THE SPECTROGRAPHIC ANALYSIS OF STUTTERER'S SPEECH UNDER DELAYED AUDITORY FEEDBACK

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A Dissertation submitted to university of Mysore in

part fulfilment for the Degree of Master of

Science in Speech and Hearing.

May 1983.

TO

PARENTS

and

SANJEEVAN MEDICAL FOUNDATION

CERTIFICATE

This is to certify that the dissertation entitled "The Spectrographic analysis of Stutterer's Speech under Delayed Auditory Feedback" is the bonafide work done in part fulfilment for the degree of Master of Science (Speech and Hearing) of the student with Register No.10

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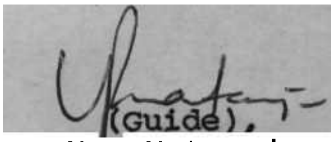
CERTIFICATE

This is to certify that this dissertation entitled "The Spectrographic analysis of stutterer's Speech under Delayed Auditory Feedback" has been prepared under my supervision and guidance.



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DECLARATION

This dissertation entitled "The Spectrographic analysis of Stutterer's Speech under Delayed Auditory Feedback" is the result of my own study undertaken under the guidance of Mr. N.P. Nataraja, Lecturer in Speech Pathology, All India Institute of Speech and Hearing, and has not been submitted earlier at any University or Institution for any other diploma or degree.

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CONTENTS

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 still remain a mystery"
>
> \- Emerick & Hatten, 1974.

Many have attempted to explain the stuttering on the basis of different theories (learning theories - Johnson, 1958? Brutten and Shoemaker, 1967? Cerebral dominance theory - orton, 1927? Travis, 1931? conflict theory, Sheehan, 1958).

The development and influence of cybernetics has given rise to a number of hypothetical models, such as those by Fairbanks (1954) and Mysak (1966) which describe the essential monitoring system for speech as closed feedback and loops and have concluded that any disruptions in the monitoring system might lead to speech disturbances.

When a normal speaker's verbal output was fedback to his ears after a short delay of about 200 m secs, marked breaks in fluency occured. This phenomenon of DAF was first reported by Lee and Black (1950, 1951). Marked reduction in stuttering has often been achieved by this process in stutterers (Adamezyk, 1959? Goldiamong, 1965 and others).

Some studies with stutterers (Ham and steer, 1967? Logue, 1962 and Neeley, 1961) found that stutterers' responses under delayed auditory feedback did not differ from the normal speaker's responses under delayed auditory feedback.

Ham and Steer (1967) found no significant mean difference in frequency of stuttering under normal auditory feedback and delayed auditory feedback but extreme individual reactions in stutterers occured under delayed auditory feedback.

Logue (1962) found that both stutterers and non-stutterers showed increased total time of reading, phonation/time ratio and vocal intensity under delayed auditory feedback in comparison to normal auditory feedback.

Some (Nessel, 1958; Lotzman, 1961; Soderberg, 1959; and others) have demonstrated that the stutterers respons to delayed auditory feedback in a manner different from that of the normals. Generally an improvement in fluency has been observed under delayed auditory feedback, although this was not found in all stutterers.

Nandur (1982) in his study found decrease in number of stuttering blocks in stutterers under binaural masking noise. Increase in fundamental frequency, vocal intensity and vowel duration were seen in both stutterers and nonstutterers under binaural masking noise.

The information regarding the behaviours of stutterers and non-stutterers under delayed auditory feedback have not been analysied to note the significance of difference between these two groups in terms of number of blocks, rate of reading, variations in fundamental frequency, vocal level (intensity). Voice onset time and vowel duration.

Very few studies have appeared in literature which have attempted to analyse the stutterers speech under delayed auditory feedback using spectrograph.

The present study was aimed at the analysis of different parameters of speech - fundamental frequency, vowel duration, voice onset time, vocal level, rate of speech, number of stuttering blocks of stutterers and normals in reading condition, in the presence and absence of binaural delayed auditory feedback conditions, using Spectrograph.

STATEMENT OF THE PROBLEM

The problem was to find out the effects of bilateral delayed auditory feedback (DAF) on the rate of speech, number of blocks, fundamental frequency, voice onset time, vowel duration and vocal level in stutterers and non-stutterers.

PURPOSE OF THE STUDY:

The purpose of the study was to test the following hypotheses;

HYPOTHESIS No. 1

(a) There will be no signigicant difference in the rate of speech of stutterers while reading under delayed auditory feedback (DAF) and Normal auditory feedback.

(b) There will be no significant difference in mean rate of speech of nonstutterers (Normals) while reading under delayed auditory feedback and normal auditory feedback.

(c) There will be no significant difference in the mean rate of speech of nonstutterers and stutterers under delayed auditory feedback.

d) There will be no significant difference in the mean rate of speech of nonstutterers and stutterers under normal auditory feedback.

HYPOTHESIS No. 2

(a) There will be no significant difference in mean values of stuttering blocks of stutterers while reading under delayed auditory feedback and normal auditory feedback.

(b) There will be no significant difference in mean values of stuttering blocks of nonstutterers while reading under delayed auditory feedback and normal auditory feedback.

(c) There will be no significant difference in the mean values of stuttering blocks of stutterers and non-stutterers while reading under delayed auditory feedback.

(d) There will be no significant difference in mean values of stuttering blocks of stutterers and non-stutterers while reading under normal auditory feed-back.

HYPOTHESIS No. 3

(a) There will be no significant difference in mean fundamental frequency values of stutterers while reading under delayed auditory feedback and normal auditory feedback.

(b) There will be no significant difference in the mean fundamental frequency values of non-stutterers while reading under delayed auditory feedback and normal auditory feedback.

(c) There will be no significant difference in mean fundamental frequency values of stutterers and nonstutterers while reading under delayed auditory feedback.

(d) There will be no significant difference in mean fundamental frequency values of stutterers and nonstutterers while reading under normal auditory feedback.

HYPOTHESIS No. 4

(a) There will be no significant difference in mean voice onset time values in two readings of stutterers underdelayed auditory feedback and normal auditory feedback.

(b) There will be no significant difference in mean voice onset time values in two readings of non-stutterers under delayed auditory feedback and normal auditory feedback.

(c) There will be no significant difference in mean voice onset time values of stutterers and nonstutterers while reading under delayed auditory feedback.

(d) There will be no significant difference in mean voice onset time values of stutterers and nonstutterers while reading under normal auditory feedback.

HYPOTHESIS No. 5

(a) There will be no significant difference in the mean vocal intensity values in two readings of stutterers under delayed auditory feedback and normal auditory feedback.

(b) There will be no significant difference in the mean vocal intensity values in two readings of non-stutterers under delayed auditory feedback and normal auditory feedback.

(c) There will be no significant difference in mean vocal intensity values of stutterers and non-stutterers while reading under delayed auditory feedback.

(d) There will be no significant difference in the mean vocal intensity values of stutterers and nonstutterers while reading under normal auditory feedback.

HYPOTHESIS No. 6

(a) There will be no significant difference in the mean vowel duration values of stutterers while reading under delayed auditory feedback and normal auditory feedback.

(b) There will be no significant difference in mean values of vowel duration of nonstutterers while reading under delayed auditory feedback and normal auditory feedback.

(c) There will be no significant difference in the mean vowel duration values of stutterers and nonstutterers while reading under delayed auditory feedback.

(d) There will be no significant difference in the mean vowel duration values of stutterers and non-stutterers while reading under normal auditory feedback.

To test thesehhypotheses, four stutterers and four nonstutterers (males) having an age range of 15 to 25 years offage were selected. They were asked to read two passages - one under delayed auditory feedback and another under normal auditory feedback conditions. The reading samples were recorded on the Tape recorder of the Speech Spectrograph and they were analysed spectrographically, for the measurement of Voice onset time and vowel duration. Fundamental frequency was measured by feeding the reading samples to Digipitch. Measuring amplifier was used to measure the vocal level. Rate of speech was calculated by counting the number of syllables read per second.

LIMITATIONS OF THE STUDY

1. The study was done using Kannada language only.
2. The study was done using only four stutterers and four nonstutterers with limited age group.
3. Only a delay of 200 mili seconds with an intensity of 62 dB SPL(graduation 5 on the volume control of delayed auditory feedback unit) was used.

IMPLICATIONS OF THE STUDY

1. This study helps to know the effects of delayed auditory feedback on the reading(speech) of normals.
2. Helps to know the effect of delayed auditory feedback on the speech of stutterers.
3. To find the similarities and differences between stuttering and artificial stuttering (stuttering produced under delayed auditory feedback).
4. This study helps to know the effect of delayed auditory feedback on the various parameters of speech of stutterers and normals such as Fundamental frequency, intensity, rate of speech, vowel duration and voice onset time.

DEFINITIONS USED IN THE STUDY:

Stuttering: "The term stuttering means: (I)(a) Disruption in the fluency of verbal expression, which is (b) characterised 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 (a) accompanied by accessory activities involving the speech apparatus related or unrelated body structures or stereotyped speech utterences. These activities give the appearence of being speech related struggle. (111) Also, there are not infrequently (a) 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 asfear, embarrassment, irritation, or the like, (b) 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).

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.

Vowel duration: Vowel duration is the duration for which the vowel is present in a word as shown by the spectrogram, expressed in terms of seconds.

Vocal intensity: Vocal intensity is the intensity of the speech signal as measured by using the sound level meter expressed in terms of dB.

Fundamental Frequency: Fundamental frequency is the frequency of the speech signal as shown by the "Digipitch" expressed in terms of Hertz.

Rate of Speech: Rate of speech is the number of syllables produoed by the individual per second.

/ CHAPTER II /

/ REVIEW OF LITERATURE /

The various theories have differed primarily in the inferences or hypothyses made about the nature of the causal factors. Diagnosogenic theory (Johnson, 1957) states that the stuttering starts in the ears of the parents and not in the child's mouth.

Attempts have been made to explain stuttering on the basis of 'Learning theories' (Johnson, 1958; Edney and Keaster, 1967; Brutten and Shoemaker, 1967; and others).

The organists (except for Tomatis, 1963) showed that abnormalities in neural or motor functioning exist in some stutterers. And those who consider stuttering as neurosis bypass the core behavior of broken words and do not really make clear why or how they are broken (Van Riper, 1971).

Green and Wells(1927) have attributed stuttering to the disorders of nervous system. Wvke (1974) hypothysized that stuttering of laryngeal origin may be a for of phonatory ataxia arising either because of disordered voluntary phonatory tuning of the vocal fold musculature or from incoordinated reflex modulation of the activity of this musculature during actual utterance.

Eisenson (1958) regarded the stuttering block primarily as a perseverative phenomenon similar to those seen in brain injured persons. Glauber (1958) regarded the disorder as a pregenital conversion neurosis. Orton (1927) and Travis (1931) said that stutterers have a lack of cerebral dominance which created mistiming of the motor impulses to the speech musculature which results in stuttering.

Robert West (1958) considers stuttering to be a form of pyknolepsy affecting the fine muscles of speech.

Schwartz (1974) has made attempts to explain the "C6re of the Stuttering block". He believed that "the disorder is essentially an inappropriate, vigorous contraction of the Posterior Crico-arytenoid muscle in response to the sub-glottal air pressure required for speech."

Ainsworth (1971) has classified the theories of stuttering in to two groups. The first type include those theories that seek the active agent, which causes stuttering, outside the child, in the immediate environment or in the culture (Johnson, 1957; Brown, Curtis, Edney and Keasta, 1967). In the second group of theories, the active agent is within the child himself. The active agent may be constitutional or psychodynamic in nature. Constitutionally, the exact agent may lie in the relatively generalized cortical activity affecting the speech areas (West, 1958? Eisenson, 1958), may involve relatively complex auditory feedback circuits (Mysak, 1960) or may be auditory feedback disturbance (Stromsta, 1959). psychodynamically the interruption in neural flow may be triggered by a primary anxiety (Travis, 1971).

It has been further stated by Ainsworth (1972) that some theories combine the possibilities in the active agent category - certain attitudes within the child plus factors in the environment (Bloodstein, 1958) or constitutional elements plus social pressures (West, 1958).

Ainsworth (1971) concludes by stating that "the process of attempting to provide a way of integrating the multiplicity of ideas and facts concerning the nature and source of stuttering continues to be frustrating and fragmentary."

According to Van Riper (1971) stutterers have a defective monitoring system for the production of sequential speech and this might be due to distorted auditory feedback. Cherry and Sayers (1956) offer an assumption that "the production of speech involves a closed feedback action by which means a speaker continuously monitors and checks his own voice production" and stammering represents a type of relaxation oscillation caused by instability of the feedback loop.

Stromsta (1962) hypothysized that discrepencies in arrival times of bone conducted and air conducted side tone may be different in stutterers than in normal speakers.

Wolf and Wolf (1959) state that in stutterers there is a 'dead-time-lag' between the auditory input and motor output of speech.

Mysak (1960, 1966) views stuttering as a disturbance of verbal automobility in internal flow due to disruption in any one of the series of internal or external servo-loop circuits.

Tomatis (1963) considers that stuttering is due to a delay created by the use of the non-dominant hemisphere for the self perception of the speech. This intracerebral dealy interval acts much in the same way as in Delayed Auditory Feedback.

Gruber (1963) says that too much of information load in the auditory system as compared with the tactual and kinesthetic feedback circuits may produce the fluency breaks.

Lani and Tranel (1971) states that stuttering results from excessive use of feedback rather than feedback distortion.

The feedback systems are important for the automaticity of speech, information about the speech output is fedback to the central integrating mechanism through auditory, tactile and kinesthetic sensory channels.

Feedback refers to the process by which the output signals are fedback to the 'Central system'.

The science of cybernetics developed by Weiner (1948) contains concepts and languages which upon their translation into speech terms can make significant theoretical and practical contributions to the field of speech pathology - Mysak (1966). Fairbanks (1954) and Mysak (1966) have made use of these concepts to develop models of closed feedback loops and have described speech mechanism as a 'servo system'.

Mysak (1966) views the speech system as having closed, multiple loop system containing feed farward, feed back, internal and external loops.

Fairbanks (1954) in his model of speech production has included an effector unit, a sensor unit, a storage unit, a mixer and a comparator unit. According to this model the output information that is the feedback is matched against the patterns in the storage which acts as input. The mixer or controller regulating mechanism changes the instructions to the effector system thus altering the output to reduce the future errors. He views speech as an example of automatic control. The acoustical output and the somesthetic feel of speech are fedback through various feedback systems. The feed-back informations are used for comparison with the intended output.

Liberman (1957) has presented a model of phonological perception in which speech production and perception are considered as two aspects of the same process. The motor theory, which is formed as a result of this model, maintains that the acoustic stimulus leads to a covert articulatory response and the proprioceptive feedback leads to discriminative event.

Mysak (1959) has also given a servo model for speech therapy. Here the clinician attempts to super-impose his speech system upon the clients. He hopes that eventually this open cycle control (stimulating and guiding) will develop into a closed cycle control (internal formulation and monitoring or the 'internalization' of the clinician as it were).

Chase (1958) has proposed a rather general formulation of the servo system feedback principle. According to him* normal utterance of a word involves successive discrete responses such as speech units, a, b, c, each of which is controlled in order by the feedback from a preceding unit. The complete word thus combines the three units in proper number and order. The effect of delayed feedback (auditory) is to cause recirculation of each speech unit, thus disturbing both the number and order of such units in the spoken word. The word spoken with feedback delay thus contains an excess number of units in the wrong order.

Lee (1951) has described speech as a series of neural feedback loops involved in the production of phonemes, syllables, words and thoughts. These separate loops are arranged in a hierarchy of speech control, the different levels of which are related to articulation, voice, word production and thinking. Lee (1951) has proposed that this model can explain normal speech, delayed auditory feedback effects, motor aphasias, natural and artificial stuttering.

Lee has stated that "this theoretical model of speech is consistent with neuro-anatomy. The model assumes that the speech mechanism is composed of loops at different levels with a common junction, presumably a centre of the brain at which both volitional and reflex switching occurs. The length of each loop is roughly proportional to the time required to perform the particular speech activity, articulation, operation of the breath system for volume, tension of the vocal cords for pitch and inflection and so on. The inner sets of loops, i.e., articulation and voice, represent the proper speech mechanism.

Lee (1951) has further considered that the hearing system is in series or inductively coupled to the voice loop for the aural monitoring function. Thus the analysis of delayed speech feedback offers the most information for understanding the voice functions of the speech system. He also explains the 'artificial stutter' induced by the delayed auditory feedback. Here, the repetition is produced because the aural monitor of the voice loop is unsatisfactory. The voioe loop continues for one or two extra cycles of action until the arrival of the delayed feedback triggers the next process. This is only a theoretical analysis of delayed auditory feedback. However, the theoretical model of the speech mechanism is itself not very clear and cannot be confirmed by either neural or behavioral analysis. - (Lee's model as reported by Smith, 1962).

These models have been used to explain the speech disturbances in a normal speaker under Delayed auditory feedback, on the basis that if this model is thrown in to oscillations, caused by instability of the feedback loop.

disturbing one's perception, stuttering belike behavior could be observed. Normal speech becomes prolonged, articulatory disturbances, repetitions, intensity rise, fundamental pitch rise and other changes are seen.

Smith (1962) comments that the primary defect in the servo system analogy is that they do not account for the diverse experimental effects of Delayed auditory feedback.

Still another inadequacy of the theories proposed by Lee (1951), Fairbanks (1954) and Chase (1958) is that they emphasize the role of auditory feedback in speech production while giving less importance to the role of kinesthetic and cutaneous feedback. According to Smith (1962), the auditory feedback is normally a vital source of regulatory control of signals for speech, but at times speaking goes on without audition, on the other hand somesthetic feedback is undoubtedly essential for the intricate patterning of speech. The wide individual differences in response to delayed auditory feedback probably arise from differences in the ability of subjects to ignore the delayed auditory signals and depend on kinesthetic and cutaneous feedback. Such flexibility in control of speech is difficult to specify in mechanical analogies.

Smith (1962) has stated that "we must assume that much of the disturbance from delayed auditory feedback is due to interference between the auditory and other types of feedbacks. The fact that a peak disturbance has been recorded with delay intervals of about 200 m. seconds - an effect that remains unexplained in mechanical analogies - probably means that a maximal interference effect between auditory and other feedback occurs at about that interval".

The different aspects of speech seem to be monitored by different feedback systems, the disordered speech has also been explained on the basis of different disordered feedback systems (Mysak, 1966). Stuttering being a speech disorder, is also been explained on the same grounds.

"Stutterers possess a defective monitoring system for sequential speech. Behaviours similar to stuttering can be produced in normal speakers by altering the auditory feedback of their speech output. Further, marked reduction in stuttering can often be achieved by altering auditory feedback in stutterers. From these findings, the possible existance of perceptual disability in stuttering, probably organic in nature has been infered" (Van Riper, 1971).

According to Van Riper (1973), 'the trouble seem to be' due to distorted auditory feedback. Motor speech is largely controlled automatically rather than voluntarily. Motor speech requires a reliable flow of information from the output if it is to be integrated for the purpose of automatic control. This feedback is through multiple bilateral channels and is processed at many levels in the central nervous system. Since speech demands an incredibly precise synchronization of simultaneous and successive bilateral motor responses, distortion could produce asynchrony and lead to stuttering.

Cherry and Sayers (1956) state that ".... the production of speech involves a closed cycle feedback action, by which means a speaker continuously monitors and checks his own voice production and that stuttering represents a type of relaxation oscillation caused by instability of the feedback loop".

Wolf and Wolf (1959) have considered stuttering as a problem due to a 'closed-time-lag' between auditory input and motor output.

According to Tomatis(1963), the disruption of speech in stutterers are due to

(i) delay created by the use of the nondominant ear for the self perception of speech; and

(ii) intracerebral delay interval which acts as much in the same way as that involved in delayed auditory feedback.

Stromsta (1962) has hypothesized that arrival times of bone conducted and air conducted side tone may be different in stutterers than in normal speakers. Butler and Stanley (1966) have suggested that the locus of the malfunctioning may be in the middle ear and that this interrupts the automatic programming of the motor output.

Sklar (1969) believes in reducing auditory feedback as a therapeutic means, which helps in stabilizing the oscillating servo system.

Gruber (1965) says "too much information (overload) in the auditory feedback than in the tactual and kinesthetic feedback circuits may produce fluency breaks".

Webster and Lubker (1968) have offered an auditory interference theory of stuttering, while accepting that this interference may be produced by various distortions in the feedback signals, for them the nature of the interaction between air and bone conducted auditory feedback in the ear of the stutterer is important. If interaction between air conducted and bone conducted feedback signals produce momentary phase or frequency distortion, it is possible that the resultant signal becomes a sufficient stimulus to produce interference.

According to Martin (1970), stutterers set too stringent a criterion and so incoming signals are misevaluated. He has stated that "in the case of a moment of stuttering, it is my hypothesis that the criterion becomes excessively conservative and decision time in the comparator is slightly delayed. In this way speech becomes distorted in a manner similar to the distortion in the speech of normals under delayed auditory feedback."

Lee (1950, 1951) and Black (1951) first reported about Delayed Auditory Feedback. When a normal speaker's verbal output was fedback to his ear after a short delay of 200 m. seconds, marked breaks in fluency occured. Delayed auditory feedback could also be called as delayed sensory feedback in the strictest sense of the term, as the self stimulation process generated by motion are interrupted between the motion and the recording sensory endings. Delayed auditory feedback is also called as delayed side tone.

Lee (1950) in his experiment used the delays of 0.1, 0.2, 0.3 seconds in reading a passage for 5 subjects. The obvious findings on their speech were increase in pitch and loudness, reduced rate of speech and disturbance in speech pattern. Lee (1950) reported that a subject might stop completely or may show stuttering like behavior. This he called "artificial stutter" consisting of repetitions of syllables especially those with fricatives.

Black (1951) studied the effect of delayed auditory feedback on 22 subjects who read 11 series of short phrases each series consisting of 5 syllable phrases. The delays were 0.00, 0.03, 0.06, 0.09 and 0.30 seconds. He observed reduced rate of reading and increase in vocal intensity. Under longer delays, blocking of speech, prolongations and slurring of speech sounds were noticed.

Fairbanks (1955) did a comprehensive analysis of various effects on speech of different intervals of delayed auditory feedback. Subjects were 16, read a passage having 98 words under 5 different delays such as 0.0, 0.1, 0.2, 0.4 and 0.8 seconds. The effects of delayed auditory feedback were, increased articulatory errors, longer duration, greater SPL and higher fundamental frequency. Disturbances in articulation were maximum at 0*2 seconds delay and they interpreted as direct effects. SPL and frequency changes were known as indirect effects. There was marked reduction in reading rate with delays of 0.1, 0+2 and 0.4 seconds with maximal slowing at 0.2 seconds.

Chase and Harvey (1958); Standfast, Rapin and Sutton (1959) observed the slowing down of speech due to delayed auditory feedback, in their study 14 young adults were required to repeat the speech sound /b/ in groups of three, first with no feedback through the earphones and then with a delay of 0.24 seconds. The visible display of speech sounds were recorded on a cathode ray oscilloscope and was photographed. The duration of specific sounds and the intervals between the grouped syllables could be measured directly and converted in to time values. There was marked increase in the duration of the intersyllable interval when auditory feedback was delayed. The mean intersyllable interval for the 14 subjects with normal speech feedback was 0.35 seconds with a range of 0.14 to 0.73 seconds. The mean intersyllable interval with delayed feedback was 0.56 seconds with a range of O.17 to 1.95 seconds.

Fairbanks and Guttman's (1958) study agrees with the above findings i.e., reduction in the number of correct words, increase in total reading time and retarded correct word rate. Here, the disturbance was maximum at 0.2 seconds.

Nataraja, Ramesh and Rajkumar (1982) have reported that normals showed speech disruptions in terms of repetitions, prolongations, hesitations and pauses under delayed auditory feedback. Apart from these disruptions, there was an increase in loudness and pitch with abnormal prosody and articulation was affected which totally contributed for the poor intelligibility of speech.

Stutterers respond in a different manner than do the normals to delayed auditory feedback. The main difference is that the stutterers become fluent under delayed auditory feedback whereas the normals show stuttering like behaviors under delayed auditory feedback.

Van Riper (1971) states that the mild stutterers perform much like normal speakers under delayed auditory feedback.

In a study by Logue (1962), 15 stutterers and 15 non-stutterers read a passage consisting of 73 words under amplified delayed auditory feedback (0.14 to O.2O seconds delay) and normal auditory feedback (NAF). The findings indicated that in both the groups, there was increased total reading time, phonation/time ratio and vocal intensity under delayed auditory feedback compared to normal-auditory feedback.

Ham and Steer (1967) conducted a study having 10 stutterers and 10 non-stutterers, who read 111 word passage under 0.1, 0.2, 0.4 and 0.8 seconds delay and normal auditory feedback. At 0.10 second delay, peak effects were observed with regard to measures of total reading time, phonation/time ration and syllable duration. The mean vocal intensity did not vary significantly among the delay conditions of normal auditory feedback but the stutterers were more variable than were non-stutterers on this measure under delayed auditory feedback.

Cohen and Edwards (1965) reported that their stuttering group experienced alternations between simultaneous feedback and randomized interval feedback for 15 sessions of one hour each for three times weekly. There were no marked reduction in the frequency of stuttering occured, but the stuttering behaviors changed significantly under this regime. Long, severe blockages disappeared, avoidance and struggle behavior decreased and most of the stuttering became repetitive and similar to "primary stuttering".

In Nessel's study (1958), 32 stutterers and 18 non-stutterers read a passage with 135 syllables under amplified 0.13 seconds delay and amplified normal auditory feedback. It was observed that nonstutterers had longer total reading times and more errors under delayed auditory feedback than normal auditory feedback. The majority of the stutterers demonstrated no appreciable change in rate under the two conditions and made fewer errors under delayed auditory feedback.

Zerneri (1966) found two groups among 102 stutterers one of which (primarily clonic ones) improved under delayed auditory feedback, similar results were observed by Bohr (1963).

In Lotzman's study (1961), 62 stutterers read a passage of verse consisting of 271 syllables and 271 syllable passage of prose under amplified conditions of normal feedback and delays of 0.05, 0.10, 0.15, 0.20, 0.25 and 0.30 seconds. Normal auditory feedback condition preceded and followed the delayed auditory feedback conditions, it was found that delayed auditory feedback completely eliminated stuttering or greatly reduced it. For majority of stutterers 0.05 second was considered to be the optimum delay for facilitating speech.

In a study by Soderberg (1969), the subjects made statements of comparable length and number about pictures and read twenty five, ten syllable phrases in the following conditions;

(i) Normal auditory feedback, (ii) Delayed auditory feedback, (iii) Duplication of condition, (iv) Normal auditory feedback and (v) Normal auditory feedback preceded by minutes of inactivity. The delay was approximately 0.14 seconds. After two sequential conditions of delayed auditory feedback, the delay was suddenly eliminated from the feedback in order to assess persistence of the delayed auditory feedback effect. Under delayed auditory feedback, he observed that for both oral reading and spontaneous speaking of the stutterers showed significantly reduced frequency and duration of stuttering and significantly increased duration of words and pitch under delayed auditory feedback. Soderberg (1969) in summary says that generally delayed auditory feedback was found to facilitate the fluency in stutterers.

Chase, Sulton and Rapin (1961) in their experiment asked 30 stutterers to read aloud under conditions of amplified normal auditory feedback and 0.20 seconds delay. They observed marked improvement in one third of their subjects.

In a laboratory setting, Goldiamond (1965) employed delayed auditory feedback and operant conditioning procedures for the treatment of stuttering. He used amplified delayed auditory feedback as punishment for stuttering. In the earlier sessions, there was increase in stuttering but to their surprise under the same negative reinforcement scheduling, the stutterers began to talk more slowly, prolonging and became very fluent. Based on this study,Goldiamond(1965) gave a set of procedures for shaping speech in stutterers. They are,

(i) Instruct the subject to prolong under delayed auditory feedback.

(ii) Gradually fade out delay from 0.25 seconds to normal auditory feedback.

(iii) Speed up the reading rate through machine programmed materials.

Using these procedures he found fluent reading in 30 stutterers.

Gross and Nathanson (1967) modified the shaping procedures given by Goldiamond (1965) and treated male stutterers over a four week period. They attended 3 30 minute sessions and four 15 minute sessions for a total of 2½ hours on the entire sequence. During the first five sessions, the subjects were instructed to establish and use a slow blending pattern under amplified delayed anditory feedback, in the fifth session, the volume of the delayed auditory feedback was normalized and later reading rate was gradually increased to a more desirable pattern and this was demonstrated previously to the subjects using a 5 point scale. 1 represented the subject's initial reading rate under amplified delayed auditory feedback and 5 represented normal rate. Eight stutterers showed significantly reduced frequency of stuttering. A six week and a six month recheck revealed that the stutterers were able to maintain a minimal stuttering in oral reading.

Van Riper (1973) made attempts to use delayed auditory feedback in stuttering therapy. In the early stages of therapy, the stutterers are made aware that even normals under delayed auditory feedback show stuttering like behavior and their reaction to this stuttering like behavior is also like the ones shown by the stutterers towards their problem. Then the stutterers were taught to "beat the machine" through systematic desensitization: This was done by introducing a brief moments of delay dosages gradually. The delay time was increased gradually from the delay producing fluency to delay which produces maximum disruption. The gain of the delayed auditory feedback is kept low in the beginning and increased gradually till he reached the threshold of breakdown.

There aressimilarities between the stuttering and artificial stuttering, i.e., the stuttering like behavior exhibited by the normals under the influence of delayed auditory feedback. They are the repetition of syllables, and prolongations of sounds (Fairbanks, 1955 and 1958).
If one assumes that the basic disturbance in normal speakers under delayed auditory feedback is temporal disruption in the programming of the motor sequences then as Black(1981) and others have suggested the increase in intensity or pitch or the slow down in rate may be considered to be secondary reaction to this core experience (Van Riper, 1921).

Neeley (1961) compared the performances of 23 adult stutterers and 23 adult non-stutterers under a time delay of 0.14 seconds. They read a passage with 100 words, five times under normal feedback conditions. 24 hours later all subjects read the same passage five times under delayed auditory feedback. The speech was amplified at 75 dB above threshold.

Speech samples produced under delayed auditory feedback were rated on a ten point scale of 'Speech disturbance'.

It was found that the mean ratings for nonstuttering group was 3.1 and for stuttering group was 4.0. The difference between the means was not significant at the 10% level, suggesting that the 'Speech disturbance' was perceived by the listeners to be essentially the same in two groups. There were no significant differences between the groups in omissions and substitutions, when the speech behavior of the two groups under delayed auditory feedback was studied with respect to the omissions, substitutions and additions of sounds and correct word rate in seconds.

Yates (1963) pointed out two weaknesses in the study which make Neeley's conclusions quite unacceptable. They are that Neeley (1961) used only (i) one time delay i.e., 0.14 second, and (ii) one intensity level(75 dB SPL) and this delay time is not the one that usually produces breakdown of speech in normal adult speaker but instead it is a delay time that often improves the speech of stutterers.

In recent years there are attempts to study the stuttering in terms of its acoustic characteristics.

Agnello (1966) indicated that the acoustic characteristics of the stuttering disfluencies of stutterers were different from their normal speech disfluencies. Some of the acoustic differences were not detectable by ears but demonstrated only by spectrographic analysis. Specially, shifts of the second formant which reflects normal forward and backward co-articulatory dynamics were not characteristic of stuttering movement.

Stromsta (1962) found anomaly in the formant transitions in their earlier dysfluencies in the children who became stutterers and had normal transitional movements in the children who grew out of these non-fluencies.

According to Van Riper (1971), it is essential to determine the use of'Schwa' vowel in the syllabic repetitions. This indicates the probability of developing stuttering on a more permanent basis, because the proper formant transitions are not present and the required co-articulation cannot be achieved.

Nowadays, Voice onset time studies have been widely used in the area of stuttering as there is increased belief that larynx is the culprit for stuttering and voice onset time reflects the faulty phonatory function in stutterers.

Agnello and Wingate (1972), Adams and Reis (1971), Hillman and Gilbert (1977) and Basu (1979) have indicated that stutterers showed a longer voice onset time for voiceless and voiced stop consonants both in reading and in isolation when compared with non-stutterers.

Adams and Hutchinson (1974) found delay in 'onset' and 'offset' of voicing in stutterers when they were compared with normals.

Adams and Reis (1971) found that stutterers had more difficulty in reading a passage which was filled with voiced and voiceless consonants than the one having only voiced consonants.

Nataraja, Ramesh and Rajkumar's(1982,) Study supports the above findings.

Hillman and Gilbert (1977) had found the voice onset time values of fluent contextual speech of stutterers and compared with the voice onset time values of non-stutterers. The rainbow passage was read by 10 stutterers and 10 non-stutterers, when the spectrographic analysis of inter-vocalic voiceless stop consonant segments were done, it indicated that non-stutterers had shorter voice onset time than stutterers.

Rawnsley and Harris (1954) in their spectrographic analysis of speech under delayed auditory feedback, observed prolongation of vowels in normals.

Agnello (1965) observed prolongation of glides and continuant sounds with the spectrographic analysis in normals.

The review of literature reveals that there are studies reporting the effect of masking noise on the speech of stutterers and the speech was analyzed spectrographically.

Nandur (1982) has studied the effect of masking noise on the speech of stutterers in terms of number of blocks, fundamental frequency variation, vocal level, rate of speech. Voice onset time and vowel duration. He concluded that:

(i) there is significant decrease in number of stuttering blocks under binaural masking noise condition in stutterers.

(ii) No significant difference between normals and stutterers in terms of rate of speech under binaural masking condition.

(iii) Both stutterers and non-stutterers showed an increase in vocal intensity level and raise in the fundamental frequency of voice under binaural masking.

(iv) There was no significant difference between stutterers and non-stutterers in terms of voice onset time. However, both stutterers and nonstutterers showed increase in vowel duration under binaural masking conditions.

Bryton and Conture (1978) investigated the effects of noise and rhythmic stimulation on stutterer's vocal fundamental frequency and vowel duration. Measurements of speech variables were obtained from audio and graphic level recordings, and from broad band and narrow band spectrograms. Results indicated that stuttering was significantly reduced during noise and rhythmic stimulation, and it was also observed that the reduction during rhythmic stimulation being significantly greater than the reduction during noise. They have interpreted the findings to suggest that temporal changes in speech production are related to decrease in stuttering that occurs during noise and rhythmic stimulation.

Decrease in stuttering were correlated with increase in vowel duration during both the conditions for 7 out of 9 subjects.

Some (Van Riper, 1971? Yates, 1963; and Neeley, 1961) have considered that there is difference between stuttering and stuttering like behavior of normals shown under delayed auditory feedback, whereas, others (Fairbanks, 1955; Fairbanks and Guttmann, 1958; and Chase et. al, 1958) have considered that there is no difference between stuttering and stuttering like behavior under delayed auditory feedback. They have further stated that "the basic behaviors of stuttering, repetition of syllables and prolongation of sounds have been found consistently in normal speakers under delayed auditory feedback".

Van Riper (1971) is of the opinion that stutterers have distorted auditory feedback system. But, according to Lani and Tranel (1971), stuttering results from excessive use of feedback rather than feedback distortion.

It is interesting to study the speech behavior of stutterers and normals under delayed auditory feedback. One of the objective ways of studying the acoustic characteristics of speech is spectrographic analysis. Therefore, it was decided to study the speech behaviour of stutterers and nonstutterers under delayed auditory feedback. Further as venkatagiri (1981) states, such a study of speech behavior of normals and stutterers under delayed auditory feedback may provide more knowledge on stuttering, and thus may be useful in better understanding of speech behavior.

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/ CHAPTER III /

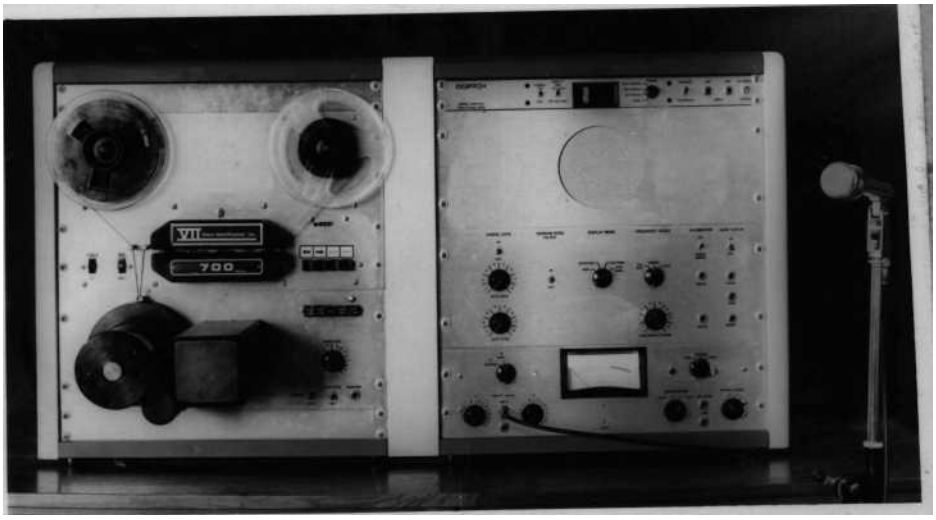
/ METHODOLOGY /

The purpose of this study was to find out the effect of delayed auditory feedback on rate of speech, fluency, fundamental frequency, Voice onset Time, vowel duration, and Vocal level in stutterers and non-stutterers.

SubjeCts:

The stutterers were selected from the clinic of All India institute of Speech and Hearing. They were diagnosed as stutterers by the qualified speech pathologists. They presented the stuttering which met one or more of the criteria given in Wingates (1964) definition of stuttering. Five of these stutterers were able to read Kannada and had Kannada as their mother tongue, were selected for the study. Four stutterers out of five were males. The age of the stutterers ranged from to years. The stuttering as rated by Speech pathologists was moderate in all stutterers. They presented no speech and/or hearing problems other than stuttering.

Four male normal subjects were matched for age, mother tongue and reading proficiency and were selected as subjects for control group, subjects of both the groups were willing to participate in the experiment.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Equipment used:

1. Delayed auditory feedback unit (Aberdeen Speech aid Model DAF-2).
2. Speech Spectrograph (Voice Identification inc., 700 Series).
3. Tape recorder of the spectrograph.
4. Measuring amplifier (B and K type 2606).
5. Digipitch and accessary of spectrograph.(DPM 10S)
6. Stop watch.

PREPARATION OF READING MATERIAL:

Two non-emotional and meaningful passages having same number of syllables were prepared. The words which were to be analyzed spectrographically had occured in both the passages. The passages were prepared in such a way that three vowels /a/, /i/ and /u/ and three consonants /t/, /t/ and /k/ were included in both the passages in initial positions of different words.

Five normal subjects were requested to read each passage and it was found that the time taken to read each passage was same.

All the speech recordings were done using the Tape recorder of the speech spectrograph in the Speech laboratory of All India institute of Speech and Hearing.

Procedure:

Each subject was asked to sit on the chair in front of the tape recorder. The following instructions were given

"Please read these lines as you usually do"

Then the earphones of the DAF unit were kept on the ears. The microphone of the delayed auditory feedback unit was clipped to the collar. The distance between the mouth and microphone of delayed auditory feedback unit was about 10 cms and it was maintained for all the subjects. The distance between the mouth and recording microphone was approximately about 18 cms and this was also maintained constant for all the subjects. A delay of 200 m.sec was used binaurally in this study. The volume of the delayed auditory feedback (dB) kept constant for all the subjectS.

After making such necessary arrangements, the first subject was given Passage A and asked to read. A delay of 200 m.sec was introduced and the reading was recorded. The Passage B was given and the delay was reduced to 0(zero) and the reading was recorded.

The same procedure was carried out for all subjects by giving delay for alternate passages, to encounter the order effect. The order of presentation of the passages were in the following manner

	Passage A	Passage B
Subject 1	DAF	NAF
Subject 2	NAF	DAF
Subject 3	DAF	NAF
Subject 4	NAF	DAF

Same procedure was used for nonstutterers also. All the speech samples were recorded on the tape recorder of the spectrograph and were subjected to analysis.

Analysis:

The speech samples thus collected for each subject were subjected to the following analysis

1. Measurement of suttering blocks - both under delayed auditory feedback and normal auditory feedback.
2. Measurement of mean values of rate of speech — both under dealyed auditory feedback and normal auditory feedback.
3. Measurement of mean values of vocal level both under delayed auditory feedback and normal auditory feedback.

4. Measurement of mean values of fundamental frequency both under delayed auditory feedback and normal auditory feedback.
5. Measurement of mean values of voice onset time for selected stop consonants both under delayed auditory feedback and normal auditory feedback.
6. Measurement of mean values of selected vowel duration both under delayed auditory feed and normal auditory feedback.

1. Measurement of stuttering blocks

The number of stuttering blocks in each of the speech sample for each subject i.e., the speech sample with and without delayed auditory feedback both in case of stutterers and non-stutterers were assessed with the help of three judges.

Three post-graduate students of speech pathology were requested to listen to all speech samples and to mark down the number of blocks in each of the speech sample of all subjects. They were also told about the definition of stuttering in the present study. The judges were seaced comfortably about approximately two metres away from the speaker of the tape recorder of the speech spectrograph. All the speech samples were played using tape recorder of the spectrograph (V.I.I. 700 series). Each judge noted down the number of blocks in each reading. Thus the number of stuttering blocks in the speech samples of all the subjects with and without delayed auditory feedback were determined.

2. **Measurement of rate of speech:**

The experimenter with the help of a stop watch determined the total time taken by each subject to read each of the passages with and without delayed auditory feedback. The number of syllables/duration gave the syllable/sec for each subject under each of the condition.

3. Measuremtnt of vocal level:

For this purpose, four sentences i.e, second, fourth, sixth and eighth in each passage was selected, using the slow scan of the speech spectrograph, speech sample of the 2.4 sec duration of each of the sentence was fed to the measuring amplifier through line input at a time, and the peak intensities of these sample was noted for three times. The maximum was considered as the average intensity of that particular bit of speech sample. Thus each sentence was analysed bit by bit and the intensity at different poritions of the sentence were noted. All the four sentences in each of the passage for all the subjects under both the conditions were subjected to intensity analysis. Thus the intensity variations within each sentence in each passage for all the subjects under both the conditions were obtained.

4. Measurement of Fundamental Frequency:

Using the same procedure that was used to measure intensity, four of the sentences in each passage was fed to the Digipitch through line input. Digipitch is an accessory of Speech spectrograph (V.I.I. 700 series) which displays the fundamental frequency digitally when a speech sample is fed. Thus, the fundamental frequency in each of the bit of the speech sample of 2.4 sec duration was determined. Four sentences in each of the speech sample of all the subjects under both the conditions were thus analyzed to determine the variations in fundamental frequency.

5. Measurement of Voice Onset Time and Vowel duration:

For this purpose, wide band, leniar spectrograms of the words Kamala, tāi, a a, adannu, idakke, uttara were obtained using speech spectrograph. The voice onset time for the stop consonants /k/, /t/, / / occuring in the initial position of these selected words were determined using time scale from the spectrograms.

The duration of vowels /a/, /i/ and /u/ in the selected words were determined again using time scale and spectrograms. These selected words were common in both the passages. Thus these words had been read with and without delayed auditory feedback by all the subjects. Using the procedure described here the speech samples of all the subjects were analysed spectrographically and thus the Voice Onset Time for three stop consonants and duration for each of the three vowels in each of the passages for all the subjects under both the conditions were obtained.

Thus the number of blocks, the syllable output/sec intensity variation, fundamental frequency variation. Voice Onset time and vowel durations were determined for all the subjects under both the conditions.

Further statistical analysis were done to determine the significance of differences on these measures in readings of all the subjects between the two conditions i.e., delayed auditory feedback and normal auditory feed back and also between stutterers and nonstutterers under similar conditions.

/CHAPTER IV /

/ RESULTS AND DISCUSSION/

The experiment was conducted to verify the hypothesis 1, 2, 3, 4, 5 and 6. Results are discussed on the basis of the significance of mean difference obtained for experimental and control group for different variables using 't' test.

1. The effect of delayed auditory feedback on rate of speech:

The number of syllables read persecond under DAF and NAF were compared in case of stutterers and nonstutterers. The results are given in Tables I and II.

Subject No.	Under DAF	Under NAF
1	4.70	6.00
2	5.12	6.21
3	2.68	4.97
4	4.14	6.96
Mean	4.16	6.03

Table I: Showing the Number of syllables read per second under DAF and NAF by nonstutterers,

Subject No.	Under DAF	Under NAF
1	1.34	0.75
2	3.28	4.04
3	1.06	1.08
4	3.95	4.83
Mean	2.40	2.67

Table II Showing the number of syllables read per second under DAF and NAF by stutterers.

In nonstuttering group, there was significant reduction in the number of syllables read per second under DAF when compared with NAF condition at 0.05 level. The mean number of syllables per second under DAF was 4.16 and mean numberof syllables per second under NAF was 6.03. Thus the hypothesis l(b) stating that "there will be no significant difference in mean rate of speech of nonstutterers while reading under DAF and NAF is rejected.

Among stutterers, there was reduction in the number of syllables per second in all subjects except for subject No.l, who showed increase in the number of syllables per second. The mean number of syllables per second under DAF was 2.40 and under NAF, it was 2. 67. Although there was reduction in the syllables per second under DAF, it was not statistically significant. Thus the hypothesis l(a) stating that there will be no significant difference in rateof speech of stutterers while reading under DAF and NAF conditions is accepted.

Thus it can be concluded that DAF has a significant effect on the rateof speech of normals and has less effect on the rate of speech of stutterers which was not statistically significant. However, among stutterers.

the effect may vary from subject to subject i.e., the rate of speech may increase in some and may decrease in some others.

Further the stuttering and nonstuttering groups under DAF were compared. There was a significant difference in the mean values of stutterers and non-stutterers under DAF. Similarly stutterers and non-stutterers under NAF showed significant difference in the means of rate of speech. Both the differences were statistically significant at 0.01 level. Therefore, the hypothesis l(c) stating that there will be no significant differencein the mean rate of speech of nonstutterers and stutterers under DAF and the hypothesis l(d) stating that there will be no significant difference in the mean rate of speech of stutterers and nonstutterers under NAF are rejected.

It was observed that stutterers took more time in reading the passages under NAF when compared with the stutterers under DAF. The mean time taken by the stutterers under NAF wasll7.5 seconds and mean time taken under DAF was 97.75 seconds. But nonstutterers took less time in reading the passages under NAF when compared with the nonstutterers under DAF. The mean time taken by nonstutterers under NAF was 29.25 seconds, and mean time taken under DAF was 44.5 seconds.

It can be concluded from this experiment that the stutterers have taken more time to read the passages under DAF(mean 97.75 secs) when compared to nonstutterers under DAF(44.5 sevs). The nonstutterers have taken less time (29.25 secs) under NAF when compared to stutterers who have taken more time (117.5 sees) to read the passages under NAF. The reduction in time taken to read the passages under DAF among stutterers may indicate the improvement in fluency under DAF.

It is further concluded that stutterers rate of reading is low compared to normals under both the conditions.

2. The effect of DAF on stuttering blocks

The number of stuttering blocks occured under DAF and NAF in both stutterers and nonstutterers were analysed and shown in the table III.

Subject No.	Stutterers		Non-Stutterers	
	Under DAF	Under NAF	Under DAF	Under NAF
1	7.99	23.33	10	0
2	9.32	10.32	3	0
3	25.65	37.65	23	O
4	6.32	5.98	4	0
Mean	17.32	19.32	10	0

Table III: Showing the number of stuttering blocks under DAF and NAF in stutterers and nonstutterers.

The inspection of the table reveals that there was a reduction in number of stuttering blocks in stutterers under DAF when compared with NAF conditions. The mean number of stuttering blocks under DAF was 171.32 and under NAF it was 19.32. However subject No.l and subject No.4 had increase in number of blocks under DAF. The reduction of number of stuttering blocks under DAF is considered as decrease in dysfluency. So the hypothesis 2(a) stating "that there will be no significant difference in mean values of stuttering blocks of stutterers while reading under DAF and NAF.

On the contrary, nonstutterers stuttered under DAF and had no stuttering blocks under NAF. The mean number of blocks under NAF was 10. Thus the hypothesis 2(b) stating that "there will be no significant difference in mean values of stuttering blocks of non-stutterers while reading under DAF and NAF"is rejected.

Further when stutterers and nonstutterers were compared in terms of mean number of blocks under DAF, there was no significant difference between the means. So they hypothesis 2(c) stating that "there will be no significant difference in mean values of stuttering blocks of stutterers and nonstutterers while reading under DAF" is accepted.

Hypothesis 2(d) stating that "There will be no significant difference in the mean values of stuttering blocks of stutterers and nonstutterers while reading under NAF" is rejected because there was no stuttering blocks in nonstutterers and stutterers had a mean of 19. 32 stuttering block under NAF.

Thus it can be concluded that stutterers under DAF improve their fluency and nonstutterers show disfluency under DAF.

3. <u>The effect of DAF on fundamental frequency of voice</u>

The changes in the fundamental frequency of voice under DAF and NAF for both stutterers and nonstutterers are given in the table.

Subject No.	Fundamental Frequency values under DAF	Fundamental Frequency values under NAF
1	128.75 Hz	128.29 Hz
2	96.47 Hz	99.37 Hz
3	105.33 Hz	103.90 Hz
4	161.95 Hz	148.75 Hz
Mean	123.16 Hz	120.07 Hz

Table IV: Snowing the mean fundamental frequency values under DAF and NAF conditions for stutterers.

It was evident from the table that there was slight increase in the fundamental frequency (not significant) of stutterers under DAF, when compared with stutterers under NAF conditions. The mean value of fundamental frequency of stutterers under DAF was 123.16 Hz and the mean value of fundamental frequency under NAF was 120.07 Hz. So, the hypothesis 3(a) stating that there will be no significant difference in mean fundamental frequency values of stutterers while reading under DAF and NAF is accepted.

Sub. No.	Fundamental Frequency under DAF	Fundamental Frequency values under NAF
1	148.58 Hz	114.35 HZ
2	172.50 Hz	145.10 HZ
3	111.60 Hz	112.30 HZ
4	147.05 Hz	112.65 HZ
Mean	144.^93 Hz	121.10 Hz

Table V: Showing the mean fundamental frequency values under DAF and NAF conditions for nonstutterers

From the above table it was found that the non-stutterers exhibited significant increase in fundamental frequency when they read the passages under DAF. Therefore, the hypothesis 3(b) stating that "there will be no significant difference in mean fundamental frequency values of nonstutterers while reading under DAF and NAF" is rejected.

When stutterers and nonstutterers were compared under DAF, there was significant differencebetween the mean values of fundamental frequency. So, the hypothesis 3(c) stating that "there will he no significant difference in mean fundamental frequency values of stutterers and nonstutterers while reading under DAF" is rejected. There was no significant difference between the mean values of fundamental frequency of stutterers and nonstutterers under NAF. Thus the hypothesis 3(d) stating that "there will be no sigdficant difference in mean fundamental frequency values of stutterers and nonstutterers while reading under NAF is accepted.

4. <u>Effect of DAF on Voice onset time</u> (VOT)

The effect of DAF on the VOT in stutterers and non-stutterers under DAF and NAF were determined.

	Stutterers		Nonstutterers	
	DAF	NAF	DAF	NAF
/k/	10	20	16.25	15.0
/t/	11.25	13.75	13.33	12.50
/ /	8.75	11.25	13.75	11.25
Mean	10	15	14.44	12.91

Table VI: Showing the mean VOT values in miliseconds for /k/, /t/ and /t/ produced by stutterers and nonstutterers under DAF and NAF.

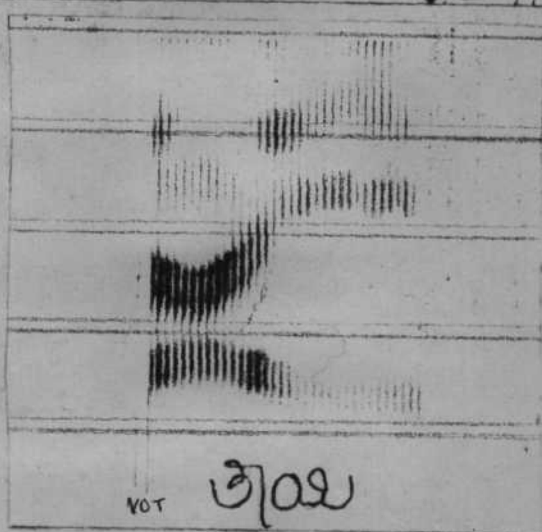
The VOT values for /k/ /t/ and / / sounds under DAF and NAF conditions among stutterers were compared There was a reduction in the VOT values for all three sounds under DAF in stutterers. But the statistical analysis showed no significant difference. So, the hypothesis 4(a) stating that "there will be no significant difference in mean VOT values in two readings of stutterers under DAF and NAF" is accepted.

In the nonstuttering group, there was increase in the VOT value for all three sounds under DAF when compared to NAF. This indicates that nonstutterers behave like stutterers under OAF in terms of VOT. However, no statistical significant differences were found. Thus the hypothesis 4(b) stating that "there will be no significant difference in mean VOT values in two readings of nonstutterers under DAF and NAF" are accepted.

Further, it can be concluded that stutterers under DAF have less difficulty in initiating the voice than under NAF and nonstutterers have more difficulty in voice initiation under DAF when compared to NAF conditions.

When the VOT values shown by stutterers and non-stutterers were compared under DAF nonstutterers had


Vowel duration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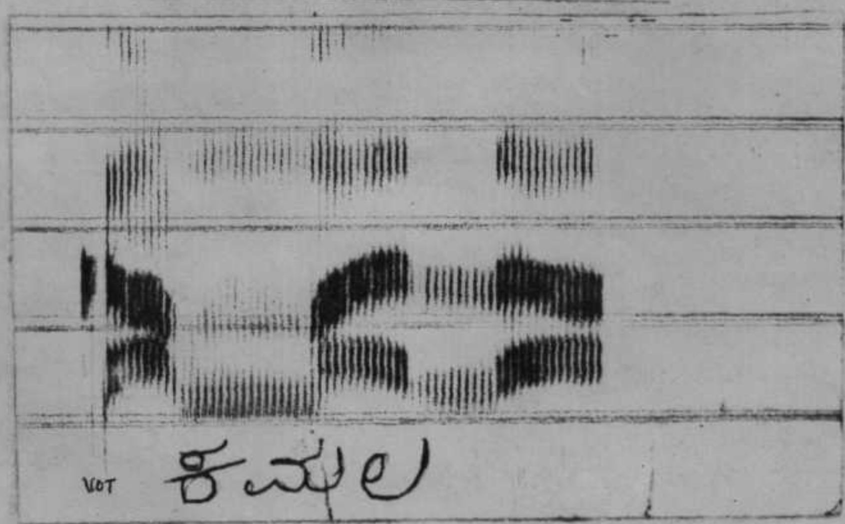
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more VOT values than stutterers. And, under NAF stutterers showed more VOT values than nonstutterers. But, still these differences were not significant statistically. So the hypothesis 4(c) stating that "there will be no significant difference in mean VOT values of stutterers and nonstutterers while reading under DAF" and the hypothesis 4(d) stating that "there will be no significant difference in the mean VOT values of stutterers and nonstutterers while reading under NAF" are accepted.

5. Effect of DAF on Vocal level

The mean values of the vocal level (intensity) while reading the passages of each subject under DAF for stutterers and nonstutterers are given in the table VII.

Sub.No.	Stutterers		Nonstutterers	
	DAF	NAF	DAF	NAF
1	86	85.50	90.62	87.06
2	95.95	94.74	96.15	94.12
3	77.50	70.56	96.04	93.56
4	85.16	81.83	93.25	78.58
Mean	86.15	83.15	94.01	88.33

Table VII: showing the mean values of vocal level in db SPL produced by each stutterer and nonstutterer for given sentences in each passage while reading under DAF and NAF.

By the inspection of the above table it was clear that there was increase in the vocal level of stutterers while reading under DAF. The mean values of vocal level of stutterers under DAF is 86.15 dB SPL, and the mean vocal level of stutterers under NAFis 83.15 dB SPL. Although there was increase in the vocal level of stutterers under DAF, it was not found statistically significant. So the hypothesis 5(a) stating that "there will be no significant difference in the mean values of vocal level in stutterers while reading under DAF and NAF" is accepted.

In non-stutterers also there was increase in vocal level of stutterers while reading under DAF(mean 94.01 dB SPL) when compared with the reading under NAF(mean 88.33 dB SPL). This was also not statistically significant. So the hypothesis 5(b) stating that "there will be no significant difference in the mean vocal intensity values in two readings of non-stutterers under DAF and NAF" is accepted.

When stuttering and nonstuttering groups were compared for this measure there was significant difference in mean values of stutterers showed 86.15 dB SPL and nonstutterers showed 94.01 dB SPL vocal level under DAF. The difference was found to be statistically significant. So the hypothesis 5(c) stating that "there will be no significant difference in mean vocal intensity values of stutterers and nonstutterers while reading under DAF" is rejected.

There was no significant difference between the mean vocal level of stutterers (83.15dB) and nonstutterers (88.33) while reading under NAF. So the hypothesis 5(d) stating that "there will be no significant difference in the mean vocal intensity values of stutterers and non-stutterems while reading under NAF is accepted.

6. Effect of DAF on Vowel Duration

The vowel duration in miliseconds for /a/, /i/ and /u/ for nonstutterers and stutterers under DAF and NAF were obtained and given in the table VIII.

Table VIII showing the mean values of vowel duration of 3 vowels /a/ /i/ and /u/ of stutterers and nonstutterers under DAF and NAF conditions:-

	Stutterers		Nonstutterers	
	DAF	NAF	DAF	NAF
(a)	167.50	106.25	100.00	90.00
(i)	96.25	105.00	151.25	86.25
(u)	105.00	122.50	142.50	116.25

Table-VIII: Showing the mean values of vowel duration of three vowels /a/,/i/,& /u/ of stutterers and nonstutterers under DAF and NAF condition

Inspection of the above table revealed that there was reduction in the vowel duration of /i/, and /u/ but increase in vowel duration of /a/ in stutterers under DAE when compared with NAF condition. But the difference was not statistically significant. So the hypothesis 6(a) stating that "there will be no significant difference in the mean vowel duration values of stutterers while reading under DAF and NAF" is accepted.

There was increase in duration of all the three vowels under DAF in non stutterers when compared to NAF conditions. But the difference was not statistically significant. So the hypothesis 6(b) stating that "there will be no significant difference in the mean vowel duration values of nonstutterers while reading under DAF and NAF" is accepted.

Further when the mean vowel durations in stutterers under DAF was compared with that of nonstutterers under DAF, there was decrease in duration of /i/ and /u/ vowels and increase in duration of the vowel /a/ in stutterers, similarly when stutterers and non-stutterers under NAF were compared in terms of vowel duration for all the three vowels in stutterers under NAF. However, both findings were not statistically significant. So the hypothesis 6(c) stating that "there will be no significant difference in the mean vowel duration values of stutterers and nonstutterers while reading under DAF" and hypothesis 6(d) stating that there will be no significant difference in the mean vowel duration values of stutterers and nonstutterers while reading under NAF are accepted.

Thus by evaluating the results obtained, it can be concluded that vowel duration of stutterers under DAF decreases wnen compared with NAF. And nonstutterers under DAF increase their vowel durations when compared with NAF conditions.

Thus, the study of these measurements warrants the following conclusions:

1. (a) The nonstutterers show stuttering like behavior under DAF i.e., show stuttering like blocks in reading under DAF.
   (b) The stutterers show reduction in number of stuttering blocks under DAF.
2. (a) The nonstutterers take more time to read a passage under DAF than to a passage under NAF.
   (b) The stutterers take less time to read a passage under DAF than under NAF, which may indicate the improvement of fluency under DAF.
3. (a) The nonstutterers increase their fundamental frequency while reading a passage under DAF.

(b) The stutterers show negligible or no change in fundamental frequency while reading under

4+ There is negligible or no change in the voice onset time in stutterers and nonstutterers while reading the passages under DAF.

5. There is negligible or no change in the vocal level of the stutterers and nonstutterers while reading under DAF.

6. There is negligible or no change in the vowel duration of stutterers and nonstutterers while reading under DAF.

Several investigators have reported regarding the effects of DAF on stuttering.(Agnello, 196&? Adams and Reis, 1971). Rawnsley and Harris (1954) in their spectrographic analysis of speech under DAF observed prolongation of vowels in normals. Agnello(1965) also observed prolongation of glides and continuent sounds under DAF in their spectrographic analysis. However, no report was available for this investigator regarding the spectrographic analysis of speech of stutterers while reading under DAF.

Chase, Sulton (1961) and Soderberg (1969) indicated a reduction in number of stuttering blocks thus increasing the fluency under DAF in stutterers. The present study supports the findings of Soderberg (1969) and Chase and Sutton (1961). Similar findings have been reported by Goldiamond (1965).

The rate of speech of nonstutterers while reading under DAF was reduced in this experiment. So the results of the present study supports the results of Fairbanks (1955, 1958). Nonstutterers in this experiment took longer time to read the passages under DAF. Nessel (1958) also found that the nonstutterers took longer duration to read the passages under DAF. In contrast, stutterers took longer time to read the passages under NAF in this experiment which goes in contrast with the results obtained by Nessel (1958) who found the majority of the stutterers demonstrated no appreciable change in the reading time under NAF and DAF conditions.

Logue (1962) found that stutterers took less time to read the passages under DAF when compared with NAF. So the results of the present study supports the findings of Nessel (1958) and not that of Logue (1962).

There was increase in the fundamental frequency when the nonstutterers read the passages under DAF. However, there was negligible change in the fundamental frequency when stutterers read the passages under DAF and NAF. This finding goes in contrast with the findings of Soderberg (1969) who found increased fundamental frequency when they read the passage under DAF, in case of stutterers.

Basu (1979) has indicated that stutterers showed a longer VOT for voiced and voiceless stop consonants in reading when compared with nonstutterers.

As the position of articulation moves backward in the oral cavity, the VOT also increases (Lisker and Abramson, 1964? Basu, 1979: Zlatin and Koenigshiecht, 1976).

In the present study it was found that /k/ consonant had maximum VOT for stutterers under NAF and for non-stutterers in both NAF and DAF which supports the above findings. There was reduction in the values of VOT in stutterers when they read the passages under DAF and nonstutterers had an increase in VOT values when they read the passages under DAF.

There was increase in the duration for all the three vowels in nonstutterers when they read the passages under DAF. Stutterers had a reduction in vowel duration for /i/ and /u/ but the duration of the vowel /a/ was increased when stutterers read the passages under DAF. Rawnsley and Harris (1954) and Agnello (1965) also found prolongation of vowels in nonstutterers under DAF.

Both stutterers and nonstutterers showed negligible variations in intensity while reading under both OAF and NAF.

Nandur (1982) found a significant increase in the intensity of voice in stutterers and nonstutterers when they read the passages under binaural masking noise. He attributed the increase in intensity of voice to the 'Lombard effect' found in normals and concluded that stutterers also have the similar effect. However, bilateral masking affected the feedback mechanism thus increasing the vocal level. But there was no significant change in the vocal level when the auditory feedback was delayed. So DAF does not produce increase in the vocal level in stutterers and nonstutterers.

Thus there is similarity between stuttering and speech of normals under Delayed Auditory Feedback.

/ CHAPTER V /

/ SUMMARY AND CONCLUSIONS /

Many studies have reported that delayed auditory feedback(DAF) has many effects on the speech and the effect of delayed auditory feedback on the speech of normals is different from the effect of delayed auditory feedback on stutterers, investigators have studied the effect of delayed auditory feedback on the fundamental frequency of voice, vocal intensity and rate of speech.

The present study was conducted to find out the effects of delayed auditory feedback on rate of speech, frequency of stuttering blocks, voice onset time, vowel duration, vocal intensity and fundamental frequency.

The study consisted of four stutterers and four non-stutterers matched for age, sex and reading proficiency. Each subject read two matched passages, one under delayed auditory feedback and nother under normal auditory feedback conditions. The amount of delay was 200 miliseconds with an intensity of 62dB SPL. The reading samples were recorded on the tape recorder of the speech spectrograph. The reading samples were analysed using the speech spectrograph, measuring amplifier, Digipitch to find out the Voice Onset Time* Vowel duration. Vocal intensity level and fundamental frequency of voice. The rate of speech was calculated by counting the number of syllables per second. The perceptual analysis was carried out by three post-graduate students of Speech pathology in order to obtain the number of stuttering blocks. The definition of Wingate (1964) was used to get the type of stuttering blocks.

The results were discussed.

CONCLUSIONS:

1. (a) The nonstutterers show stuttering like behaviour under delayed auditory feedback i.e., show stuttering like blocks in reading under delayed auditory feedback.
   (b) The stutterers show reduction in number of stuttering blocks under delayed auditory feedback.
2. (a) The nonstutterers take more time to read a passage under delayed auditory feedback than a passage under normal auditory feedback.
   (b) The stutterers take less time to read a passage under delayed auditory feedback than under normal auditory feedback, which may indicate the improvement in fluency under delayed auditory feedback.
3. (a) The nonstutterers increase their fundamental frequency while reading a passage under delayed auditory feedback.

(b) The stutterers show negligible or no change in fundamental frequency while reading under delayed auditory feedback.

4. (a) There is negligible or no change in the Voice Onset time in stutterers and nonstutterers while reading the passage under delayed auditory feedback.

5. There is negligible or no change in the Vocal level of the stutterers and nonstutterers while reading under delayed auditory feedback .

6. There is negligible or no change in the vowel duration of stutterers and nonstutterers while reading under delayed auditory feedback.

RECOMMENDATIONS FOR FUTURE STUDY:

1. The experiment may be tried using large samples.
2. Different delay times may be used to do the experiment.
3. Different age group and sex can be subjected to the experiment to note the effect of delayed auditory feedback.
4. The intensity of the delay may be varied in conducting the experiment to note their effects on the speech of stutterers and nonstutterers.
5. Spontaneous speech and reading under DAF may be compared by spectrographic analysis.

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APPENDIX I

EQUIPMENT USED FOR THE EXPERIMENT

1. Speech Spectrograph (Voice Identification Inc., 700 Series). This instrument was used to measure the Voice onset time and Vocal duration of the speech of normal and stutterers. This instrument can be used for
   (a) Frequency analysis,
   (b) Intensity analysis,
   (c) Time measurement.

2. Delayed Auditory feedback Unit (Aberdeen Speech aid Model DAF-2). Used to give delay in speech. Has the provision to give a delay of 0 to 300 miliseconds^ Delay can be given monoaurally or binaurally. Has got a volume control so that the intensity of the signal can be changed.

3^ Digipitch (Model DPM 10 S pitch analyser). An accessory of the speech Spectrograph. The instrument takes the input of 100 miliseconds or one second and gives the digital display of the fundamental frequency.

4. Measuring amplifier (B & K Type 2606). used for measurement of vocal levels of the reading samples recorded from the subjects of the study.

Measuring amplifier can also be used for

(i) measurement of intensity,

(ii) has the provision for slow, fast and hold display.

(iii) has got A, B, C, D networks to measure the intensity of signals at different frequency ranges.

APPENDIX - II

PASSAGE A

ದಾರಿಯಲ್ಲಿ ಹೋಗುತ್ತಿರುವಾಗ ಕಮಲಳಿಗೆ ಒಂದು ಡಬ್ಬಿ ಸಿಕ್ಕಿತು. ಆ ಡಬ್ಬಿಯನ್ನು ತೆರೆದು ನೋಡಿದಾಗ ಅವಳಿಗೆ ಬಹಳ ಆಶ್ಚರ್ಯವಾಯಿತು. ಹೊಳೆಯುತ್ತಿರುವ ಬಂಗಾರದ ಪದಕ ಆ ಡಬ್ಬಿಯಲ್ಲಿತ್ತು. ಗಾಯತ್ರಿಯನ್ನು ಕರೆದು ತೋರಿಸೋಣವೆಂದುಕೊಂಡಳು. ಆದರೆ ಅವಳನ್ನು ಕರೆಯದೆ ಅದನ್ನು ತೆಗೆದುಕೊಂಡು ಮನೆಗೆ ಹೋದಳು. ತಾಯಿಗೆ ಅದನ್ನು ತೋರಿಸಿದಾಗ ಅವಳಿಗೂ ಆಶ್ಚರ್ಯವಾಯಿತು. "ಟಾಂಟಾಂ" ಹೊಡಿಬೇಡ ಎಲ್ಲರ ಮುಂದೆ ಎಂದು ಅವಳ ತಾಯಿ ಎಚ್ಚರಿಸಿದಳು. ಇದಕ್ಕೆ ಉತ್ತರವಾಗಿ ಕಮಲಳು 'ಸರಿ' ಎಂದು ಹೇಳಿದಳು.

PASSAGE B

ಕಮಲ ಮತ್ತು ಗಾಯತ್ರಿ ಸ್ನೇಹಿತೆಯರು. ಕಮಲಳ ಹತ್ತಿರ ಒಂದು ಪದಕದ ಸರ ಇತ್ತು. ಅದನ್ನು ಅವಳು ಡಬ್ಬಿಯಲ್ಲಿ ಇಟ್ಟಿದ್ದಳು. ಒಂದು ದಿನ ಕಮಲಳು ಗಾಯತ್ರಿಯೊಂದಿಗೆ ಸಿನಿಮಾಕ್ಕೆ ಹೋಗುವಾಗ ಆ ಸರವನ್ನು ಧರಿಸಿದ್ದಳು. ಹೊರಡುವ ಮೊದಲು ಕಮಲಳ ತಾಯಿ ಬೇಗ ಬರಲು ಹೇಳಿದರು. ಕಮಲಳು ಇದಕ್ಕೆ ಉತ್ತರವಾಗಿ 'ಸರಿ' ಎಂದು 'ಟಾಟಾ' ಮಾಡಿ ಹೊರಟಳು. ದಾರಿಯಲ್ಲಿ ಹೋಗುವಾಗ ಗಾಯತ್ರಿಯು ಪದಕವನ್ನು ನೋಡಿ 'ಬಹಳ ಚೆನ್ನಾಗಿದೆ' ಎಂದು ಹೇಳಿದಳು. ಅವರಿಬ್ಬರೂ ಸಿನಿಮಾ ನೋಡಿ ಬೇಗನೆ ಮನೆ ಸೇರಿದರು.

The underlined words were subjected to spectrographic analysis.