electronics Corporation).

The distance between the vertical striation observed for articulatory release in stop consonants and the initiation of phonation indicated by the vertical striations (for the vowel component) was measured in millimetre scale. VOT wae calculated by using the formula:

$$\frac{VOT}{s} = l \times d$$

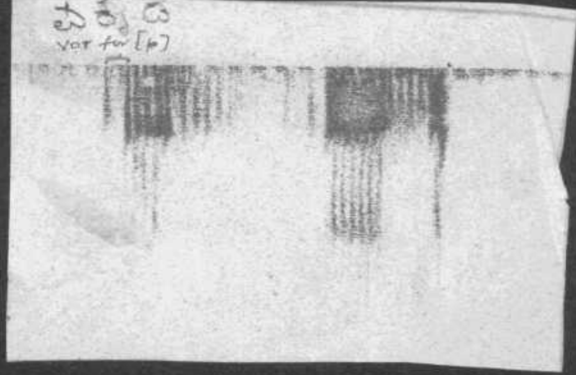
where l - length of the paper/1.e., diametre of the drum

s = speed of the drum

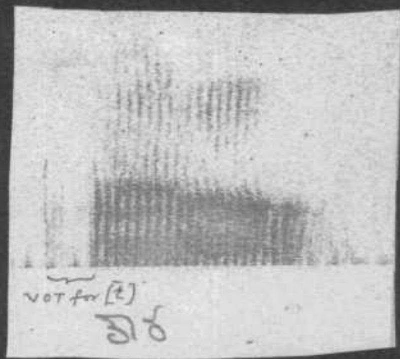
d = distance between articulatory release striation and striation for onset of phonation.

SPECTROGRAMS OF (p), (t), (ṭ) and (k) IN READING

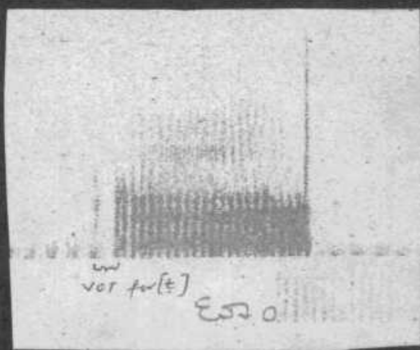
(p) in (PAKKADA..)



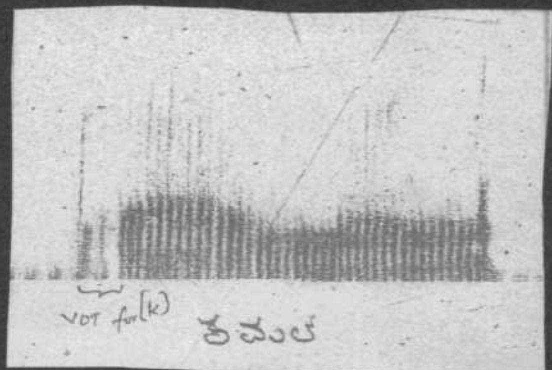
(t) in (TAAR..)



(ṭ) in (ṬAAM..)



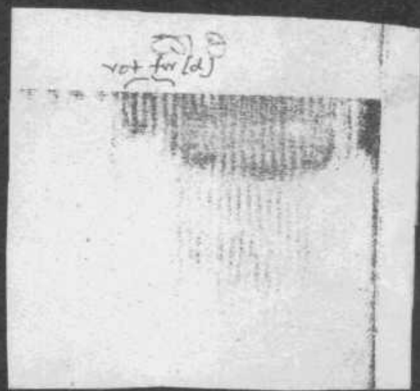
(k) in (KAMAL..)



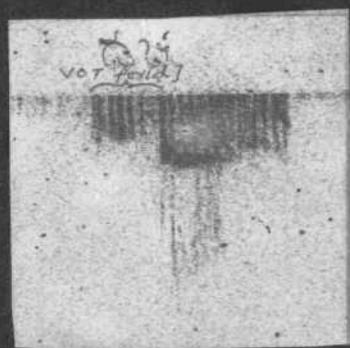
SPECTROGRAMS Of (b), (d), (d) and (g) IN READING

(b) An (BAMGARADA..)

(d) in (DAARI..)

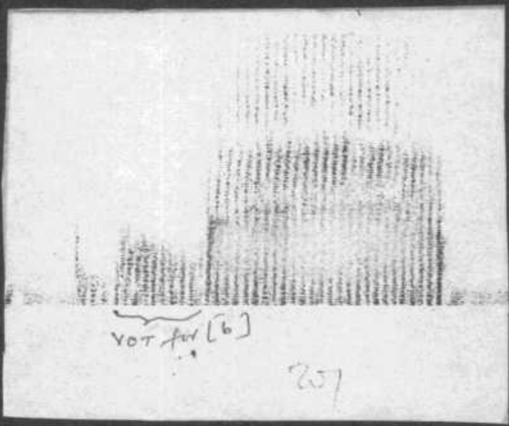


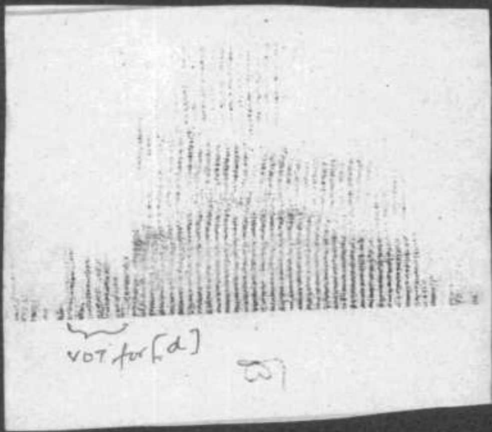
(d) in (DAB..)

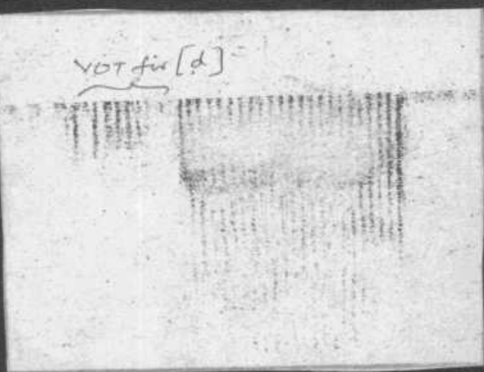


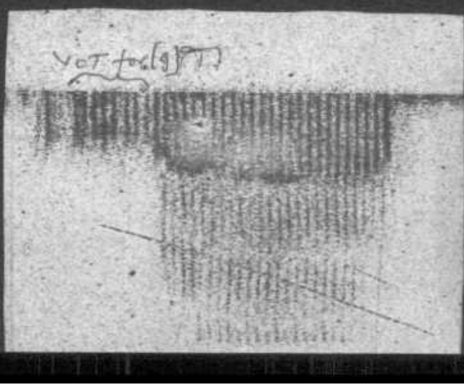
(9) in (GAAY..)

SPECTROGRAMS OF (b), (d), (ḍ) and (g) IN ISOLATION

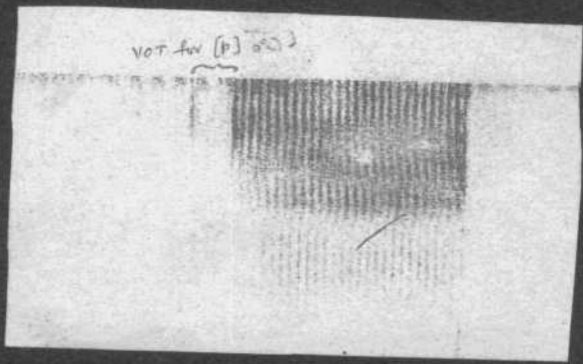


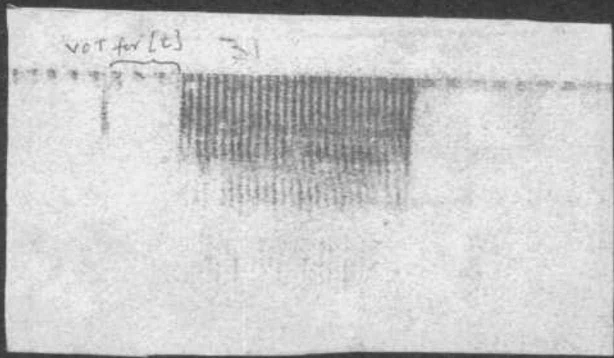


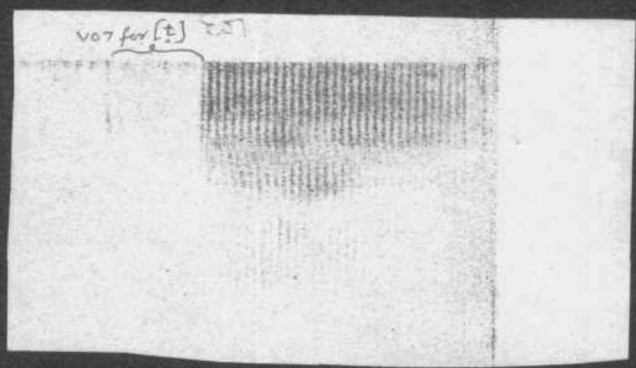


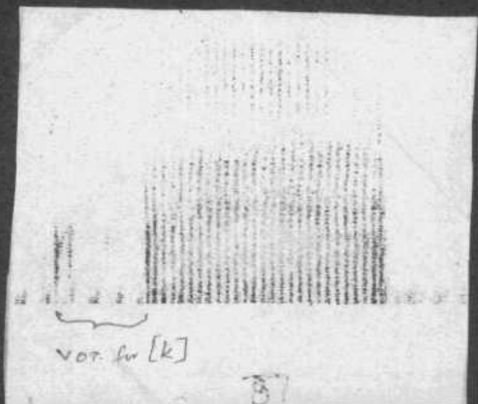


SPECTROGRAMS OF (p), (t), (ṭ) and (k) IN ISOLATION









Wide-band spectrograms of the recordings were made and from these, VOT's were measured by marking off the interval between the release of the stop and the onset of glottal vibration, i.e., voicing. The point of voicing onset was determined by locating the first of the regularly spaced vertical striations which indicate glottal pulsing, while the instant of release was found by fixing the point where the pattern shows an abrupt change in the overall spectrum. Oral closure is marked spectrographically by the total or almost total absence of acoustic energy in the formant frequency range[1]; oral release is marked by the abrupt onset of energy in the formant frequency range. Zero time was assigned to the reference point, the instant of release; thus, measurements of VOT before release are stated as negative numbers and called voicing lead, while measurements of VOT after the release are stated as positive numbers and called voicing lag.

CHAPTER IV

RESULTS AND DISCUSSION

VOT's for (p), (t), (ţ), (k), (b), (d), (d) and (g) were obtained for stutterers and non stutterers in reading and in isolation from the respective spectrograms. VOT for each voiceless and voiced sound in reading and in isolation is compared between the matched pair of subjects which are shown in tables 1(a), 1(b), 2(a) and 2(b). The mean, median and range of VOT's for stutterers and non stutterers for voiceless stop sounds in reading and for syllables in isolation were computed. These values are shown in tables 3,4,5,and6.

Table 1(a) gives the comparison of VOT's for voiceless stop sounds in reading for each matched pair of subjects. It can be noted from table l(a) that each stutterer consistently showed a longer VOT for each voiceless stop sound than that of non stutterer. For example, when VOT's for (p) sound for subject 1 and 6 (matched, stutterer and non stutterer respectively) are compared, subject 1 showed a VOT of 108.39 m.secs. Whereas, subject 6 showed a VOT of 11.61 m.aecs. (Difference of VOT is 96.78 m.secs.) The difference of VOT was always seen for each voiceless stop sound within each pair of subjects. The range of differences

Sl.Nos. of the pairs of Matched subjects	p Sttrs.	p Non Sttrs.	t Sttrs.	t Non Sttrs.	ṭ Sttrs.	ṭ Non Sttrs.	k Sttrs.	k Non Sttrs.
1 & 6	108.39	11.61	139.35	15.48	85.16	27.09	147.10	38.71
Difference	96.78		123.87		58 .07		108.39	
2 & 6	332.90	7.74	23.23	11.61	100.65	23.23	46.45	30.97
Difference	325.16		11.62		77.42		15.48	
3 & 10	15.48	11.61	23.23	15.48	46.45	27.09	38.71	30.94
Difference	3.87		7.75		19.36		7.77	
4 & 9	19.35	11.61	38.71	15.48	38.71	23.23	30.97	27.09
Difference	7.74		23.23		15.78		3.88	
5 & 7	15.48	7.74	30.97	11.61	77.41	23.23	77.41	27.09
Difference	7.74		19.36		54.18		50.32	
Range of Diff.	3.87-325.16		7.75-123.87		15.48-77.42		3.88-108.39	

Table 1(a): showing the comparison of VOT's for voiceless stop sounds in reading for each Hatched pair of subjects.

Sl.Nos. of the pairs of matched subjects	b		d		ḍ		g	
	Sttrs.	Non Sttrs.	Sttrs.	Non Sttrs.	Sttrs.	Non Sttrs.	Sttrs.	Non Sttrs.
1 & 6	123.87	30.97	123.87	38.71	123.87	46.45	116.12	77.41
Difference	92.90		85.16		77.42		38.71	
2 & 8	77.41	15.58	46.45	38.71	77.41	46.45	69.68	54.19
Difference	61.83		7.74		30.96		15.49	
3 & 10	77.41	27.09	92.90	30.97	77.41	42.58	116.12	54.19
Difference	50.32		61.93		34.83		61.93	
4 & 9	89.03	23.23	54.19	46.45	77.41	61.94	89.03	77.41
Difference	65.80		7.74		15.47		20.62	
5 & 7	154.84	30.97	309.68	38.71	100.65	42.58	61.94	46.45
Difference	123.87		270.97		58.07		15.49	
Range of Diff.	50.32-123.87		7.74-270.97		15.47-77.42		15.49-61.93	

Note: All are negative numbers.

Table l(b): Showing the comparison of VOT's for voiced stop sounds in reading for each matched pair of subjects.

SL.Nos. of the pairs of watched subjects	p		t		ţ		k	
	Sttrs.	Non Sttrs.	Sttrs.	Non Sttrs.	Sttrs.	Non Sttrs.	Sttrs.	Non Sttrs.
1 & 6	387.09	34.87	209.03	38.71	340.00	58.06	372.26	77.41
Difference	352 .22		170.32		281.94		294.85	
2 & 8	340.64	19.35	158.71	23.23	387.10	34.87	209.81	58.06
Difference	321 .29		127.48		352.23		151.75	
3 & 10	116.12	19.35	77.41	34.84	85.16	42.58	65.48	46.45
Difference	96..77		42.57		42.58		19.03	
4 & 9	30.97	15.48	77.41	23.23	92.90	30.97	77.41	38.71
Difference	15 .49		54.18		61.93		38.70	
5 & 7	30.97	15.48	42.54	23.23	58.06	38.97	85.16	46.45
Difference	15.49		19.31		19.09		38.71	
Range of Diff.	15.49-352.22		19.31-170.32		19.09-352.23		19.03-294-85	

Table 2(a): Showing the comparison of VOT's for voiceless stop sounds in isolation for each matched pair of subjects.

Sl.Nos. of the pairs of Matched subjects	b		d		ḍ		g	
	Sttrs.	Non Sttrs.	Sttrs.	Non Sttrs.	Sttrs.	Non Sttrs.	Sttrs.	Non Sttrs.
1 & 6	193.55	7.74	170.32	85.16	154.84	100.65	178.06	131.61
Difference	185.81		85.16		54.19		46.45	
2 & 8	103.39	69.68	139.35	85.16	131.61	92.90	154.84	100.65
Difference	33.71		54.19		38.71		54.19	
3 t 10	131.61	81.29	189.03	96.77	154.84	100.65	162.58	108.39
Difference	50.32		92.26		54.49		54.19	
4 & 9	77.41	57.41	139.35	81.29	96.77	85.16	139.35	108.39
Difference	20.00		58.06		11.61		30.96	
5 & 7	85.16	77.41	96.77	85.16	116.12	96.77	157.85	116.12
Difference	7.75		14.61		19.35		41.73	
Range of Diff.	7.75-185.81		14.61-92.26		11.61-54.19		30.96-54.19	

Note:- All are negative numbers.

Table 2(b): showing the comparison of VOT's for voiced stop sounds in isolation for each matched pair of subjects.

Table 3

	p	t	ţ	k
Stutterers				
Mean	96.32	51.10	69.68	68.13
Median	19.35	30.97	77.41	46.45
Range	15.48 to 332.90	23.23 to 139.35	38.61 to 100.65	30.97 to 147.10
Non Stutterers				
Mean	10.06	13.93	24.77	30.96
Median	11.61	15.48	23.23	30.94
Range	7.74 to 11.61	11.61 to 15.48	23.23 to 27.09	27.09 to 38.71

Table 3 shows the Mean, Median and Range of VOT's for voiceless atop sounds in reading.

Table 4

	b	d	d	g
Stutterers				
Mean	-104.51	-125.42	-91.35	-90.58
Median	- 89.03	- 92.9	-77.41	- 89.03
Range	-154.84 to - 77.41	-309.66 to - 46.45	-123.17 to - 77.41	-116.12 to -61.94
Non Stutterers				
Mean	- 25.57	- 38.71	-48.00	- 61.93
Median	- 27.09	- 38.71	-46.45	- 54.19
Range	- 30.97 to - 15.58	- 46.45 to - 30.97	-61.94 to -42.58	- 77.41 to - 46.45

Table 4 Shows the Mean, Median and Range of VOT's for voiced stop sounds in reading.

Table 5

	p	t	ṭ	k
Stutterers				
Mean	181.16	113.02	192.64	162.02
Median	116.12	77.41	92.90	85.16
Range	30.97 to 387.09	42.54 to 209.03	58.06 to 387.10	65.48 to 372.26
Non Stutterers				
Mean	20.91	28.65	41.09	53.42
Median	19.33	23.23	38.97	46.45
Range	15.48 to 34.87	23.23 to 38.71	30.97 to 58.06	38.71 to 77.41

Table 5 shows the Mean, Median and Range of VoT's for voiceless stop sounds in isolation.

Table 6

	b	d	ḍ	g
Mean	-118.22	-146.96	-130.84	-158.54
Median	-103.39	-139.35	-131.61	-157.85
Range	-193.55 to - 77.41	-189.03 to - 96.77	-154.84 to - 96.77	-173.06 to -139.35
Non Stutterers				
Mean	- 58.71	- 86.71	- 95.23	-113.03
Median	- 69.68	- 85.16	- 96.77	-108.39
Range	- 81.29 to - 7.74	- 96.77 to - 81.29	-100.65 to - 85.16	-131.61 to -100.65

Table 6: Shows the Mean, Median and Range of VOT's for voiced stop sounds in isolation.

Language	No.of S's		p	t	ṭ	k	b	d	ḍ	g
Kannada	5	Mean	10.06	13.93	24.77	30.96	-25.57	-38.71	-48.00	-61.93
		Range	7.71 to 11.61	11.61 to 15.48	23.23 to 27.09	27.09 to 38.71	-30.97 to -15.58	-46.45 to -30.97	-61.94 to -42.58	-77.41 to -46.45
Hindi*	1	Mean	12	11	11	16	-89	-88	-74	-47
		Range	5-20	5-20	5-15	10-25	-115 to -75	-120 to -50	-140 to -30	-70 to -35
Tamil*	1	Mean	12	10	-	27	-61	-64	-	-56
	-	Range	0-45	0-25	-	15-40	-75 to -40	-100 to -45	-	10 to -80
Marathi*	1	Mean	0	11	11	21	-106	-98	-	-81
		Range	0	10-15	10-15	20-25	-145 to - 85	-110 to - 75	-	-90 to -70
English*	4	Mean	28	Eng/t/ 39	-	43	7/-65	Eng/d/ 9/-65	-	17/-45
		Range	0-45	15-70	-	30-65	0-15/ -65	0-25/ -20 to -90	-	0-13/ -45

* Data as presented by Lisker and Abramson (1964).

Table 7 Shows Mean and Range of VOT in reading of sentences for different language for normal speakers (in m.secs.)

are 3.87 to 325.16, 7.75 to 123.87, 15.48 to 77.42 and 3.88 to 108.39 for (p), (t), (ț) and (k) sound respectively is reading.

Table 3 shows the mean, median and range of VOT's for stutterers and non stutterers for voiceless stop sounds in reading. It can be seen from table 3 that the stutterers consistantly showed a longer VOT for each voiceless stop sound when compared with non stutterers. For example, the meand VOT for (p) sound in reading is 98.32 m.sec., with a range of 15.48 to 332.90 m.secs., whereas for non stuttering group the mean VOT for (p) is 10.06 m.secs., with a range of 7.74 to 11.61 m.secs. Similarly for the other voiceless stop sounds also the mean VOT was longer than that of non stuttereres. Thus the hypothesis 1(a), which states that there will be no difference between stutterers and non stutterers for VOT values of voiceless stop sounds in reading, is rejected.

A comparisons of VOT's for voiceless stop sounds in isolation for each pair of stutterer and non stutterer has been presented in table 2(a). It is evident from table 2(a) that each stutterer displayed a longer VOT in spectrogram for each voiceless stop sound in isolation, than that of non stutterer. For example, VOT for (p) sound in isolation for subject 1 (a stutterer) is 387.09 m.secs., and that of subject 6 (a non stutterer, matched with subject 1) is 34.87

m.secs. The difference of VOT for these two subjects for /p/ sound in isolation is 352.22 m.secs. The difference in VOT was always observed for each voiceless stop sound in isolation within each pair of subjects. The range of differences are 15.49 to 352.22, 19.31 to 170.32, 19.09 to 352.23 and 19.03 to 294.85 m.secs., for (p), (t), (ţ) and (k) sound respectively in isolation.

The mean, median and range of VOT's for voiceless stop sounds in isolation have been shown in table 5. It can be noted from table 5 that in isolation also stutterers consistently showed a longer VOT values for each voiceless stop sounds. For example, the mean VOT for stutterers for (p) in isolation ia 181.16 m.secs., and the range is 30.97 to 387.09 m.secs., and for the non stutterers the mean VOT for (p) in isolation is 20.91 with a range of 15.48 to 34.87 m.secs. similarly, the VOT's for stutterers for other voiceless stop sounds (t), (ţ) and (k) in isolation ere longer than that of non stutterers. Thus, the hypothesis 1 (b), that there will be no difference between stutterers and non stutterers for VOT values of voiceless stop sounds in isolation is rejected.

The VOT values for voiced stop sounds in reading for each pair of subjects (stutterer and non stutterer) have been compared in Table 1(b). It can be seen from table 1(b) that each stutterer showed a longer VOT for each voiced stop sound in reading than that of the non stutterer who has been matched with the stutterer with respect to age, sex and language background. For example, when subjects 2 and 8 are compared for the VOT values of (b) sound in reading, subject 2(a stutterer) shows a VOT of -77.41 m.secs., and subject 8 (non stutterer) shows a VOT of -15.58 m.secs. (The difference of VOT is -61.83 m.secs.). The VOT difference is noted for each pair of subjects for all the voiced stop sounds in reading. The range of differences are -50.32 to -123.87, -7.74 to -270.97, -15.47 to -77.42 and - -15.49 to -47.42 for (b), (d), (d) and (g) sounds respectively, in isolation.

Table 4 represents the mean, median and range of VOT's for voiced stop sounds in reading for stutterers and non stutterers. It can be made out from table 4 that mean VOT's for each voiced stop sounds in reading for the stutteres are longer than that of non stutterers. For example,the mean VOT of (b) for stutterers is -104.51 m.secs., with a range of -154.84 to -77.41 m.secs., and the mean for the same sound in reading for non stutterers is -25.57 m.secs., with a range of -30.97 to -15.58 m.secs. Longer VOT's for each voiced sounds viz., (d), (d) and (g) in reading are also observed for the stutterers when compared with non stutterers. Thus, the hypothesis 2(a) that there will be no difference between stutterers and non stutterers for VOT values of voiced stop sounds in reading, is rejected.

Table 2(b) shows the VOT values of voiced stop sounds in isolation for each matched pair of subjects. It is evident from table 2(b) that all the stutterers consistently show a longer VOT value for each voiced stop sound than that of the non stutterers. For example, the VOT values for (b) in isolation for subjects 1 and 6 (stutterer and non stutterer respectively) are -193.55 and -7.74 m.sec., respectively. (The difference is -185.81 m.sec). The range of differences between VOT values between stutterers and non stutterers are -185.81 to -7.75, -92.26 to -14.61, -54.19 to 11.61, -54.19 to -30.96 for (b), (d), (d) and (g) sounds respectively.

Mean, median and range of VOT values for voiced stop sounds in isolation for stutterers and non stutterers have been presented in table 6. It can be noted from table 6 that the mean VOT for each voiced stop sound is longer for stutterers than that of non stutterers when both the stutterers and non stutterers read the sounds, in syllables, in isolation. For example, the mean VOT for (b) in stutterers is -118.22 m.secs., with a range of -193.55 to -77.41 m.secs., and for the non stutterers the mean VOT is -58.71 m.secs., and the range is -81.29 to -7.74 m.secs. Thus, the hypothesis 2(b) which states that there is no difference between stutterers and non stutterers for VOT values of voiced stop sounds in isolation, is rejected.

Hillman and Gilbert (1977) studied the VOT for voiceless stop sounds in fluent reading of stutterers and found the VOT to be longer than that of non stutterers. Their study was limited to only voiceless stop sounds, in reading condition. Agnello (1975) studied the VOT for both voiced and voiceless stop sounds for stutterers and non stutterers and found the VOT values to be more in stutterers than that of non stutterers. The present study supports the findings of Hillman and Gilbert (1977) and that of Agnello (1975).

According to Hillman and Gilbert (1977), "Breathing disturbances often exhibited by stutterers may account for long VOT values observed in the fluent speech of the stutterers. Such disturbances as shallow inhalation and shallow exhalation bring about reduced subglottal pressures and weak airflows which may be slow to start and may be limited duration. The inability to generate adequate and steady subglottal pressures would also contribute to a delay in the onset of phonation and increase in VOT".

since the present study finds a longer VOT in syllables in isolation also for the stutterers than that of non stutterers, the explanation given by Hillman and Gilbert (1977), may have to be reviewed.

According to Schwartz's model 'the inappropriate vogorous contraction of posterior cricoarytenoid in response to subglottal air pressure required for speech' leads to an increase in voice onset time. His model also states that 'when a speaker has the difficulty to inhibit the posterior cricoarytenoid reflex activity hie VOT will be more'. Probably the 'inappropriate vigorous contraction of the posterior cricoarytenoid' as indicated by Schwartz (1976) in his model may account for the longer VOT values for the stop sounds in reading and in isolation for the stutterers.

The mean, median and range of VOT values computed for the non stutterers (Tables 3, 4, 5 and 6) shows that the VOT for voiced stop sounds for the non stutterers are always negative, that is, there is always a voicing lead for the voiced stop sounds. The voiceless stop sounds always showed a voicing lag (indicated by positive numbers). For example, for the non stutterers, the mean VOT for (p) sound is 20.91 m.secs., in isolation (with a range of 15.48 to 34.87 m.secs.) whereas, the mean VOT for (b) sound in isolation is -58.71 m.secs., (range -81.29 to -7.74 m.secs.) (Ref. Tables 5 and 6). Thus hypothesis 3(a) which states that there will be no difference between VOT for voiced stop sounds and VOT for voiceless stop sounds in non stutterers is rejected.

In case of stutterers also there is always a voicing lead for voiced stop sounds which are shown by the negative numbers, both in reading and in isolation (ref. Tables 4 & 3).

For the voiceless stop sounds there is a consistent voicing lag. This is indicated by positive numbers. For example, the mean VOT for (b) in stutterers is reading is -104.51 m.secs., (range -154.84 to -77.41 m.secs.) and the mean VOT for (p) in stutterers in reading is 98.32 m.secs., with a range of 15. 48 m.secs., to 332.90 m.secs., (ref. tables 4 and 3). Thus, the hypothesis 3(b) which states that there will be no difference between VOT for voiced stop sounds and VOT for voiceless stop sounds in stutterers is refuted. The findings of the present study agree with that of Lisker and Abramson (1964) who states that "In English /bdg/ and /ptk/ differ every where in the time of voice onset relative to release".

It can be noted from table 5 and table 3 that VOT for each voiceless stop sound in isolation is higher than that of in reading for stutterers. For example, the mean VOT for /p/ in isolation for stutterers is 181.16 m.secs., (range 30.97 to 287.09) and the mean VOT for the same sound in reading for the stutterers is 98.32 m.secs., (range 15.48 to 332.90 m.secs.) when the mean VOT velues for the voiced stop sounds in isolation for the stutterers, (Table 6) are compared with that of in reading for stutterers (Table 4), the VOT values in isolation are found to be longer than in reeding. For example, in case of (b) in isolation, the mean VOT value for the stutterers is -118.22 m.secs., (range

-193.55 to -77.41 m.secs.) whereas, the mean VOT value for the same sound in reading for the stutterers is -104.51 m.secs., with a range of -154.84 to -77.41 m.secs., (ref. tables 6 and 4). Thus the hypothesis 4(a) that there will be no difference between the VOT for syllables in isolation and VOT for the same sounds in spontaneous reading in stutterers is rejected, i.e., the VOT values for the stop sounds, in syllables, in isolation is longer than in spontaneous reading.

Table 5 and table 3 also indicate that VOT values for syllables in isolation are more than that of the same sounds in reading in non stutterers also. For example, the mean VOT for (p) in isolation for non stutterers is 20.91 m.secs., with a range of 15.48 to 34. 87 m.secs., and the mean VOT of the same sound in spontaneous reading for non stutterers is 10.06 with a range of 7.74 to 11.61 m.secs. The other voiceless stop sounds also displayed a longer VOT in isolation than that of in spontaneous reading in case of non stutterers. For voiced stop sounds also the VOT values are noted to be longer than in spontaneous reading (ref. table 6 and table 4). For example, mean VOT for (b) in isolation for non stutterers is -58.71 m.aecs., with a range of -81.29 to -7.77 m.secs., and the mean VOT for the same sound in reading is -25.57 m.secs., with a range of -30.97 to -15,58 m.secs. Similarly other voiced stop sounds in isolation displayed longer VOT values than that of in spontaneous reading in non stutterers. Thus the hypothesis 4(b) which states that there will be no difference between the VOT for syllables in isolation and in spontaneous reading in non stutterers is rejected, i.e., the now stutterers show a longer VOT for the stop sounds in isolation than that of in spontaneous reading.

Maker and Abramson (1964) & Hillman and Gilbert (1977) found that there is a consistent increase in VOT for stop sounds in English as the place of articulatory constriction moves backwards in the oral cavity. Hillman and Gilbert (1977) found the same to be true with stutterers also. Tables 3, 4, 5 and 6 indicate that there is a difference in VOT values with respect to the position of articulatory constriction in case of stutterers, however, the stutterers of the present study did not show any such consistent change in VOT with respect to the position of articulatory constriction. For example, the mean VOT values in reading for the voiceless stop sounds (p), (t), (ţ) and (k) 98.32 m.sec., 50.10 m.secs., 69.68 m.secs., and 68.13 m.secs., respectively. These values show that there is a difference between the VOT for each stop sounds with respect to the position of articulatory constriction in stutterers. Thus the hypothesis 5(a) which states that there will be no difference between the VOT for each sounds with respect to the position of articulatory constriction in stutterers is rejected.

Similarly it can also be noted from tables 3, 4, 5 and 6 that is case of non stutterers the VOT values are different for different stop sounds. However, there is a consistant increase in VOT as place of articulation moves back in the oral cavity. For example, far the non stutterers the mean VOT's for voiceless stop sounds (p), (t), (ţ) and (k) in reading are 10.06 m.secs., 13.93 m.secs., 24.77 m.secs., and 30.96 m.secs., respectively (ref. table 3). A consistent increase in VOT as the position of articulatory constriction moves backwards in the oral cavity has also been observed for the voiceless stop sounds in isolation and the voiced stop sounds both in isolation and in reading for the non stutterers (ref. tables 4, 5 and 6). Thus, the hypothesis 5(b) that there will be no difference between the VOT for each sounds with respect to the position of artlculatory constriction in non stutterers is rejected.

In the present study, an increase in voice onset time as the position of articulatory constriction moves backwards in the oral cavity has been observed for non stutterers.

Table 7 shows the mean and range of VOT values for each voiceless and voiced stop sounds in different languages for the normal speakers (non stutterers). The mean VOT for stop sounds in initial position of a word in sentences level in Hindi, Tamil, Marathi and English as presented by Lisker and Abramson (1964) have been shown and compared with that of the values obtained in the present study in Kannada language.

Mean VOT for (p) in Kannada was found to be less than that of Hindi and Tamil,i.e., Mean VOT for (p) in Kannada is 10.06 m.secs., whereas for Hindi and Tamil it is 12 m.secs. In case of English the mean VOT for (p) was reported to be 26 m.secs. Thus, English initial (p) has got a longer VOT than that of Kannada. In Marathi, the mean VOT for the same (p) sound was reported to be zero m.secs.

VOT for (t), (ţ) and (k) sounds in Kannada was found to be more than that of Hindi and Marathi. VOT for (t) and (k) in Kannada was found to be more than that of Tamil.

In English the voiceless stop sounds in initial position of a word (in reading) show a longer VOT's than that of Kannada.

When the mean VOT values of Kannada voiced and voiceless stop sounds are compared with that of other languages, a clear difference was observed, thus the hypothesis 6 which states that there will be no difference between the VOT for stop consonants in Kannada and the reported VOT for other stop consonants in other languages in non stutterers is rejected. Voicing lead in case of all voiced stop sounds and voicing lag for all voiceless stop sounds in initial position of words have been observed consistency for all the subjects. This may be a characteristic feature in Kannada language.

The results of the present study reveal that, the stutterers have shown a longer VOT for the voiceless and voiced stop sounds both in reading and in isolation when compared to that of non stutterers who were matched according to age, sex and language background. The longer VOT observed in the present study in case of stutterers may be due to difference in laryngeal muscle activity as pointed out by Wyke (1972) and Schwartz (1974) or breathing disturbances (Hillman and Gilbert, 1977) or due to difference in neurological function (Schwartz, 1974).

The present study also indicatea that there is a difference in VOT between each voiceless stop sound and its voiced counterpart, i.e., there is always a voicing lag for the voiceless stop sounds (indicated by positive numbers) and a voicing lead for the voiced stop sounds (indicated by negative numbers) and this has been observed both for stutterers and non stutterers, in reading as well as in isolation. Like English language (as pointed by Lisker and Abramson, 1964) this way be a characteristic feature is Kannada language. However, this has to be confirmed by further extensive studies with many subjects. From the data as presented by Lisker and Abramson (ref. Table 7), it can be noted that, in case of Marathi language the VOT for initial (p) sound is zero, which means, there is an absence of voicing lag in initial (p) sound. In the present study, for Kannada language this was not noted in case of any stop sounds.

For the non stutterers there were always a consistent increase of VOT values both in reading and in isolation as the position of erticulatory constriction moved backwards in the oral cavity. Lisker and Abramson (1964) and Hillman and Gilbert (1977) observed the same phenomenon for English language in case of normal speakers. But, unlike the results obtained by Hillman and Gilbert (1977) far stutterers, the stutterers of the present study did not show a consistent relation between the VOT and position of articuiatory constriction in the oral cavity. This may be due to varieties of stutterers depending on severity and nature of stuttering or other factors.

The mean VOT values in Kannada (which have been obtained from the present study) for all the voiced and voiceless stop sounds in initial position of words (in spontaneous reading of a passage constructed for the study, which includes the words having the stop sounds in initial position) have not been observed to be same with that of English or Tamil or

Hindi or Marathi. This indicates that VOT varies from language to language.

CHAPTER V

SUMMARY AMD CONCLUSIONS

The notion that the larynx is a culprit for stuttering dates back as early as the eleventh century. Recently the explanation regarding the basic nature, cause and Maintenance of stuttering has been given on the basis of laryngeal dysfunction. Voice Onset Time (VOT) is one of the parameters among the temporal aspect of speech, which indicates laryngeal function. VOT has been 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). Studies have shown that VOT in stutterers is longer than that of non stutterers in case of english stop sounds.

The present study was undertaken to compare the VOT's of stutterers for voiced and voiceless stop sounds of Kannada language in spontaneous reading and in syllables, in isolation with that of non stutterers.

The following hypotheses were posed -

1. There will be no difference between stutterers and non stutterers for VOT values of voiceless stop sounds, (a) in reading (b) in isolation.

2. There will be no difference between stutterers and non stutterers for VOT values of voiced stop sounds (a) in reading (b) in isolation.

3. (a) There will be no difference between VOT for voiced stop sounds and VOT for voiceless stop sounds in non stutterers.

(b) There will be no difference between VOT for voiced stop sounds and VOT for voiceless stop sounds in stutterers.

4. There will be no difference between the VOT for syllables in isolation and VOT for the same sounds in spontaneous reading (a) in stutterers (b) in non stutterers.

5. There will be no difference between the VOT for each sounds with respect to the position of articulatory constriction (a) in stutterers (b) in non stutterers.

6. There will be no difference between the VOT for stop consonants in Kannada and the reported VOT for atop consonants in other languages in non stutterers.

To test the hypotheses five stutterers and five non stutterers were taken. The two groups of subjects were matched in terms of age, sex and language background. For the purpose of this study a passage in Kannada was constructed. This passage included words which contained /p/, /t/, /ṭ/, /H/, /b/, /d/, /d/, and /g/ sounds in initial position. The subjects were instructed to read the passage. Besides this, the subjects also read the syllables of the same sounds mentioned above, in isolation, with the vowel (a) (in cv paradigm). The speech samples were recorded in a high quality tape recorder. The initial segments of the words having the aforesaid sounds and the syllables were separated and displayed in wide band spectrograms, using a Kay 6061 B Sonagraph. VOT measurements were made using the technique followed by Lisker and Abramson (1964).

The results of the study revealed that -

1. The stutterers showed a longer VOT for voiceless and voiced stop sounds both in reading and in isolation when compared to that of non stutterers.

2. There was a difference in VOT between each voiceless stop sound and its voiced counterpart; i.e., there was always a voicing lag for the voiceless stop sounds (indicated by positive numbers) and a voicing lead for voiced stop sounds (indicated by negative numbers). This was observed for both stutterers and non stutterers in reading as well as in isolation.

3. The stop sounds in isolation consistently displayed

a longer VOT in spectrograms than in reading.

4. There was a consistant increase in VOT with respect to the position of articulatory constriction (as it moved backward in the oral cavity) in case of non stutterers.

5. No consistent variation in VOT with respect to the position of articulatory constriction was observed for stutterers. However, there was a difference in VOT for various stop sounds.

6. The mena VOT values for the stop sounds in initial position of words in Kannada (obtained from the present study) were observed to be different than that of other Languages. Thus VOT varies from language to language.

Recommendations for further study

1. The same study may be repeated with a large number of stutterers and non stutterers.

2. VOT may be studied for various groups of stutterers depending upon severity.

3. Age and sex dependency with VOT may be studied.

4. VOT for stop sounds in running speech and that of isolated words may be studied for stutterers and non stutterers.

5. VOT for stop sounds in medial and final positions of words may be studied.

6. A comparison of VOT before and after therapy may be studied in case of stutterers.

7. VOT for atop sounds in isolation may be studied for various language speakers to see whether VOT for isolated sounds are language dependent or sound dependent.

8. VOT for Kannada stop sounds (or any other language which is the mother tongue) and English stop sounds (or any other language which is second language) may be studied comparatively in stutterers and in non stutterers.

9. VOT for stutterers and non stutterers may be studied by OscillographAc method and the results can be compared with Spectrographic method.

BIBLIOGRAPHY

Abbott (James, A), Repressed hostality as a factor in adult stuttering. Journal of Speech Disorders, Vol. 12, No. 4, 1947 (p 428-430).

Abramson, A.s. & Lisker, L., Voice-timing perception in Spanish word-initial stops. Journal of Phonetics, Vol. 1, 1973 (p 1-8).

Adams (Martin, R), some comments on "Time-out as punishment for stuttering", Journal of Speech & Hearing Research, Vol. 13, No. 1, 1970 (p 218-220).

_________________ Comments on Schwartz's "The core of the stuttering Block", Journal of Speech & Hearing Disorder. Vol. 40, 1975 (p 136).

_______________ et.al., "The effect of reduced reading rate on stuttering frequency". Journal of Speech & Hearing Research, Vol. 16, No. 4, 1973 (p 671-684).

Adams, R., & Hayden, P., The ability of stutterers and non-stutterers to initiate and terminate phonation during production of isolated vowel, Journal of speech & Hearing Research, 1976 (p 290-296), Vol. 19.

Adams, M.R., & Reis, R., The influence of the onset of phonation on the frequency of stuttering, Journal of Speech & Hearing Research, Vol. 14, 1971 (p 639-644).

_____________________ Influence of the onset of phonation on the frequency of stuttering; A replication and Re-evaluation: Letter to the Editor, Journal of Speech & Hearing Research, Vol., 17, 1974 (p 752-754).

_____________________ The influence of the onset of phonation on the frequency of stuttering. Journal of Speech & Hearing Research, Vol. 14, 1971 (p 639-644).

Agnello, J.G., and Goehl, H., "Spectrographical patterns of disfluencies in the speech of the stutterers". Convention address, A.S.H.A., 1965, cited in Nature of stuttering by C.Van Riper, Printice-Hall, Inc., Englewood Cliffs, N.J.,(1971).

Agnello, J.G., and Wingate, M.E., some acoustical and physiological aspects of stuttered speech, paper presented at the Annual Convention of the American Speech & Hearing Association, San Francisco (Nov., 18-21, 1972). Cited by Schwartz, M., in core of the stuttering block', Journal of Speech & Hearing Disorders, Vol. 39,1974.

Ainsworth, S., Methods for Integrating Theories of stuttering in 'Handbook of Speech Pathology and Audiology', Ed: Travis, L.E., Appleton-Century-Crofts, New York, 1971.

Ainsworth (Stanley), 'Integration of theories of stuttering'. Journal of Speech Disorders, Vol. 10, No. 3, 1945, (p 205-209).

Anderson (Jeanette) & whealdon (Mary, L.), 'A study of blood group distribution among stutterers'. Journal of Speech Disorders, Vol. 6, No. 1, 1941,(p 23-28).

Andrews (Gavin) et. al., 'Current research in stuttering', J. Austral., coll., Sp., therapists, vol. 17, 1967, (p 15-19).

Atkinson, C.J., Vocal responses during controlled aural stimulation, Journal of speech and Hearing Disorders, Vol. 17, 1952, (p 419-426).

Besozzi (Thomas. E.,) and Adams (Mortin ,R.,) 'The influence of prosody on stuttering adaptation'. Journal of Speech & Hearing Research, Vol. 12, No. 4, 1969, (p 818-824)

Brenner, N.C., Perkins, W.H., & Soderberg, G.A., The effect of rehearsal on the frequency of stuttering. Journal of speech & Hearing Research, Vol. 15, 1972, (p 483-486).

Brodnitz (Friedrich, S.,) Voice problems of the actor and singer, Journal of Speech & Hearing Disorders, Vol.19, No. 3, 1954, (p 322-326).

Brown, S.F., Stuttering in relation to word accent and word position, J. Abnormal soc., Psychol., Vol. 33, 1938, (p 112-120).

Curry (E. Thayer), 'Hoarseness and voice change in male-adoleacents', Journal of Speech & Hearing Disorders, Vol. 14, No. 1, 1949, (p 23-25).

Datatreye (T), Effects of continous contingent,random contingent and random negative stimulation on selected responses in a moment of stuttering, (Mysore university, Dissertation, 1973).

Davies, D.v., ed., Gray's Anatomy, 34th edition, Orient Longmans, Mew Delhi (1969).

Eisenson, J., & Horowitz, B., The Influence of proposition-ality on stuttering, Journal of speech and Hearing Disorders, Vol. 10, p 193-197 (1945).

Emerick, L.L.,and Hatten, J.T., Diagnosis and evaluation in speech pathology, Englewood cliffs, N.J., prentice Hall, p 175 (1975).

Freemen, F.J., and Ushijma, T., Laryngeal activity accompany-ing the moment of stuttering: A preliminary report of E.M.G. investigations, J. fluency. Dis., Vol. 1, p 36-45 (1975), cited by Starkweather et al., in Journal of Speech and Hearing Research, Vol. 19, p 481-492 (1976).

Freeman, F.J., Ushijima, T., & Hirose, H., Reply to Schwartz's "The core of the stuttering block" Journal of speech and Hearing Disorders, Vol. 40, p 137-139 (1975).

Faaborg-Andersen, K., "Electromyographic investigation of intrinsic laryngeal muscles in humans". Acta Physiol. Scand., Vol. 41, Suppl., p 140 (1951).

Fakuda, H., Sasaki, C.T., & Kirchner, J.A., "Vagal afferent influences on the phasic activity of the posterior cricoarytenoid", Acta Otolaryng. vol. 75, p 112-118 (1973).

Geetha Pai, V., The relation between fundamental frequencies and resonant frequencies of the voice tract, Disserta-tion, University of Mysore (1974).

Goldstein (Leonard, D) and others, Relationship between "Achievement imagery" and stuttering behavior in collage males, Proceed., Iowa Acad., scien., Vol.62 (1955).

Gould (Wilber James), "Quantitative assessment of voice function in Microlaryngology", Folia Phoniat. Vol. 27, p 190-200 (1975).

Guitar, B., Reduction of stuttering frequency using Analog Electromyographic Feedback, Journal of speech and Hearing Research, Vol. 18, p 672-685 (1975).

Gupta (S.K.) and others, Perceptual study of segments of intervocalic stops and affricates, J. Audio., Engineer., Soc., vol. 21 (1973).

Hanna, R., Wifting, F., and McNeill, B., A biofeedback treatment for stuttering. Journal of speech and Hearing Disorders, Vol. 40, p 270-273 (1975).

Harris (K.s.) and others, some aspects of the production of oral and nasal labial stops, Lang. speech. Vol. 8 (1965).

Healey C.E., & Mallard, A.R., Factors contributing to the reduction of stuttering during singing, Journal of Speech and Hearing Research, Vol. 19, p 475-480

Hillman, R.E., and Gilbert, H.R., Voice onset time for voiceless stop consonants in the fluent reading of stutterers and non-stutterers, J.,Acoust., Soc., Amer., Vol. 61, p 610-612 (1977).

Hirose, H., "An electromyographic study of laryngeal adjustments during speech articulation: A preliminary report". In status report on speech Research, SR-25/26, Haskins Laboratories, New Haven, Conn., (1971).

Hockett, C.F., A course in Modern Linguistics, Oxfort & IBM Publishing Co., New Delhi, Calcutta, Bombay, (1970).

Irving, R.W., and Webb, M.W., Teaching esophageal speech to a pre-operative severe stutterer, Annals of otology, Rhinology & Laryngology, Vol. 40, p 1069-1080 (1961).

Kay Electric Company, Operation Manual Issue A, June, 1968, Kay Electric company, Pine Brook, New Jersey.

Kostic (Djordje), Linguistic syndrome of stuttering. Text of a lecture delivered to the department of Psychology faculty & advanced graduate students, university of Wisconsin-superior, Aug., 2 (1972).

Kenyon, E.L., The etiology of stammering: The Psychophyslologic facts which concern the production of speech sounds and of stammering, Journal of speech and Hearing Disorders, Vol. 8, p 337-348 (1943)

Ladefoged, P., A Course in Phonetics, Harcourt Brace, Jovanovich, Inc., New York (1974).

Liberman, A.M., and others, Discrimination of relative onset time of the components of certain speech and nonspeech patterns, J. Exp., Psychol., Vol. 61 (1961).

Liberman, A.M., and others, Some cues for the distinction between voiced end voiceless stops in initial position. Lang., Speech. Vol 1, Part 3 (1958).

Lisker, L, Closure duration and the intervocalic voiced-voicelese distinction in English, Language, Vol.33 (1957).

Lisker, L., and Abramson, A.S., A cross language study of voicing in initial stops: Acoustical Measurements, word. 20, p 384-422 (1964).

Lisker, L., and Abramson, A.s., Distinctive features and laryngeal control. Language. 47, p 767-785 (1971).

____________ some effects of context on voice onset time in English stops, Language & Speech, Vol. 10, Part I, p 1-28 (1971).

MacKenzie, F.A., A stutterer's experience in using a electrolarynx. In Johnson, W., (Ed.), Stuttering in children & adults. Minneapolis: University of Minnesota Press (1955).

Mallikarjuna, B., Relevance of Mahapyana in speech Therapeutics, Dissertation, Univversity of Mysore (1974).

Monsen, R.B., Toward measuring how well hearing impaired children speak. Journal of Speech & Hearing Research, Vol. 21, Mo. 2, p 197-219, (1978).

Murakami, Y., and Kirchner, J.A., Respiratory movements of the vocal cords. An electromyographic study in cat. Laryngoscope. Vol. 82, p 454-467 (1972).

O'Neil, J.J., The role of the vocal cords in human respiration, Laryngoscope, Vol. 69, p 1494-1507 (1959).

Ogura, J.H., Togawa, K., et.al., Masai obstruction and the mechanics of breathing. Arch., Otol., Vol. 83, p 135-150 (1966).

Parimala Rao, Dichotic delayed auditory feedback in normals and stutterers, Mysore University, Dissertation (1977).

Perkins, W.H., Speech Pathology (II edition), Saint Louis: The C.V. Mosby company (1977).

Perkins, W., Rudas, J., Johnson, L., & Bell, J., Stuttering: Discoordination of phonation with articulation and respiration. Journal of Speech and Hearing Research, Vol. 19, p 509-522 (1976).

Potter, R., Kopp, G, & Green, H., Visible Speech. New York, Van Nostrand (1947).

Preati, A.J., High-speed sound spectrograph, J.,acoust., soc. Am., Vol. 40, p 628-634 (1966).

Rathna, N., and Nataraja, N.P., Stuttering and hearing loss. The Journal of the All India Institute of Speech and Hearing, Vol. 3, p 193-197 (1972).

Robinson, F.B., Stuttering, Englewood Cliffs, N.J., Prentice Hall Inc., (1964).

Rontal, E., et.a., Objective evaluation of vocal pathology using voice spectrography, Ann.,Otol.,Rhinol., Laryngol., Vol. 84, p 662-671 (1975).

Schwartz, M.F. Author's response to zimmermann and Allen, and Adams, Journal of speech and Hearing Disorders. Vol., 40, p 136-137 (1975).

______________ stuttering solved, 1st edition, McGraw-Hill Book Company, New York (1976).

Starkweather, C.W., Hirechman, P., & Tannenbaum, R.S., Latency of vocalization onset: stutterers versus Non stutterers, Journal of speech and Hearing Research, Vol. 19, p 481-492 (1976).

Stromsta, C.,"A spectrographic study of Dysfluencies labeled as stuttering by parents", De therapia Vocis et Loquellae, I (1965), 317-20. Cited in Nature of Stuttering, by C. Van Riper, Printice-Hall Inc., Englewood Cliffs, N.J., (1971).

Summarfield, G.A., and Haggard, M.P., "Speech rate effects in the perception of voicing", Speech synthesis and perception (Psychol., Lab., University of Cambridge, England, 1972). Cited by Hillman, R.E., and Gilbert, H.R., in "Voice onset time for voiceless stop consonants in the fluent reading of stutterers and non stutterers", J., Acoust., Soc., Amer., Vol. 61, p 610-612 (1977).

Suzuki, M., & Kirchner, J.A., The posterior cricoarytenoid as an inspiratory muscle, Ann., Otol., Vol. 78, P 849-864 (1969).

Van Delnse, J.B., et., al., Problems of the singing voice, Folia Phoniat, Vol 26, p 428-434 (1974).

Van Riper, C, The Nature of Stuttering, Prentice-Hall Inc., Englewood Cliffs, N.J., (1971).

________ The Treatment of Stuttering, Prentice-Hall Inc., Englewood Cliffs, N.J., (1973).

Vijayalakshmi, A.R., Effect of three verbal stimuli on fluency of stutterers, Mysore University, Dissertation, (1973).

Wajskop, M., & Sweerts, J., Voicing cues in oral stop consonants. Journal of Phonetics, Vol. 1, p 121-130 (1973).

Whitehead, R.L., and Emanuel, F.W., Some spectrographic and perceptual features of vocal fry, abnormality rough and modal register vowel phonation. J., Commun., Dis., Vol. 7, p 305-319 (1974).

Wingate, M., A standard definition of stuttering, Journal of Speech 6 Hearing Disorders, vol. 29, p 464-488 (1964).

sound and pattern in "artificial" fluency, Journal of speech & Hearing Research, Vol. 12, p 677-688 (1969 a)

________ Stuttering and word length, Journal of Speech & Hearing Research, Vol. 10, p 146-152 (1967).

,Stuttering as phonetic transition defect, Journal of Speech & Hearing Disorders, Vol. 34, p 107-108 (1969 b).

Winitz, H., LaRiviere, C, & Herriman, E., Variations in VOT for English initial stops, J. Phonetics, Vol. 3, p 41-52 (1975).

Wolfe, V.I., & Bacon, M., Spectrographic comparison of two types of spastic dysphonia. Journal of Speech & Hearing Disorders, Vol. 40, p 325-352 (1976).

Wood, K.S., Terminology and nomenclature in Handbook of Speech Pathology and Audiology, Ed., Travis, L.E., Appleton-Century-Crofts, New York (1971).

Wyke, B., Phonatory reflex mechanisms and stammering, _Folia Phoniat_, Vol. 26, p 321-336 (1974).

Zimmermann, G., & Allen, E.L., Questions concerning Schwartz's "The core of the stuttering block", Journal of Speech & Hearing Disorders, Vol. 40, Pp 135-136 (1975)

Zlatin, M.A. & Koenlgaknecht, R.A., Development of the voicing contrast: A comparison of voice onset time in stop perception and production. _Journal of speech & Hearing Research_, Vol. 19, p 93-111.

APPENDICES

APPENDIX I

Instructions:-

ಕೆಲವು ಕನ್ನಡ ವಾಕ್ಯಗಳನ್ನು ಮತ್ತು ಕೆಲವು ಶಬ್ದಗಳನ್ನು ನಿಮಗೆ ಕೊಡಲಾಗುತ್ತದೆ. ದಯವಿಟ್ಟು ಅವುಗಳನ್ನು ಓದಿ. ನೀವು ತಯಾರಾ? ಈಗ ಶುರು ಮಾಡಿ:—

The passage:-

ಕಮಲ ಆಗ ತಾನೇ ಶಾಲೆಯಿಂದ ಮನೆಗೆ ಬಂದಿದ್ದಳು. ಗಾಯತ್ರಿ ಅವಳೊಡನೆ ಆಟವಾಡಲೆಂದು ಬಂದಳು. ಇಬ್ಬರೂ ಬೀದಿಯಲ್ಲಿ ಚೆಂಡಾಟವಾಡತೊಡಗಿದರು. ತಾರಸಿಯ ಮೇಲೆ ಚೆಂಡು ಬಿತ್ತು. ಪಕ್ಕದ ಮನೆಯ ಹುಡುಗ ಆ ಚೆಂಡನ್ನು ತೆಗೆದು ಕೊಟ್ಟ. ಅಷ್ಟರಲ್ಲಿ ಕತ್ತಲಾಯಿತು. ಕತ್ತಲಾದುದರಿಂದ ಇಬ್ಬರೂ ತಮ್ಮ ತಮ್ಮ ಮನೆಗಳಿಗೆ ಹೊರಟರು.

ದಾರಿಯಲ್ಲಿ ಹೋಗುತ್ತಿರುವಾಗ, ಕಮಲಳಿಗೆ ಒಂದು ಡಬ್ಬಿ ಸಿಕ್ಕಿತು. ಡಬ್ಬಿಯನ್ನು ತೆರೆದು ನೋಡಿದಾಗ ಅವಳಿಗೆ ಬಹಳ ಆಶ್ಚರ್ಯವಾಯಿತು. ಬಂಗಾರದ ಹೊಳೆಯುತ್ತಿರುವ ಪದಕ ಆ ಡಬ್ಬಿಯಲ್ಲಿತ್ತು. ಗಾಯತ್ರಿಯನ್ನು ಕರೆದು ತೋರಿಸೋಣವೆಂದುಕೊಂಡಳು. ಆದರೆ ಅವಳನ್ನು ಕರೆಯದೆ, ಅದನ್ನು ತೆಗೆದುಕೊಂಡು ಮನೆಗೆ ಹೋದಳು. ತಾಯಿಗೆ ಅದನ್ನು ತೋರಿಸಿದಾಗ, ಅವಳಿಗೂ ಆಶ್ಚರ್ಯವಾಯಿತು. "ಡಾಂ ಟಾಂ ಹೊಡಿಬೇಡ, ಎಲ್ಲರ ಮುಂದೆ" ಎಂದು ಎಚ್ಚರಿಸಿದರು ಅವಳ ತಾಯಿ.

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ಪಾ	ತಾ	ಟಾ	ಕಾ
ಬಾ	ದಾ	ಡಾ	ಗಾ

*The sounds which are underlined were subjected to analysis, however, in the original passage which was given to the subjects while recording, none of the sounds were underlined.

APPENDIX II

Subject 1:- Y.A.Kishore Kumar No. 19600 Age: 19.5 Yrs.

Sex: Male Mother Tongue: Kannada

Other languages: English, Hindi

Onset of stuttering: At the age of 3 years

The case reports that he was a left hander and later he started using his right hand for vital purpose.

speech evaluation: A case of severe stuttering, characterised by arrest of articulatory postures, silent and audible pauses and repetitions. Secondaries like eye blinking, head movement, leg and hand movement are present.

Advice:- Prolongation therapy at AIISH. The case underwent prolongation therapy for one month during April-May 1979 and discharged with a considerable improvement. He was subjected to the experiment after therapy.

Subject 2:- B. Magesh No. 21995 Age: 15 years

sex: Male Mother Tongue: Kannada

Other languages: Nil

Onset of stuttering : At the age of 10 yaars

Speech evaluation,- Moderate stuttering, characterized by hesitations, prolongations and silent pauses.

secondaries like facial grimaces were present.

Advice: Prolongation.

The case underwent therapy for a month during April-May 1979. showed a considerable improvement in fluency. He has been asked to keep up prolongation. This subject also was subjected to the study after therapy.

Subject 3:- Sujit Kumar No:19692 Age:17 Years

Sex: Male Mother Tongue: Kannada

Onset of stuttering: At the age of 6 years

Speech evaluation : Moderate stuttering characterized by prolongation of syllables, repetition and silent pauses. Secondary symptom was trembling of lips. Stuttered more for the sounds (p), (t), (n), (v), (ch), (r)

Avice: Prolongation

The case underwent therapy at K.R.H. Clinic for a month, showed improvement and then was subjected to experimentation.

Subject 4: Anand Babu NO. 179 Age 15 yrs 6 months

Sex: Male Mother Tongue: Kannada

other language : English

Onset: At the age of 7 years

Speech evaluation: Moderately severe stuttering characterised by repetitions of syllables, sucking of air, pauses, etc.

Eye blinking was observed as a secondary symptom.

Advice: Prolongation.

The case attended therapy at AIISH and showed improvement.

He was subjected to experimentation after therapy.

Subject 5:-Anil No. 4805 Age:20 years

Sex: Male Mother Tongue: Kannada

Other language: English

Onset: At the age of 6 years

Speech evaluation: Moderately severe stuttering Characterised by repetitions, prolongation, hesitation and pauses. Secondary symptom was pursing to lips.

Advoce: Prolongation therapy at AIISH.

He underwent therapy for 30 sessions in AIISH Clinic and showed improvement. He was included as a subject for the experiment after therapy.

Subject 6:-Normal

Subba Rao Sex: Male Age: 19.5 years

Mother Tongue: Kannada

Other languages: Telugu, Hindi, English

No family history of any speech and hearing problem.

Student of III B.sc., Speech and Hearing

Subject 7:- Normal

Sridhar Sex: Male Age: 20 years

Mother Tongue: Kannada

Other languages: English, Hindi

No family history of any speech and hearing problem.

Student of II B.Sc., Speech and Hearing

Subject 8:- Normal

Uday Kumar Age: 15 years Sex: Male

Mother Tongue: Kannada

Othe language:English

No family history of any speech and hearing problem.

Student of IX standard

subject 9:- Normal

Harish sex: Male Age: 15 yrs., 7 months

Mother Tongue: Kannada

Other language: English

No family history of any speech and hearing problem.

student of X standard.

subject 10:-Normal

Prakash Age: 17 years sex: Male

Mother Tongue: Kannada: Other Languages: English, Hindi. No family history of any speech and hearing problem. Student of I PUC.

APPENDIX III

SPECIFICATION OF KAY 6061-B SONAGRAPH

Frequency Range	: 85 to 16,000 Hz in two ranges
Displays available	: Frequency-Vs-Amplitude-Vs-Time (Conventional)
	Frequency-Vs-Amplitude-Vs-Time (Contour)
	Amplitude-Vs-Frequency
	Amplitude-Vs-Time
Analysis time	: 1.3 Minutes
Effective Resolution	: 80 - 8000 Hz; 45 & 300 Hz
	160 - 16000 Hz; 90 & 600 Hz
AGC Range	: Variable 20 to 4 dB down to 10
Frequency Calibration	: Switchable at 50; 500 or 1000 Hz intervals
Response	: ± 2 dB over entire range
Recording time	: 80 - 8000 Hz 2.4 Secs.
	160 - 16000 Hz 1.2 Secs.
Amplifier characteristics	: Flat or 13 dB high-frequency pre-emphasis
Input Impedance	: 200, 600 or 10,000 ohms, switchable
Recording Medium	: Nickel-Cobalt plated turntable
Microphone supplied	: Altec-Lansing 681 A dynamic
Power supply	: 117 V, 50/60 CPS, 100 W; regulated
Dimensions	: 25" h x 20" w x 18½" d
Weight	: 125 Lbs. (approx.)