DICHOTIC DELAYED AUDITORY FEEDBACK IN NORMALS AND STUTTERERS

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C E R T I F I C A T E

This is to certify that the dissertation entitled "Dichotic Delayed Auditory Feedback in Normals and Stutterers" is the bona fide work in part fulfillment for M.Sc. in Speech and Hearing of the student with the Register Number.

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C E R T I F I C A T E

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

Guide

D E C L A R A T I O N

This dissertation is the result of my own study undertaken under the guidance of Dr. N. Rathna, Professor and Head of the Department of Speech Pathology, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier at any university for any other diploma, or degree.

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"Thanks to one and all."

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CHAPTER I

INTRODUCTION

Speech may be regarded either as a form of tracking behaviour, dependent for its smooth execution on feedback control, or as an operant behaviour dependent for its execution on the environmental and internal contingencies that it produces. Both conceptualizations in recent years, have led to a very large amount of empirical work whioh is highly relevant to the understanding and modification of stuttering behaviour (Yates, 1970).

"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 and Hatten, 1974).

Various theories have been put forward to explain the onset of stuttering, its development and maintenance (Theory of Cerebral Dominance by Orton, 1927 and Travis, 1932; Diagnosogenic theory of Stuttering by Johnson, 1957; Wischner's Anticipatory Theory of Stuttering, 1947, 1950, 1952; Conflict Theory of Stuttering by Sheehan, 1958; and other theories).

Therapeutic methods based on these theories have . shown changes in stuttering behaviour. 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 loops. Any disruption in the monitoring system might lead to speech disturbances.

Any comprehensive account of different methods used in the treatment of stuttering must include those which alter the stutterer's perception of his own speech. Much work has been carried out relating to the monitoring of speech and the phenomenon known as Delayed Auditory Feedback, DAF (Yates, 1963a). Although speech is a greatly overlearned skill, it turns out to be surprisingly susceptible to interference (Yates, 1970).

When a normal speaker's verbal output was fed back to his ears after a short delay of about one fifth of a second, marked breaks in fluency occurred. This phenomenon of DAF was first reported by Lee (1950a, 1950b and 1951) and Black (1951). A reverse, that is, marked reduction in stuttering can often be achieved by the same process in stutterers (Adamexpk, 1959; Goldiamond, 1965; and others).

Based on the above observations many studies have been conducted to note the effect of DAF on normal speakers and en stutterers.

The effects of DAF observed in normal speakers by various studies are shown in Table I.

Research has demonstrated that the stutterers respond to DAF in a manner different from that of the normals (Nessel, 1958; Lotzmann, 1961; Soderberg, 1959; and others). Generally an improvement in fluency was observed under delay, though this was not true for all stutterers. Lotzmann (l96l) found that by varying the delay times, until an optimal delay was reached the stutterers blocks of all kinds were reduced or were completely eliminated. Time delay of 0.05 sec seemed to produce the greatest fluency. Soderberg (1959) reported that his severe stutterers showed a significant reduction in the frequency and duration of stuttering under DAF both in oral reading and in spontaneous speech. Other authors (Adamezyk, 1959; Bohr, 1963; Goldiamond, 1965; Gross and Nathanson, 1966; Nessel, 1958; and Zerneri, 1966) have also observed a reduction in stuttering under DAP.

TABLE 1

31. No.	Observations	Author/Authors of the study	Year
1	Repetitions of syllables and prolongations of sounds were observed	Black, Lee	1951 1950a 1950b
8	Oral reading and speaking rate were slowed down	Black Pairbanks	1951 1955
3	Articulatory disturbances were observed and analyzed. Substitutions were unusual and occurred primarily on stressed syllables. Sounds were omitted, but most of the errors were repetitive reduplications of sounds and syllables resembling stuttering	Fairbanks and Gattmann	1958
4	Vocal intensity increased	Atkinson Spilka	1953 1954
5	Fundamental pitch of the voice tended to rise	Fairbanks	1985
6	Critical delay for most young male adults was at 0.2 seconds delay	Fairbanks, Fairbanks and Guttmann	1955 1958
7	Prounced emotional reactions as measured by galvanic skin response were noticed	Haywood	1963
8	Males were more vulnerable than the females	Bachrach, Mahaffey and Stromsta	1964 1965

Some studies with stutterers (Ham and Steer, 1967; Logue, 1962; and Neelley, 1961) found that stutterers' responses under DAF did not differ from the normal speakers' responses under DAF.

DAF studies with normals and with stutterers mostly dealt with speech disruptions under different variables like (1) Different time delays, (2) Different levels of intensity of the fed back speech, (3) Sex differencies, and (4) Age differences.

The study by Abbs and Smith (1970), "Laterality differences in the auditory feed back control of speech", was of a different nature and gave a new way of using DAF, in that, it used dichotic listening with DAP to identify cerebral dominance in speech.

The cerebral hemisphere controlling speech is said to be the dominant hemisphere. Hughlings Jackson in 19th century introduced the concept of a "leading hemisphere". Research has indicated that in normal righthanders the left hemisphere processes linguistic symbols and the right hemisphere processes non-linguistic symbols. Localization of language to one hemisphere has been a characteristic feature of human communication.

The theory of cerebral dominance put forth by Orton (1927), which was later developed by Travis in 1932 said that in stutterers, lack of cerebral dominance creates a mistiming of motor impulses to the bilateral speech muscles and that produced stuttering. Their cerebral hemispheres were said to be symmetrical.

Many methods of finding out the dominant or leading hemisphere have been used, e.g. Handedness, Eyedness, Footedness, and studies with amobarbital tests. In recent times, dichotic listening techniques have been used with normals and with stutterers for the same purpose. Dichotic listening studies by Broadbent (1954), Curry (1967), Darwin (1969), Kimura (1961a, 1967), Milner, et al (1968), Nandur (1976), Sinha (1959), Sparks and Geschwind (1968), and Studdert-Kennedy and Shankweiler (1970) have supported the findings that the crossed auditory pathways in man were stranger or more numerous than the uncrossed auditory pathways and the left hemisphere - right ear - was more important for perception of speech and that the right hemisphere - left ear - processed non-linguistic stimuli like music and other environmental sounds.

Curry and Gregory (1969) conducted an experiment to study the performance of stutterers on dichotic listening tasks which were thought to reflect Cerebral Dominance.

Twenty stutterers and twenty non-stutterers were given one monotic verbal listening task and three dichotic listening tasks, of which one dichotic listening task was verbal and two were non-verbal. The non-stuttering adults shoved an expected tendency to do better with their right ear in the dichotic word tasks. The stutterers, however, showed no significant laterality effect in favour of the left hemisphere - right ear.

The above report has been contradicted by Dorman and Porter (l975). In their study, sixteen righthanded, moderate to severe adult stutterers and twenty non-atuttering controls were given a dichotic nonsense syllable test to determine hemispheric specialization for speech. Both male and female stutterers evidenced right ear advantages in syllable identification similar in magnitude to those found in normals indicating no difference in cerebral speech lateralization between stutterers and non-stutterers.

DAP as a dichotic listening task was used to find the iaterality differences in auditory feedback control of speech in normals by Abbs and Smith (1970). In their study, eight female subjects read seven sentences under four conditions of delay of 0.0 sec, 0.1 sec, 0.2 sec and 0.3 sec. to each ear, at 90 dB SPL, while at the same time the other ear received a masking noise of 85 dB SPL.

Total speaking time and articulatory errors vere measured. There was no significant difference in total speaking time between delayed presentation to right ear and delayed presentation to left ear. Articulatory errors indicated that auditory delay in the right ear produced a significantly greater number of speech errors than delayed presentation to the left ear. These differences were found more at 0*3 aec. and at 0.3 sec* Relays. %he results of this study support the finding that the left hemisphere - right ear - processes linguistic symbols. This study was conducted only with normals and not with any clinical group.

It was felt that it would be interesting to see if there was any difference in the response between normals and stutterers to DA? as a dichotic listening task.

Statement of the Problem

The present study intended to study the laterality differences in auditory feedback of speech in normals and is stutterers.

The main objective of the present study was to find out if there was laterality difference in auditory feedback of speech between normals and stutterers when one ear received DAF speech and the other ear received NAF (Normal Auditory Feedback) speech simultaneously under amplificed conditions.

The other objectives were to find out if there were differences in speech performance between DAF to both ears and DAF to one ear and NAF (Normal Auditory Feedback) to other ear condition, to find an optimal delay for fluency and an optimal delay for maximum speech disruption.

The present study concerned itself with the following hypotheses:

1. a) There would be no significant difference in speech errors between Right ear DAF - Left ear NAF, and Left ear DAF - Right ear NAF conditions in normals.

   b) There would be no significant difference in speech errors between the above conditions and DAF to both the ears condition in normals.

2. a) There would be no significant difference in speech performance between Right ear DAF - Left ear NAF, and Left ear DAF - Right ear NAF conditions in stutterers.

b) There would be no significant difference in apeech performance between the above conditions, and DAF to both the ears condition in stutterers.

3. Normals and stutterers would not differ significantly in apeech performance in the above conditions.

4. a) There would be no significant difference in the time taken to read the 'one minute' passage between Right ear DAF - Left ear NAF and Left ear DAF - Right ear NAF conditions in normals.

   b) There would be no significant difference in the time taken to read the 'one minute' passage between the above conditions and DAF to both the ears condition in normals.

5. a) There would be no significant difference in the time taken to read the 'one minute' passage between Right ear DAF - Left ear NAF and Left ear DAF - Right ear NAF conditions in stutterers.

b) There would be no significant difference in the time taken to read the 'one minute' passage between the above conditions and DAF to both the ears condition in stutterers.

6. Normals and stutterers would not differ significantly in the time taken to read the 'one minute' passage under Right ear DAF - Left ear NAF, Left ear DAF - Right ear NAF and DAF to Right ear and Left ear conditions*

7. There will be no significant difference in speech errors between NAF to both Right ear and Left ear condition and Right ear DAF - Left ear NAF, Left ear DAF - Right ear NAF and DAF to both Right and Left ear conditions in normals.

8. There will be no significant difference in speech performance between NAF to both Right and Left ear condition and Right ear DAF - Left ear NAF, Left ear DAF - Right ear NAF and DAF to both Right and Left ear conditions in Stutterers.

9. There would be an optimal delay for fluency in stutterers among the three delays used, under the three different conditions.

10. There would be an optimal delay for maximum speech disruption in normals among the three delays used, under three different conditions.

Brief Plan of the Study

Fifteen normals and fifteen stutterers between the age range of 16 - 25 years were taken for this study. All the thirty subjects were tested under four conditions, individually. They read ten 'one minute' passages in English under the following conditions:

I Condition (R) (L) NAF NAF	-	Normal auditory feedback speech at 96 dB SPL to Right and Left Ears simultaneously.
II Condition (R) (L) DAF DAF 0.1 0.1 0.2 0.2 0.3 0.3	-	DAF speech to both ears simultaneously at 95 dB SPL, at three time delays of 0.1 sec., 0.2 sec., and 0.3 sec.

III Condition - DAF speech to Right ear and NAF speech to Left ear simultaneously at 95 dB SPL under three time delays of 0.1 sec., 0.2 sec., and 0.3 sec.

(R)	(L)
DAF	NAF
0.1	NAF
0.2	NAF
0.3	NAF

IV Condition - DAF speech to Left ear and NAF speech to Right ear simultaneously at 95 dB SPL and at three time delays of 0.1 sec., 0.2 sec., and 0.3 sec.

(R)	(L)
NAF	DAF
NAF	o.1
NAF	0.2
NAF	0.3

The time taken to read the 'one minute' passages in all these conditions was noted down using a stop watch. Articulatory disturbances and fluency changes were analyzed by listening to the tapes.

An Ahuja hi-fi tape recorder with an extra replay head was connected to an external motor. This formed the DAF unit. The speed of the motor was changed to get different delay timings. The subjects/speech was picked by an Ahuja and an Ampex Microphone and was recorded on magnetic tapes. The subject's speech was replayed after a specific delay and was amplified by using Arphi Speech trainers. This amplified speech was fed back to the subject's ears through TDH-39 Ear phones in circumaural cushions. With the help of a selector switch, the different conditions were chosen for the experiment.

Limitations of the Study

1. Due to shortage of time, only fifteen normals and fifteen stutterers were taken for this study.

2. Calibration of time delays could be done only approximately.

3. Changes in speech under DAF were noted by listening to the tapes alone. Other changes due to DAF were not taken into consideration.

Implications

1. The present study throws more light on the concept of cerebral dominance in stutterers.

2. The DAF equipment devised could be used in the clinic in diagnosis and in treatment.

3. The optimal delay for fluency in stutterers could be used in the treatment of stutterers.

Definitions

1. Stutterers: Stutterers are those individuals who exhibit in their speech and in their reading, prolongations and/or repetitions and/or hesitations of sounds, syllables, words or phrases with or without secondaries like eye blinking or tongue protrusion to such a degree that it attracts the attention of listeners and, who have been so diagnosed by a qualified Speech Pathologist.

2. Dichotic Listening Task,: A task wherein two different messages are given to two ears separately but simultaneously.

3. Articulatory disturbances: Articulatory disturbances are substitutions, omissions and additions of speech sounds.

   Substitutions, omissions and additions of syllables, words or phrases are also taken as speech errors.

4. Fluency changes: In normals, repetions, hesitations and prolongations of speech sounds, syllables, words or phrases are considered as fluency changes.

   In stutterers, the fluency changes are the effortless and uniform prolongations and change in the number of repetitions and hesitations of speech sounds, syllables, words or phrases.

CHAPTER II

REVIEW OF LITERATURE

> Oral communication is one of the highest forms of behaviour of which the human being is capable; consequently, a problem in oral communication may be considered as one of the most serious handicaps that a human can experience.
>
> - Mysak (1966)

One of such serious problems in human communication is stuttering. Stuttering, a disorder of rhythm, is said to be a complicated multidimensioned jig-saw puzzle, with many pieces still missing (Van Riper, 1971). Stuttering of even moderate severity is clearly obvious and highly disturbing both to the stutterer and to the listener. As a result, many professionals and non-professionals have been intensively working on stuttering and on its treatment for many years. This interest has produced a multitude of ideas, theories and procedures but only a limited amount of hard data (Brutten and Shoemaker, 1967).

The various theories have differed primarily in the inferences or hypotheses made about the nature of the casual factors. One group of theories said that stuttering was inherited and stutterers had a constitutional predisposing factor. Orton (1927) and Travis (l931) said that in stutterers there was a lack of Cerebral Dominance, which created mistiming of the motor impulses to the speech Musculature, which resulted in stuttering. West (1958) drew a parallel between stuttering and pyknolepsy, an epileptic form of disorder. Eisenson (1958) regarded the stuttering block primarily as a perservative phenomenon, similar to those seen in brain-injured persons. Bloodstein (l959) surveyed studies of stutterers' heart rate, blood chemistry, brain waves and basic motor and sensory processes and found the results to be conflicting and inconclusive. Glauber (1958) regarded the disorder as a pregenital conversion neurosis. Johnson's (1957) Diagnosogenic theory says that stuttering starts in the parents' ears and not in the child's mouth. Wischner (1947, 1950, 1952), Shames and Sherrick and Brutten and Shoemaker (1967) hold that stuttering is a learned behaviour.

The various theories based on organicity, psycho-analysis and learning have contributed, to some extent, in understanding the problem. These theories fail because they do not account adequately for the basic disruption of motor sequences that occur when a word is stuttered. The learning theorists do not give satisfactory explanation for the 'form' and intermittency of the acre behaviour.

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

In contrast with the different views mentioned is the view that stutterers have a defective monitoring system for the production of sequential speech and this might be due to distorted auditory feedback (Van Riper, 1971). Many assumptions and hypotheses have been made to explain stuttering based on these observations. Cherry and Sayers (l956) offer an assumption that, ". . .the production of speech involves a closed feedback action by which means a speaker continually monitors and checks his own voice production," and further says that stammering represents a type of relaxation oscillation caused by instability of the feedback loop. Butler and Stanley (1966) suggest that the locus of the malfunctioning may be in the middle ear and that this interrupts the automatic programming of the motor output. A hypothesis has been made by Stromsta (1962) who said that discrepancies in arrival times of bone-conducted and air-conducted side tone may be different in stutterers than in normal speakers. Wolf and Wolf (1959) explain stuttering rather naively and inadequately as being due to a "dead time lag" between the auditory input and motor output of speech. Gruber (1965) feels that too much information (overload) in the auditory as compared with the tactual and kinesthetic feedback circuits may produce fluency breaks.

Speech being largely controlled automatically rather than voluntarily requires a reliable flow of information from the output for its integration. This feedback returns through multiple bilateral channels (air, bone, tissue, tactile, kinesthetic, etc.) and is processed at many levels in the central nervous system, a situation where distortion of signals could possibly take place. Since speech demands an incredibly precise synchronization of simultaneous and successive bilateral motor responses, such distortion could produce asynchrony and lead to stuttering.

Studies by Black (1951) and Lee (l950a, 1950b, 1951) show that fluency breaks similar to stuttering can be produced in normal speakers by altering the auditory feed-back of their speech output. A reverse, that is, reduction in stuttering in stutterers can often be achieved by the same process. Disturbances in speech can be produced in normal speakers either by delaying their auditory feedback or by distorting their feedback or by masking their auditory feedback.

Unfortunately our current knowledge of how speech is programmed and controlled is far from satisfactory (Van Riper, 1971). 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 describe speech mechanism as a Serve system.

Servo mechanism is a word derived from Latin 'Servus' or slave and therefore describes a slave system. Closed loop control systems are different from open loop systems in as much as they are error-sensitive, error measuring, . self-adjusting and goal-directed mechanisms. They feed-back into the machine information pertaining to its performance and thereby effect automatic corrections, whenever error performance signals are received (Mysak, 1966).

It seems evident that the speaking system has at least the rudiments of a servo system or a closed cycle system. In Fairbank's (1954) well known model, there are effector. unit, a sensor unit, a storage unit, a comparator to match input information against the patterns contained in the storage component, and a mixer or controller regulating mechanism which alters the output so as to reduce future error signals.

The general analogy of the aural vocal mechanism with a servo system, auch as proposed by Fairbanks, is diagrammed in Figure I. In Figure I (a), the output mechanism is the speech musculature, arranged to produce sounds, according to a definite time and sound pattern. The sound pattern of this output is fed back to the ear in two ways - as bone conducted and air conducted sound - and is used by the aural system to control brain integration relative to the correctness of what has been said. This comparison in turn controls the utterance of the succeeding words.

Figure I (b) gives the model of closed cycle servo system analogous to the speech system.

The details of Fairbank's analogy are as follows:

The controller is an automatic device that issues specific orders to the effector. It does not originate the message, but receives its instructions from a separate unit not shown. The speaking system must vary its output as a function of time, according to instructions laid down

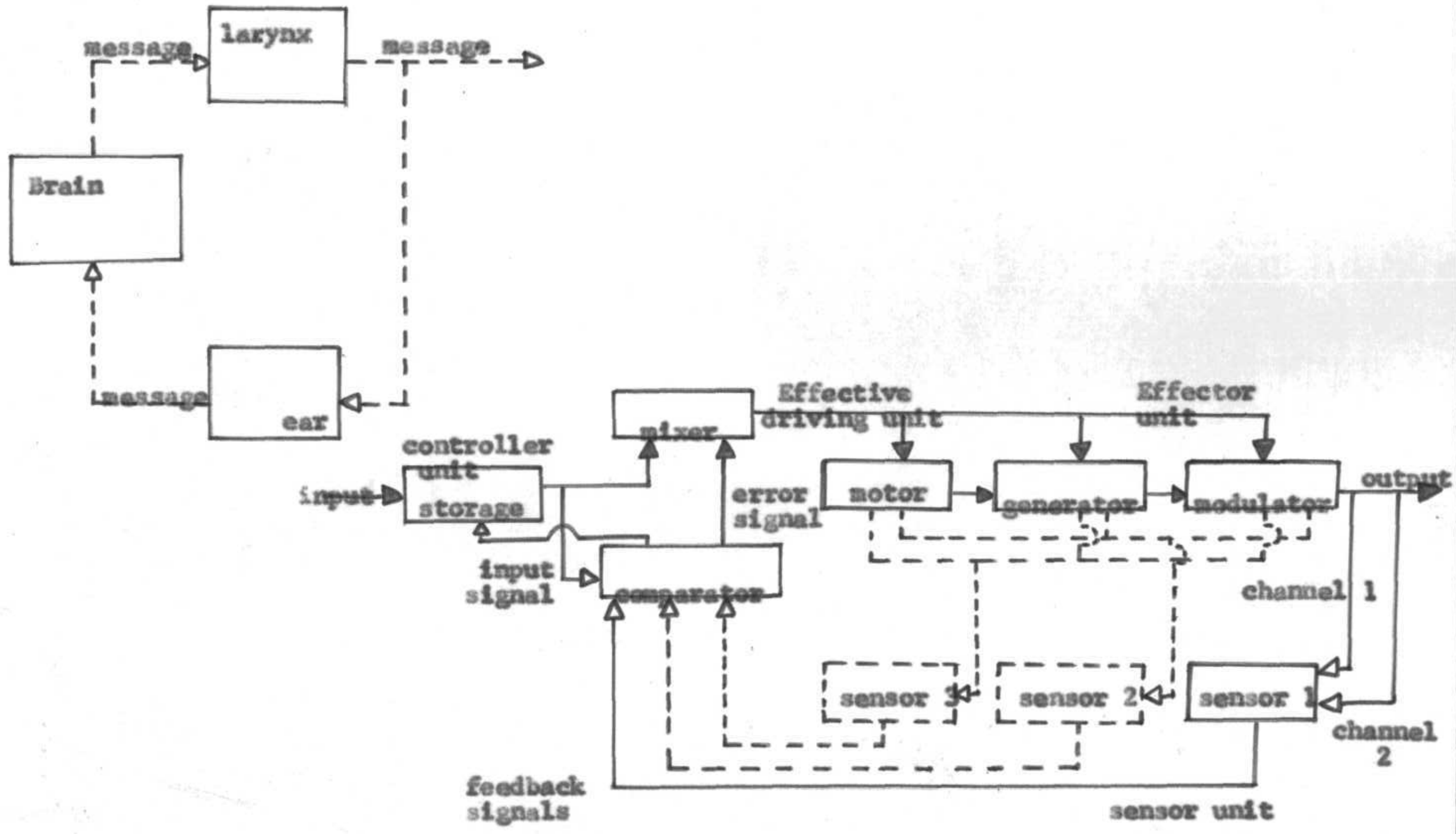


Figure Ia - Elements of speech control system
Ib - Model of closed cycle servo system (Fairbanks)

at the input. The output consists of qualitatively different units that must be displayed in a time sequence that is unique. The selection and ordering of units are carried on in advance usually for a number of units, and represent a set of input instructions. As speaking continues, each set is replaced by another. As the first component of the controller, therefore, we provide a storage device, which receives and stores the input and gives off an <u>input</u> signal.

The number of units that it can store is comparatively small and the time it will retain them is short.

A stored unit of instruction or input corresponds to a unit of output. Each such unit functions what is termed as a control point, sometimes called <u>set point</u>. The control points are the unit goals of the output. The input signal corresponding to a control point goes simultaneously from the storage component to the controller's other two components, a comparator and a mixer. The purpose of these two are to modify the operation of the effector. The comparator also receives the feedback signals. With the input and feedback signals, it performs a calculation, essentially subtraction, in which it determines the difference between the two. The comparator and mixer reduce the difference between the two and the necessary adjustments are then made to provide an effective driving signal to the effector anit.

The system has an important undiagrammed characteristic In the mixer, the rate of change of the effective driving signal is caused to vary with the magnitude of the error signal. When the error signal is large, as at the start of the unit, the corrective change is rapid. It becomes progressively slower as the error signal is reduced. An advantage of this feature is reduction of overshoot.

One evident feature of the model as well as the live system is that it contains many components in a complicated arrangement and readily becomes disordered. The model can be caused to repeat, prolong and hesitate by several different manipulations, one of which is feedback delay. By similar manipulations, it can be caused to make other kinds of mistakes, such as, substitutions, distortions and omissions.

The second model given by Mysak (1966) also makes use of the closed loop system. Speech mechanisms are complex mechanisms which have minor control loops or subsystems operating within main loops or large overall control systems Mysak views the speech system as a closed, multiple-loop system, containing feed forward and feedback interval and external loops.

Considering both the internal and external loop aspects of the total speech systems, the following ten operations may be recognized during a full cycle of speech behaviour.

1. Thought propagation
2. Word formation (feed forward)
3. Thought pattern-Word pattern comparison (feedback)
4. Word production (feed forward)
5. Actual word product-Desired word product comparison (feedback)
6. Word product-Thought pattern comparison (feedback)
7. Internal, multiple loop speech recycling
8. Word product-Listener reaction comparison (feedback)
9. Actual listener reaction-Desired listener reaction comparison (feedback) - and
10. Internal and external multiple speech recycling

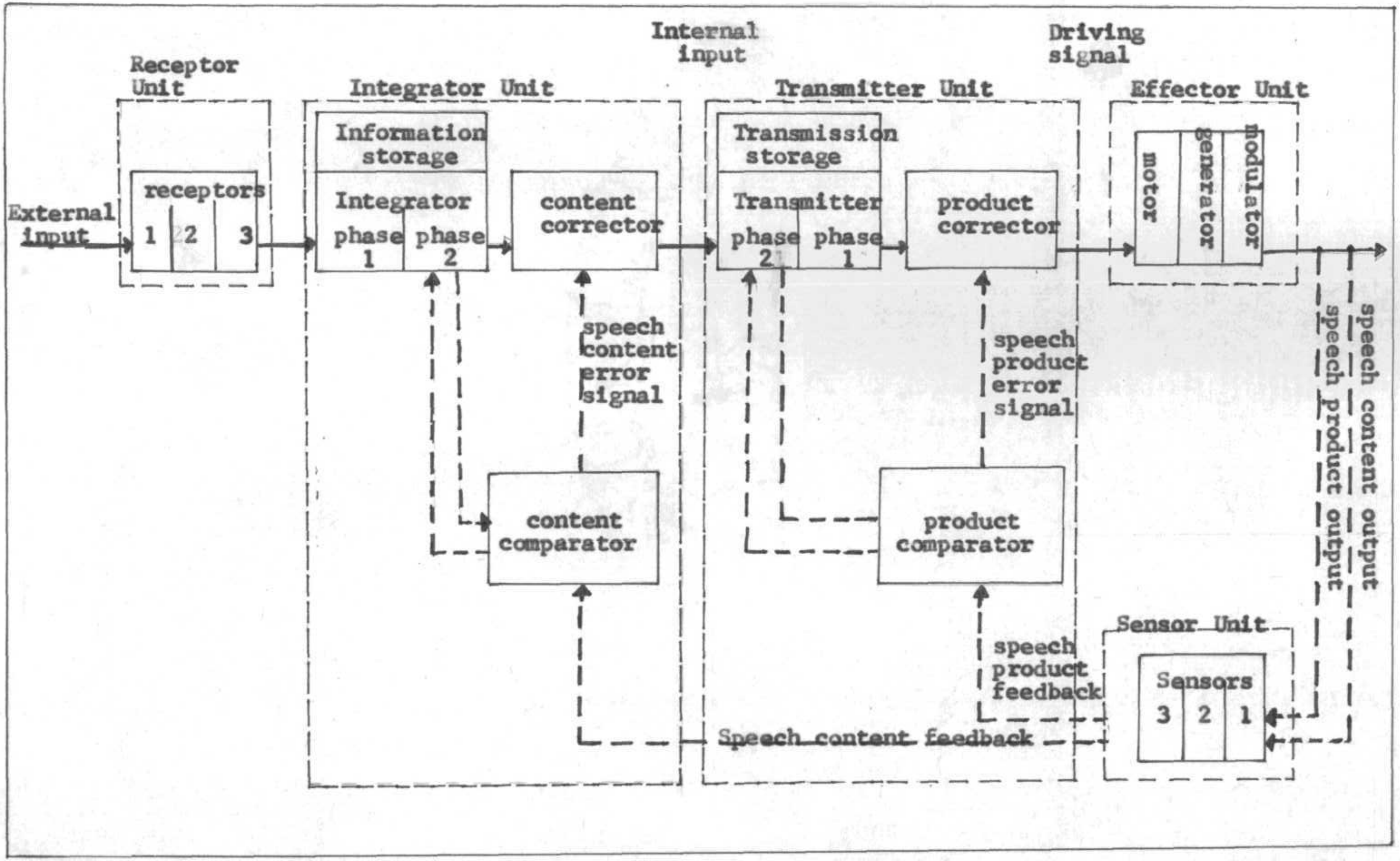
Malfunctioning in any one of the ten operations may reflect itself in some type of oral communicative disorder.

A model of internal loop was presented by Mysak in 1959 and it was an extension of the model designed by Fairbanks (1954). The present model (1966) given in Figure II, Cybernetic analogue of the speech system, has the following components.

Receptor: It forms the first section of the internal loop. It is made of three basic components, Receptors 1, 2 and 3. Receptor 1 processes radiant energy via the eye. Receptor 2 processes sound pressure energy via the ear and Receptor 3 processes mechanical energy via the end organs of touch.

Figure III which gives the anatomical scheme of the speech system uses an eye, ear and a finger to represent the 3 receptors. The cybernetic analogue places all the components within one unit to indicate the usual concomitant bisensory reception of such external speech stimuli.

Integrator: It has Phase 1, Phase 2 integrator and the information storage component. Incoming information in the form of speech sounds or other percepts may be registered, retained, recalled or responded to by this unit. Phase 1 integration involves the recognizing and attaching of



Receptor Unit
receptors
1 2 3
External input
Integrator Unit
Information storage
Integrator
phase 1
phase 2
content corrector
speech content error signal
content comparator
Internal input
Transmitter Unit
Transmission storage
Transmitter
phase 2
phase 1
product corrector
speech product error signal
product comparator
Driving signal
Effector Unit
motor
generator
modulator
speech content output
speech product output
Sensor Unit
Sensors
3 2 1
speech product feedback
Speech content feedback

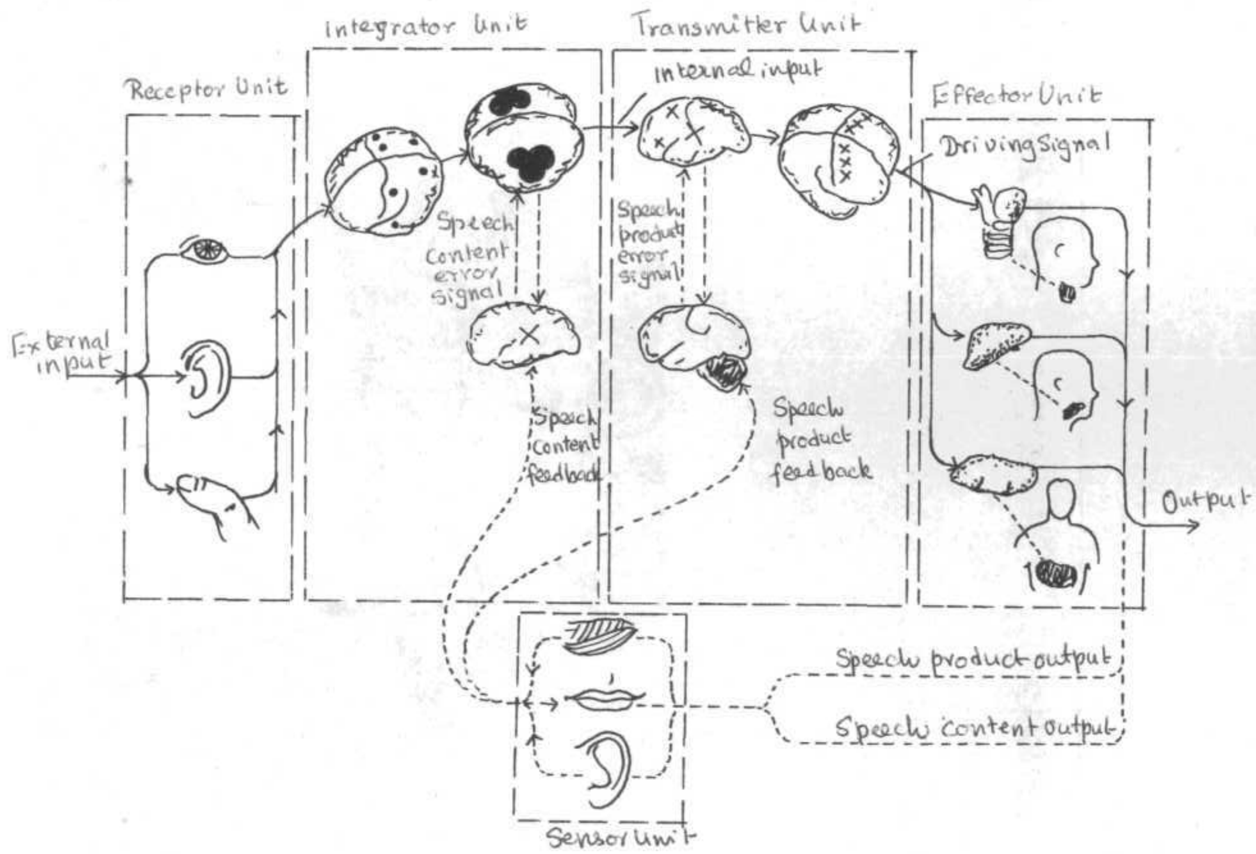


Figure III - Anatomical schema of the speech system significance to incoming stimuli; Phase 2 intergration involves the interpreting and elaborating of incoming stimuli. Information retention is subtended by the storage component which retains or releases stored information upon command.

Phase 1 integration represents the perceptualizing process served by the many primary sensory areas in the brain which recognize and pattern incoming auditory, visual and tactile stimuli. Phase 2 integration represents the conceptualizing process served by the many secondary sensory areas of brain, which further process the various incoming stimuli. It also has an error measuring device existing within the unit.

There is also speech content comparator and speech content corrector device. Once the integrator has selected a response, it presents the neural pattern or nervous arrangement representing the idea to the cortico-thalamic area, which is the Phase 2 transmitter component of the Transmitter unit. This automatically activates the neural pattern of corresponding words.

Transmitter: It has three basic parts. Ideas or speech intentions issuing from the integrator unit automatically excite word patterns in Phase 2 transmitter component which in turn activate appropriate signals in the Phase 1 transmitter component. Phase 1 transmission is responsible for exciting, simultaneously, the motor generator and modulator components of the effector unit which are actually responsible for producing the desired spoken words.

The speech product comparator receives input signals as well as the output feedback. It signals and determines the difference between the two; error signals, if present, represent the amount by which the command issued by Phase 2 transmission has not been achieved by the effector unit. These error signals are then sent to the speech product corrector which combines error signals and input signals into a new corrected driving signal. The error signal also returns to the Phase 2 transmitter component where it can . trigger off the next command when the present output is error-free, or where it can hold the next command when the output contains error factors. This latter function represents a predictor potential existing within the speech product comparator (Fairbanks, 1954).

The last component is Transmission Storage and it represents the place where functional words and patterns are stored.

Effector Unit: It is directly responsible for the production of speech events. It consists of 3 components: the motor, the generator, and the modulator. The motor is responsible for producing the air column which supports speech, the generator is responsible for vibrating this air column or for voicing, and the modulator is responsible for breaking up the voiced air stream into particular articulatory units.

Sensor Unit: This is the last section of the model. It has at least 3 components and is responsible for feeding back speech product and speech content data. Sensor I feeds back auditory dimensions of sound uttered; Sensor 2 the tactile dimension and Sensor 3 the proprioceptive dimension. The unit may include Sensor 4 which represents the visual dimension.

Mysak's servo system model includes the receptor, integrator, transmitter, effectorand sensor units. Both integrator and transmitter units include storage components as well as corrector devices. The system has two outputs, namely, speech product and speech content.

Mysak has extended his view point of servo system to stuttering also. Stuttering is viewed as a condition of verbalizing deautomaticity. Deautomaticity was seen as the possible result of disturbances in reflexive and automatic mechanisms in various parts of the total linguistic circuitry.

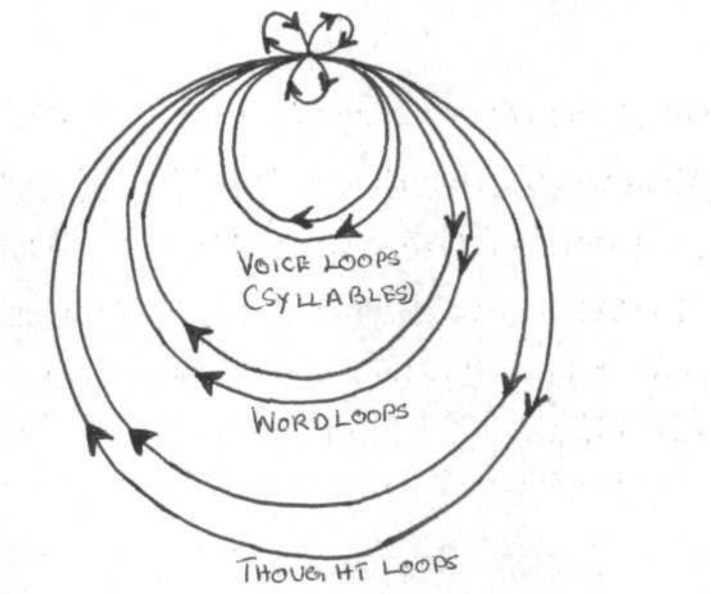
Mysak (1959) has also given a servo model for speech therapy. Here, the clinician attempts to superimpose his speech system upon the clients. He hopes that eventually this open cycle control (stimulating and guiding) will develop into a closed cycle control (internal formation and monitoring,or the "internalization"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

Lee (1961) and Chase (1958) have also given their assumptions regarding neural and behavioural organization of speech mechanism and the consequences of disruption of the normal mechanism.

Lee (1951) described speech as a series of neural feedback loops, as shown in Figure IV, 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. According to Lee, this model will explain normal speech, delayed speech feedback effects, motor aphasias, and natural and artificial stuttering.

Figure IV

ARTICULATING LOOPS. PHONEMES



Model of the neural mechanisms of speech proposed by Lee

Lee said that this theoretical model of speech is consistent with neuroanatomy. 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, labeled articulation and voice, represent the speech mechanism proper.

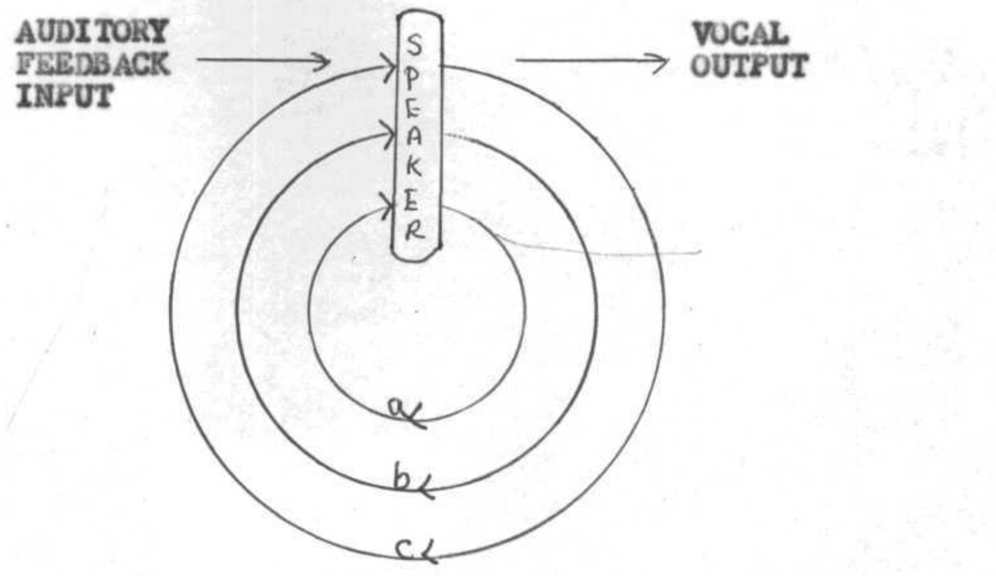
Lee proposed further that the hearing system is in series or inductively coupled to the voice loop for the aural monitoring function. Thus the analysis of delayed speech feedback offers the most information for understanding the voice functions of the speech system. The other two loops, word production and thought, have more to do with speech habits.

According to Lee's analysis, the articulation loop and voice loop are monitored at the reflex level - the articulation of phonemes by tactile and kinesthetic means and the voice loop by aural means- Any speech element at the level of the syllable may be repeated if the hearing monitor is not satisfied. When the monitor is satisfied, the signal ascends to the next loop and forms a part of the next larger component. Monitoring of the loops governing word production and thought is volitional and involves decision-making in organizing speech patterns. The word-loop also provides a device for stalling or maintaining the speech flow as a defense against interruption. This stalling mechanism gives a nervous quality to speech, which all speakers utilize more or less. When used excessively, such stalling represents what is called Class I stutter.

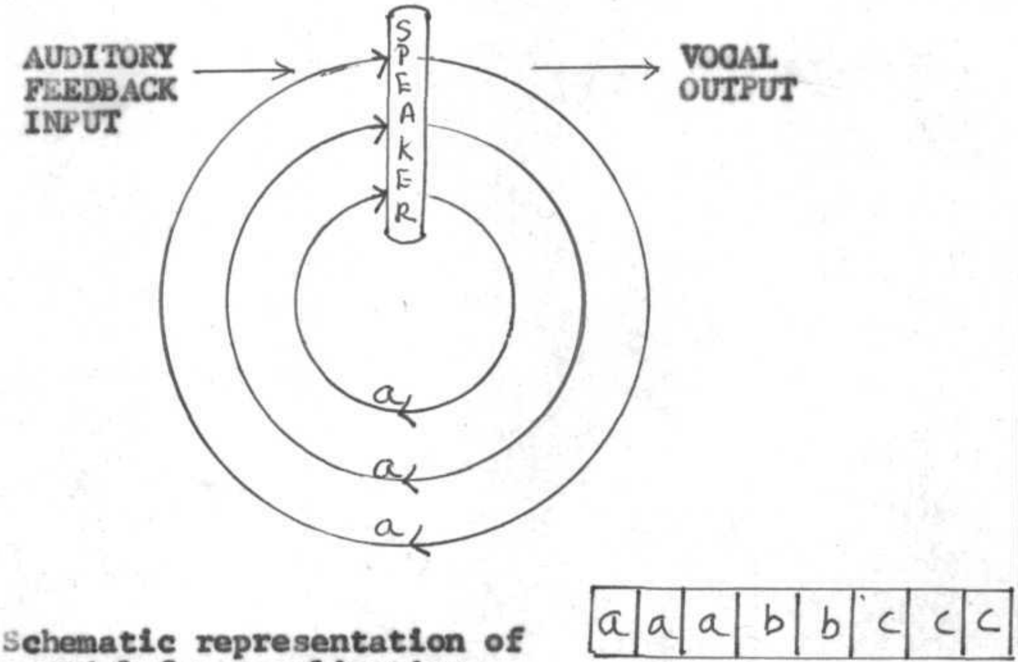
Lee also explains the 'artificial stutter' induced by the delayed speech feedback. Here, the repetition is produced because the aural monitor of the voice loop is unsatisfied. The voice loop continues for one or two extras cycles of action until the arrival of the delayed feedback triggers the next process. 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 behavioural analysis (Lee's model as reported by Smith, 1962).

Chase (1958) has proposed a rather general formulation of the servo system feedback principle. His view, which can be designated the recirculation theory, is illustrated in Figure V. According to chase, normal utterance of a word involves successive discrete responses, such as, speech units a, b and 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 hearing, as shown in the drawing at the bottom of Figure V, 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.

Mechanical devices have the advantages of objectivity and the quantitative point of view. Smith and others (1962)



(a) Schematic representation of a model for normal vocalization.



(b) Schematic representation of a model for vocalization under delayed auditory feedback

Figure V Chase's model of speech

believe that the models are too simplified to describe the workings of either the auditory or the speech mechanism and are too general to provide a useful basis for prediction. Smith (1962) said that these analogies have failed to take into account some established facts about speech, hearing and behaviour in general.

These models could be used to explain the speech disturbances In a normal speaker under DAF, on the basis that if the model is thrown into oscillations caused by instability of the feedback loop, disturbing one's perception, stuttering like behaviour could be observed. Normal speech becomes prolonged, articulatory disturbances, repetitions, intensity rise, fundamental pitch rise and other changes are seen.

Smith comments that the primary defect in the servo system analogies is that they do not account for the diverse experimental effects of delayed auditory feedback. Another defect of the servo system theories is that they are not consistent with certain well-established information about the motion systems of speech. Stetson (l95l) and his co-workers have given a clear conception of how the movements involved in speaking are specialized and organized to maintain the speech pattern. The servo system descriptions do not allow for the complexity of the neuromotor integrative systems involved in the control of speech.

Still another inadequacy of the theories proposed by Lee, Fairbanks and Chase is that they emphasize the role of auditory feedback in speech production, while giving less importance to the role of kinesthetic and cutaneous feedback. Smith says that auditory feedback is normally a vital source of regulatory control of signals for speech, but at times sneaking 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 to and depend on Kinesthetic-cutaneous feedback. Such flexibility in control of speech is difficult to specify in mechanical analogies.

Smith said that we must assume that much of the disturbance from delayed auditory feedback is due to interference between the auditory and other types of feedback The fact that a peak disturbance has been recorded with delay intervals of about 0.2 second - an effect that remains unexplained in mechanical analogies - probably means that a maximal interference effect between auditory and other feed-back occurs at about that interval.

Smith (1962) explains the neurogeometric theory, a new operational approach. In that, the sensory control of speech is primarily an intrinsic neural process, the characteristics of which are determined by the basic sensori-neuromotor mechanisms of perceptual-motor integration. Speech as organized motion can be described as made up of integrated patterns of postural, transport and manipulative movements, differentially controlled by sensory feedback processes. Precision of motion organization thus depends on the sensitivity of sensory feedback mechanisms, including the auditory system, to spatial and temporal differences in stimulation. The neural centres involved in the regulation of this system function neurogeometrically, that is, the internuncial cells of the central system respond on the basis of stimulus differences and in so doing continually correct the motion pattern. The central neural detector neurons makes possible the regulation of speech movements by sensory feedback processes. Smith and others argue that there are different" types of detector systems for the regulation of continuous or sustained and discrete component movements of speech or other sound production. They assume that if an integrated speech or instrumental pattern is interrupted by delay of the critical feedback signals, the organization of the sustained and discrete postural, sound generating, tone-generating and articulatory movements would be changed. Thus, they believe that the variable quantitative effects produced by delays of different magnitude arise from changes in organization of the different movements. One such effect of delay is a degenerative change from the smoothly controlled phnasing of normal speech to the discrete, repetitive movements known as artificial stutter. This effect is analogous to the shift in organization of tracking motion from continuous pursuit to discrete movements when feedback signals are delayed. More research work needs to be done in this area.

The report by Wyke (1970) gives information regarding the neurological mechanisms involved in speech and how they could be disturbed to result in stuttering. The Laryngeal Mucousal Mechano receptor reflexes, the Laryngeal Myotactic Mechano receptor reflexes and Laryngeal Articular Mechano receptor reflexes in conjunction with the reflex mechanisms involved in the control of respiratory, pharyngeal, glottal, masticatory and oral musculature play a critical part in the unconscious regulation of the rapid and precise changes in tone of the many muscles in the act of speaking. A subject after he decides what he wants to say, voluntarily presets the tension patterns of his laryngeal musculature: One of the postulates in this hypothesis is that the abnormally, slow or inaccurate voluntary presetting of laryngeal and respiratory musculature might result in stuttering. This might result in wrong sound emerging until it is detected by the subject's acoustic monitoring which might induce him to result in Musculature to yet another pattern of tension distribution, which might be erroneous and the whole process might be repeated.

The different explanations given for the production and maintenance of normal speech is far from satisfactory. Yet, signal distortion, interference, or overload of the system used in monitoring speech could lead to stuttering is clearly shown in many studies. One of the methods of bringing about disturbance in speech is by delaying one's own auditory feedback of speech.

Delayed Auditory Feedback (DAF)

DAF was first reported by Lee (1950a, 1950b, 1951) and Black (1951). They said that when a normal speaker's verbal output was fed back to his ear after a short delay of about l/5th of a second, marked breaks in fluency occurd. DAF could also be called as delayed sensory feedback in the strictest sense of the term, as the self-stimulation processes generated by motion are interrupted between the motion and the recording sensory endings. The general method of delaying the auditory feedback of the sounds of speech is to record the sounds on a magnetic tape, and then hold these sounds on for a specified delay period by means of a tape loop. After travelling through the loop, the tape reaches a play back head that transmits the recorded sounds to the subject's ears by means of earphones. DA? has also been called as delayed side-tone.

The effects of DAF on normal speakers

In Lee's original experiments in 1950 (as reported by Smith, 1962) five subjects read a passage of 372 phonemes with 65 spaces into the microphone of a magnetic tape recorder. The subjects wore sound resistant earphones to prevent the normal air conduction of their speech sounds to their ears. Lee made use of the tape-loop system and adjusted the intensity of the played back delayed speech sounds, to mask the immediate bone conducted feedback. Measures of total reading time were obtained under normal conditions and under three delays of 0.1, 0.2 and 0.3 sec. The most obvious effects of delaying the auditory feedback of speech were slowing down of speech, increased intensity and higher pitch and a serious disturbance in the speech pattern. Three subjects read progressively more slowly as the delay interval was increased from 0.1 to 0.3 seconds, but the other two subjects showed only a slight decrease in reading rate. Lee reported that a subject might stop completely or, if he attempted to maintain normal speech rate with delayed feedback, would begin to stutter. This so-called 'artificial stutter' consisted of repetitions of syllables, especially those with fricative sounds, such as, 'sh' and 'ch'.

Lee attempted to derive a predictive formula to describe the effects of delayed feedback on reading time. His basic assumption was that the speaker functions as a machine and that a single formula could be found to describe, the effect of feedback delay on reading time. He proposed that: $T = n(d+t)$, where T is the reading time with delayed feedback, 'n' is the number of units of speech plus the intervals between words, and t'is the normal reading time, and 'd' is the delay interval . This formula generally predicts a linear relationship between delay and reading time. As Lee's data show, such a relationship was found only with some of the subjects.

Lee has given a theoretical basis for the effects of DAF, which has been mentioned previously. He does not offer an explanation for individual differences in time data. Smith (1962) says that these different forms of adapting to feedback delay indicate the speech control in somewhat more flexible than Lee implies, and that aural monitoring is not necessarily a higher level of control than somesthetic monitoring. The subjects, who performed most successfully under DAF, were probably able to ignore for the most part the non-synchronized sounds of speech and to control their speech mainly by somesthetic feedback signals.

Black (1951) studied the effect of delayed side-tone upon vocal rate and intensity. Twentytwo subjects read 11 series of short phrases, a series consisting of five, five syllable phrases. Phrases vere timed for normal duration and intensity and grouped into tests that were equivalent in mean duration and intensity values under normal reading circumstances. With each series the subjects heard his side-tone in a different time relationship with his speaking. These relationships were 0.00 sec., 0.03 sec., 0.06 sec., 0.09 sec. 0.30 sec. delays. The effects of delayed side-tone were reduced rate of reading and increased vocal intensity. The maximum single decrement in ratio occured with the change from 0.03 to 0.06 sec. delay. Shorter delays retarded the speech. A kind of 'stretching out' feeling was reported. Under longer delays, blocking of speech, facial contortions, prolongation and slurring of sounds were noticed. The maximum overall reduction in ratio occured with 0.18 sec. delay and maximum vocal intensity with 0.27 sec. delay. An intensity increase of 6.9 dB higher than the lowest mean value was noticed at 0.27 sec. delay.

In support of Black's findings, Rawnsley and Harris (1954) observed prolongation of vowels and Coblenz and Agnello

(1966) observed prolongation of glides and continuant sounds, in their spectrographic analysis of speech under DAF. Spilka (1954) conducted an investigation to determine the vocal rate duration and intentity correlates of delayed speech feedback with time of feedback delay and reading materials as variables.

A lengthening of average syllable duration, an increase in percent phonation time, and an increase in mean vocal intensity were observed under DAF. Some vocal changes appear to be related to the reading materials employed. A significant interaction was found between the reading passages and the delay times employed.

A comprehensive analysis of various effects on speech of different intervals of DAF was carried out by Fairbanks in 1955. Sixteen young men read a passage made up of six sentences containing a total of 98 words under five auditory conditions, all employing constant amplified feedback. In the first condition, the feedback was not delayed and in the others 0.1, 0.2, 0.4 and 0.8 sec. delays were used. DAF speech was returned to the ears via earphones and mixed with undelayed, unamplified auditory feedback.

DAF resulted in various types of speech disturbances. They were increased articulatory errors, longer duration, greater SPL and higher fundamental frequency. The effect was found to be relative within the range of time delays employed. Disturbances in articulation and duration were maximum at 0.2 sec. delay and they were interpreted as direct effects. Fairbanks proposed to combine measures of these two effects into one and he called it the Correct Word Rate (CWR). The CWR was the number of correct words uttered by the total time taken to read the passage. SPL and frequency changes were known as indirect effects. There was a marked reduction in reading rate with delays of 0.1, 0.2, and 0.4 sec. with maximal slowing at 0.2 sec.

DAF increased the rate of articulatory error, indicating greater effect upon articulation than upon duration. Fairbanks also compared the relative number of articulatory errors with the number of words that were misread. The relative number of articulatory errors was determined by dividing the number under each delay condition by the number under normal conditions of speaking. The results showed that delay has far less effect on word organization than it has upon articulatory movements involved in the formation of syllables.

The slowing down of speech, an effect which has been observed by many investigators has also been studied by Chase, Harvey, Standfast, Rapin and Sutton (1958, 1959).

In their study, fourteen young adults were required to repeat the speech sound "b" in groups of three, first with non-feedback through earphones and then with a delay of 0.24 sec. 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 into time values. The results shoved that there was a marked increase in the duration of the inter-syllble interval when auditory feedback was delayed. The mean inter-syllable interval for the 14 subjects with normal speech feedback was 0.35 sec. with a range of 0.14 to 0.73 sec. The mean inter-syllable interval with delayed feedback was 0.56 sec. with a range of 0.17 to 1. 7 sec. This difference was statistically significant (as referred by Smith, 1962).

In another systematic study, Fairbanks and Guttmann (1958) analyzed the articulatory disturbances produced by feedback delay in terms of types of errors made in reading. Sixteen men read a prose passage of 55 words, seven times in all. The first was a pre-experimental reading under normal conditions. The subjects wore earphones and spoke into the microphone for given experimental readings for which feedback delays of 0.0, 0.1, 0.2, 0.4 and 0.8 sec. were used and speech was amplified. Finally a post-experimental reading was made under normal conditions. In agreement with previous reports the general effect of time delay was, reduction in the number of correct words, increase in total reading time and retarded correct word rate. Disturbance was maximum at 0.2 sec. delay.

In order to measure articulatory accuracy, the correct word rate in words/sec, was calculated from the total number of correct words uttered and the total reading time. The errors in speech were then classified into errors of substitutions, omissions, additions and miscellaneous errors. Substitution errors which were described as involving improbable phonetic elements and monophonetic sounds occured on stressed syllables. Omissions often involved several phonetic units of speech. Additions appeared to be non-purposeful responses and were almost always double articulations. Non-repetitive additions were unstressed and occured between words. The common types of errors which were less were classified as miscellaneous and they were the slighting and shifted juncture. Peak disturbances were found at 0.2 sec. with declining levels of disturbance at the longer delay intervals. The Chase, et al. (1959) findings in general confirmed those of Fairbanks and Guttmann. Peak disturbances in this study were also at 0.242 sec. delay.

Some of the most striking effects of delayed speech feedback are the emotional disturbances, frustration and fatigue that result from sustained performance under DAF conditions. Lee (1950) first observed that speaking against delayed side-tone for more than a few seconds produced marked emotional tension and frustration, fatigue and reddening of the face. Hanley, Tiffany and Brungard (1959) have studied the emotional effects, specifically in relation to intensity of the delayed feedback, using skin resistance changes as a measure of emotional involvement. Fifty subjects were tested with five sound pressure levels of delayed side-tone. The latency of the skin resistance change and the pattern of the recorded change were analyzed. It was found that both the latency and the pattern were directly related to the SPL of the delayed side-tone.

Haywood (1963) also studied the emotional disturbances in terms of Palmar sweating (PSI), heart rate, and pulse rate. These were studied before, during and after subject: read into a delayed auditory feedback recorder. The effect of delayed feedback experience showed a very significant increase in PSI with no change in heart rate or pulse pressure. It was concluded that (a) stimulation involving disruption of speech patterns resulted in patterns of physiological arousal which were different from those associated with pure physiological stimulation, (b) PSI was an adequate and useful measure of arousal, particularly for speech related research.

The other aspect of speech which was studied under DAF was effect of side-tone upon intelligibility. A group of listeners heard intelligibility tests in noise and in quiet. The speakers read with delay of 0.02 to 0.09 sec. introduced into their side-tone. The listener heard either the original saying or the original plus the delayed saying of speech material. Speech was received less accurately in every delay condition except when speakers read with 0.05, 0.08 and 0.09 sec. delay. Atkinson (1952), Fulton and Spuehler (1962) conducted a study on the same lines. They Investigated the effects of frequency filtering and delayed side-tone on vocal responses. The different aspects studied were the effect of delay on phonation time ratios and words per minute, under 0.0 sec, 0.18 sec. and 0.20 sec. delay conditions and with 500, 1000, 1587 and 2000 cps. band pass frequency filters. Results indicated that words/min. were more affected by delay than were phonation time ratios.

Delayed speech feedback has been used with different personality characteristics to see their vulnerability to DAF. Spilka (19549 studied the vocal responses of 150 young college males under synchronus and delayed speech feedback. The amount and direction of the change occuring in rate-duration and intensity of voice variables were related to selected personality variables. The conclusions made were: (l) Of the voice variables studied, the amount of change occuring in vocal intensity variation due to delayed speech feedback appears to be most closely related to personality functioning and this vas positively related to inadequacy and instability of the self-conceptual system as indicated by measures which reveal negative self attributes and poor general personality adjustment and paranoid behavioural tendencies, decreases in vocal intensity variation were related to schizoid, socially withdrawing and isolating, modes of behavioural adjustment. DAF could be used vith different 'types of personality' to observe their responses.

Goldfarb and Braunstein (1958) reported that schizophrenic children showed less speech disturbance under . DAF than did a control group. They revealed that several children in the experimental group identified the delayed voice as belonging to another person. The results suggested a relationship between identified effects of DAF and the child's concept of self-identity, and hence it was posited that an advanced development of self-identity and concept function as might be found in the case of the normal child, could make the child more dependent on unaltered speech feedback. Results tend to support the view that schizophrenics as individuals have reduced contact with reality and have speech which reflects deficiencies in monitoring system.

Another study done with adults which is of different nature was the one by Rouse and Tucker (1966). The effect of DAF on speech in American and Foreign students were studied. Fifteen students speaking English (Group A), thirteen Foreign students speaking English (Group B) and thirteen American students speaking French (Group C) read two fifty-word prose passages under simultaneous and under delay of 225 m.sec. conditions. The performance of Group A replicated the findings of previous students under DAF. Correct Word Rate was reduced, errors and time taken to read were more under DAF. Groups B and C suffered considerably less in interference than the control group. The explanation for this could given by a explanation for the bilingual phenomena. Jackobvits and Lambert (1961) had found difference in semantic satiation among bilinguals. Those with clearly separate language systems in discrete contexts had less transfer of satiation from one language to the other. The second explanation was given by Fillenbaum's study (1963) which found that DAF has smaller effects on speech when reading was difficult than when it was easy.

The Abbs and Smith (1970) study of laterality differences in the auditory feedback control of speech has a lot of relevance to the present study. The basis for their study was, if externally produced speech could be perceived by the same system that a listener uses to monitor and perceive self-product speech, it could be assumed that auditory feedback to the right ear would be more critical in influencing speech production than auditory feedback to the left ear.

A hybrid computer was used for the feedback of speech. Feedback intensity was determined by a method very similar to that used by Fairbanks (1955). Six subjects, judged the amplified feedback, through the earphones and feedback without the earphone to be equally loud. Then that amplified level was used as a reference level. The intensity used with delay conditions was than set at 30 dB above this reference, which resulted in an overall level of about 90 dB SPL. White noise at 85 dB SPL was given to the other ear not receiving DAF speech. The level of noise was determined by finding an intensity that completely masked self-produced binaural speech. Eight female subjects underwent four conditions of DAF, 0.O, 0.1, 0.2 and 0.3 sec. to each ear during speech. Under each of eight conditions counter balanced for order effect, the subjects read seven sentences.

Total speaking time and number of articulatory errors were noted down. Results showed that the delay to right ear produced a significantly greater number of speech errors (articulatory errors) than delayed presentation to left ear at 0.2 and at 0.3 sec. delays. The two ears did not differ in terms of total speaking time.

The experiment has tested a special dimension of DAF on speech, the effect of vocal aural time lags on speaking time and articulation errors in right ear and left ear listening.

The differences in reaction of two ears to different feedback parameters of speech may mean that vowels, where most elongations under delay occurs (Abbs, 1968) are monitored equally for feedback control by both ears, while consonants (where most misarticulations occured, 20 consonantal errors and 1 vowel error) are monitored by right ear. Vowels may be controlled adjunctly by feedback channels other than auditory, that is, propriocepti e or tactile. These findings seem consistent with speech identification data on laterality differences by Shankweiler and Studdert-Kennedy (1967). The delay functions found for the monaural hearing did not show the peaked perturbing effect at 0.2 sec. that has been reported in studies of binaural hearing of delayed speech.

The findings of Abbs and Smith's study add to past research on auditory feedback control by disclosing that either the specialized functions of the separate ears or their binaural co-ordination are degraded by voca-aural time lag.

The experimental findings confirm the assumption that auditory input during speech encompasses the differential function of the two ears in controlling speech production.

The theoretical question raised by the findings is whether the ear bias is due to ear preference alone or to a bias determined by speech action and the active mechanism of hearing. If preference was caused by ear itself, it must have consisted of a preference for parameters of certain speech sounds. The aural bias in auditory feedback control appear related most decisively to those components of speech demanding the greatest precision of motor control, i.e., articulation components.

This technique could be used as a dichotic listening technique which could be used to test ear preference which could reflect upon dominance.

Any phenomenon might undergo adaptation if the same phenomenon is repeated many times. The effect of DAF is not an exception to this. There have been observations on

2 types of adaptation to delaying hearing, i.e., adjustment within a single period of exposure and changes in mode of response to the delayed feedback with repeated exposures. Observations on adjustments within a stable period were first reported by Atkinson (1953), who investigated reading performance during a five-minute period of delayed feedback, using delay intervals from 0.03 to 0.3 sec. Subjects showed the usual slowing of speech under delay conditions, as well as increased intensity. No real evidence of improvement in reading during the course of the exposure was found. Neither reading rate nor SPL changed significantly during the given minutes. However, Atkinson did not rule out the possibility of adaptation with longer periods of performance.

Adaptation with repeated exposure

Tiffany and Hanley (1956) studied the adaptation of 20 subjects to delayed speech feedback over a series of 24 readings during two weeks. The task was to read a 45-vord prose passage with a feedback delay of 0.18 sec. Measures of reading time and fluency were obtained. The results showed no significant adaptation in reading rate over the interval studied. However, there was a significant adaptation in fluency from the first series of readings to the second series. Readers learned to avoid repetitions and omissions of words, syllables, and sounds. However, the adaptation phenomenon was not consistent. Some subjects were markedly worse over the series of readings, while others showed improvement.

In another study of adaptation, Winchester, Gibbons, and Krebs (1959) found significant decrease in reading time after the first two reading periods. Reading time decreased from the first to the tenth test period. Adaptation might be due to adaptation to reading material. This indication of significant adaptation in reading rate to delayed speech feedback differs from Tiffany and Hanley's negative finding.

Persisting after effects

In an early study, Black (1951) observed that the decreased rate of reading resulting from delayed speech feed-back of 0.18 sec. and persisted to some extent for reading done immediately after the exposure period. Black (1955) planned a study to measure these after effects. An experimental and a control group, each composed of 28 subjects, read 10 lists of 5-syllable phrases. The phrases were read at 5-second intervals, while the duration and relative SPL of each phrase were recorded. A delay of 0.3 sec. was introduced during the reading of lists 3 and 4, then discontinued with no warning to the subjects. The author found the reading rate to be retarded even in list 5. Black concluded that reading rate continued to be affected for at least 150 seconds after the delay had been discontinued.

Tiffany and Hanley (1956) reported observations on after effects of delayed speech feedback at the conclusion of their two weeks study. The after effects were related to the degree to which the speaker had been disturbed during the delay period. Readers who were greatly disturbed by the feedback delay read more slowly in post-exposure period, and those who were disturbed less tended to increase their reading rate in the post-exposure period.

The decrease in speech disturbance may not be true adaptation. It may be that the speakers by using certain strategies learn to "beat the machine". They do this by using slow speaking or sudden shifts of pitch or loudness or sudden attempts timed by finger movements or other means (Van Riper 1971). Goldiamond, Atkinson and Bilger (1962) showed that when subjects were instructed not to listen to the DAF they could read more words per minute than when they were asked to listen to it. In this way, attention to proprioceptive feedback probably creates a buffer against the DAF stimuli.

Sex differences in the production of artificial stuttering, vith the male being more vulnerable than the female to DAF, have been found by Bachrach (1964) and by Mahaffey and Stromsta (1965), but another study by Buxton (l969) found no sex differences.

Two more important studies have thrown a good deal of more light on the conditions producing breakdown in speech. Winchester and Gibbons (1957) divided 160 normally hearing adults into four groups, who were allocated to one of four conditions involving DAF presented: binaurally, uniaurally, uniaurally with a masking tone in the other ear, and no DAF or masking tone. The results indicated that uniaural delay without masking of the other ear produced less disturbance than uniaural delay with the masking, although all three delay conditions produced significantly more disturbance than the control condition.

Chase and Guilfoyle (1962) presented delayed and undelayed feedback simultaneously to both ears. The gain of the undelayed feedback was varied from one-third, two-thirds, or equal to that of the delayed feedback. CWR and total time were measured. However, speech was still disturbed compared with normal conditions when the gain of the undelayed feedback was made equal to that of the delayed feedback.

Individuals differ to some extent in terns of the delay interval required to produce the DAF effect, but critical delay for most young male adults seems to range from 0.16 to 0.22 sec. (Fairbanks, 1951; Fairbanks and Guttmann, 1958; and Chase, et al., 1959) with females showing a longer critical delay time. The delay time which is best for producing disruption and the intensity of the delayed signal are related, but the most pronounced effects are found when the delayed feedback is at least loud enough to mask the fundamental frequency of the bone-conducted side-tone - 50 dB or more above threshold (Butler and Galloway, 1957). Brubaker (1952) also showed that the SPL of the DAF signal must be greater than that of the subject's own speech before disruption occurs. Most investigators have used levels of 80 dB or more for the delay. Binaural DAF is said to produce more disturbance than monaural. Arens and Popplestone (1959) found that normal speakers with high verbal facility (as measured by verbal IQ on the Weschsler - a dubious criterion) - were able to resist the DAF better than those with low verbal IQs. Buxton (1969) reported that the faster a speaker's maximum rate of speech, the shorter the delay time that produces the most disruption. Also, rapid speakers in general were less affected by DAF at all delay intervals from 0.10 to 0.60 sec. In this connection, Mackay (l968) also says "The slower the subject's maximum rate, the higher his frequency of stuttering under DAF."

Mackay (1969) showed that normal speakers could overcome the DAF disruption by voluntarily drawling or prolonging the duration of syllables, a technique used in stuttering therapy. Mackay (1969) also discovered that when normal speakers used very nasalized speech, they became relatively fluent under DAF, a finding which is paralleled by the fluency of stutterers when using a dialect or other strange manner of speaking (Van Riper, 1973).

So far, we have reviewed the effects of DAF on adults. The effect of DAF on children has been studied by Chase, et al. (1959), Smith and Tierney (1972) and Godfarb and Brunstein (1958). The results generally indicated that younger children (4 to 6 years old) were less severely affected than older children (more than 7 years). The difference could be probably a developmental effect, related to the increasing degree of control speech mechanism during childhood.

Accelerated Auditory Feedback:

Eventhough the normal auditory feedback of speech is mainly air borne sound, it is somewhat slower in reaching the ear than electronically conducted sound. It is possible to accelerate the feedback of time of speech sounds to a speaker's ears over the normal transmission time. The original experiment on accelerated speech feedback was by Peters (1954), who compared reading rates with normal feedback time of 0.001 sec. with rates when the auditory feedback was accelerated to intervals of 0.0003 sec. (equivalent to B.C. feedback) and 0.00015 sec. The subjects who were instructed to read naturally read progressively faster as the feedback time was decreased and when the intensity of the auditory feedback was decreased.

These results on accelerated feedback are consistent with the many observations on DAF, which have shown that retarded speech is associated with increased feedback time and increased intensity. Within a limited range, speaking rate appears to be a direct function of the feedback interval.

Similarities between stuttering and the behaviour exhibited by normal speakers on DAF

The basic behaviours of stuttering, repetition of syllables and prolongations of sounds, have been found consistently in some normal speakers under delayed auditory feedback (Fairbanks, 1955; Fairbanks and Guttmana, 1958; and Chase, et al., 1958). If one assumes that the basic disturbance in normal speakers under DAF is temporal disruption in the programming of the motor sequences, that is, that the time order of events is disturbed, then as Black (1951) 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, 1971).

Some authors feel that DAF non-fluencies are not stuttering. Neelley 6961) compared the performances of 33 adult stutterers and 23 adult non-stutterers under time delay of 0.14 sec. They read a 100-word passage five times under normal auditory feedback conditions. 24 hours later, all subjects read the same passage five times under DAF. The speech was amplified at 75 dB above threshold.

The speech behaviour of the 2 groups under DAF was studied with reference to the omissions, substitutions and additions of sounds and correct word rate in seconds. There were no significant differences between the group in omissions and substitutions.

Samples of speech produced under DAF were rated on a 9 point scale of 'speech disturbance'. The mean rating for stuttering group was 4.0 and the mean rating for non-stuttering group was 3.1. 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.

Performance of stutterers and non-stutterers under DAF were not very different.

The speech behaviour of stutterers under NAF was compared with the speech behaviour of non-stutterers under DAF with regard to the decrement of the frequency of error words over 5 readings of the passage (adaptation effect), the consistency of error words and certain listener data. (An error word was a word in which any portion of an instance of omission, substitution, or addition of sounds occured.) The error word adaptation percentages for stutterers over the five readings under NAF were quite similar to the stuttering adaptation percentages quoted in literature. Error decrement for the non-stutterers under DAF was erratic and significantly different.

The Neelley study has been widely accepted as evidence that DAF speech disruptions are completely different from those shown by stutterers (Van Riper, 1971). Yates (1963b) has pointed out two extremely important weaknesses in the study "which make Neelley's conclusions quite unacceptable". First of all, Neelley used only one delay time (0.14 sec.)

and one intensity level, and this delay tine 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. As Neelley's judges were able to tell that the samples were different, Neelley concluded that DAF disruptions bore no resemblence to stuttering ones (as quoted by Van Riper, 1971). Yates (l963b) remarks:

> But these empirical findings are totally irrelevant to the issue whether speech behaviour under DAF is determined by the same factors which maintain stammering behaviour. The two groups are in no way meaningfully comparable in these respects. The stammerers in the experiment had presumably spent many years adapting to and working out ways of dealing with their perceptual defect (assuming it to exist). The subjects with normal speech were being, on the contrary, subjected to DAF for the first time. Hence, it is in no way surprising that the speech of Ss subjected to DAF for the first time is different from that of long-standing stammerers. The problem concerning underlying mechanisms of stammering cannot in fact be resolved by the kind of experiment reported by Neelley. The problem can be solved only by a direct attack on the auditory monitoring skills of stammerers (p. 116).

The Responses of Stutterers to DAF

Studies have shown that stutterers respond in a different manner than do the normals to DAF. Generally, their fluency is improved under delay rather than disrupted.

The less severe stutterers perform much like normal speakers and have difficulty being fluent. These differences suggest the presence of subpopulations of stutterers or merely the type of monitoring used (Van Riper, 1971).

Some of the major findings of stutterers response to DAF are reviewed here. Soderberg (1969) has summarized short term studies and long term studies of DAF on the speech of stutterers. Ham and Steer (1967) conducted a study on 10 stutterers and 10 non-stutterers. They read the same 111-word passage throughout randomized conditions of amplified DAF (0.1, 0.2, 0.4 and 0.8 sec delay) and NAF. Both groups were found to display similar peak effects at 0.10 sec. with regard to measures of total reading time, phonation/time ratio, and syllable duration. Longer delay times tended to decrease the duration measures. These investigators also noted that mean vocal intensity did not vary significantly among the delay conditions of NAF but the stutterers were more variable than were non-stutterers on this measure under DAF. Ham and Steer reported no significant mean difference in frequency of stuttering under NAF and DAF but that extreme individual reactions to stuttering occured under DAF.

Logue (1962) had stutterers and non-stutterers, 15 in each group. They read the same 73-word passage under randomized conditions of amplified DAF (0.14 to 0.20 sec. delay) and NAF. The findings indicated that both groups increased total reading tine, phonation/time ratio, and vocal intensity under DAF in comparison to NAF. No significant difference between the delays was reported.

In a study by Stark and Pierce (l970), 15 adult stutterers and 15 matched non-stutterers were studied. Their responses were compared on a patterned syllable-repetition task under various auditory feedback conditions. The feedback signals were clicks activated by an electro-mechanical device at the time of lip closure. They were . either synchronus (SAF) or delayed (DAF) or a combination (SAF/DAF). SAF was presented at a 40 dB SL, DAF by binaural air conduction with a delay of 140 or 200 m.sec. at S.L.'s of 0, 10, 20 and 30 dB in DAF alone and at S.L.'s of 40, 50, 60 and 70 dB in SAF/DAF. Performances were evaluated in terms of pattern duration, lip closure duration and number of pattern errors.

Stutterers and non-stutterers responded similarly to the feedback conditions. The following three differences were found: (l) During SAF alone, stutterers showed greater duration of lip closure than non-stutterers; (2) With increased intensity of DAF, they showed a greater increase in number of pattern errors than non-stutterers; and (3) There were non-systematic differences between stutterers and non-stutterers in duration of lip closure during DAF and SAF/DAF conditions.

Another interesting study by Cohen and Edwards (1965) had stutterers experience alternations between simultaneous feedback and randomized interval feedback for 15 sessions of one hour each, 3 times weekly. No marked reduction in the frequency of stuttering occured, but the stuttering behaviours changed significantly under this regime. Long, severe blockages disappeared, avoidance and struggle behaviour decreased, and most of the stuttering became repetitive and similar to "primary stuttering".

A critical review of some of these studies was done by Soderberg (1968). He said that the discrepancies in the studies might have been due to the use of non-critical delay times or the small number of subjects.

In contrast to the studies mentioned, Nessel (1958) found substantial differences between the speech patterns of 32 stutterers and 18 non-stutterers under DAF. The subjects were allowed to become familiar with a 135-syllable passage by reading it silently, then they read the same passage aloud under amplified NAF and 0.13 sec. delay. Nessel concluded that non-stutterers had longer total reading times and more errors under DAF than NAF. In contrast, the majority of the stutterers demonstrated no appreciable change in rate under the 2 conditions and made fewer errors under DAF. He termed it as distraction effect.

Bohr (1963) in South Africa found that stutterers were more fluent under DAF; Zerneri (1966) found two groups among 102 stutterers, one of which (the primarily clonic ones) improved under DAF.

In other studies, direct comparisons were not made between stutterers and non-stutterers, but generally the effect of DAF on the frequency of stuttering was investigated. Soderberg (1959) reported the effect of DAF (approximately 0.14 sec.) on the vocal fluency, rate and pitch of 30 stutterers. The subjects made statements of comparable length and number about pictures, read twentyfive 10-syllable phrases and they sustained vowels after each of the foregoing kind of speaking under each of the following serially ordered conditions: (l) NAF; (2) DAF; (3) duplication of condition (2); (4) NAF; and (5) NAF preceded by 6 minutes of inactivity. After two sequential conditions of DAF, the delay was suddenly eliminated from the feedback in order to assess persistence of the DAF effect. Under DAF, he observed that for both oral reading and spontaneous speaking of the stutterers significantly reduced the frequency and duration of their stuttering and significantly increased the duration of their words and pitch of their voices under DAF. The persisting effects of DAF were limited to a slight, but there was significant carry over in pitch.

In their article on sensory feedback and motor performance, Chase, Sutton and Rapin (1961) reported an experiment in which 30 stutterers read aloud under conditions of amplified NAF and 0.20 sec. delay. They noted that a third of the subjects showed a marked improvement in speech under DAF.

Lotzmann's (1961) study is one of the most extensive studies in DAF and stuttering research. He made sixtytwo stutterers read aloud a 271-syllable passage of verse and a 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 sec. NAF condition preceded and followed the DAF conditions. Lotzmann's major finding was that DAF completely eliminated stuttering or greatly reduced it. He pointed out that the minimum number of stuttering was concentrated between 0.05 and 0.10 sec. delay, and the lowest total reading time occured at 0.05. For majority of stutterers, 0.05 sec. was considered to be the optimum delay for facilitating speech. When the speech of stutterers was compared before delay and after delay, Lotzmann observed that stuttering was reduced spontaneously by about a third. He inferred that adaptation might account in part for this decrease since the same material was read in every condition (as quoted by Soderberg, 1969, p.29).

Soderberg (1969), while summarizing the short-term studies, said that these effects of DAF on the speech of stutterers as a group are somewhat equivocal. Direct comparisons between the studies are difficult because different experimental designs and criteria measures were utilized. Generally, DAF was found to facilitate the fluency of stutterers.

Soderberg (1969) considered studies by Adamczyk (1959) Goldiamond (1965), and Gross and Nathnson (1967), as long-term studies.

Adamczyk (1959) treated 15 stutterers under 0.25 sec. amplified delay over a period of 3 months. Two groups of children and adults met five times a week for 30 to 40 minute sessions. The stutterers chatted, children told fairy tales and adults had discussions under DAF. One third of the time was devoted to talking without DAF. He reported considerable improvement in thirteen of the cases and slight improvement in two, even though he did not quantify his findings. When the stutterers came back for routine weekly check-ups, after therapy period, no appreciable changes were observed.

Goldiamond (1965) employed DAF and operant conditioning procedures for the treatment of stutterers in a laboratory setting. He used amplified DAF as an adversive stimulus or form of punishment for stuttering. Although he found this procedure substantially reduced the stuttering rate and increased the reading rate, he obtained conflicting results When DAF was introduced as a form of punishment for fluency (each word stuttered shuts off DAF for 10 seconds). This at first resulted in increase of stuttering, but surprisingly, under the same negative reinforcement scheduling, the stutterers began to talk more slowly, prolonging, and became very fluent.

Goldiamond evidently had considered the possibility that DAF alone and quite apart from its alleged punishment role, might be fluency-enhancing,for he applied continuous DAF to one stutterer for a short time and found no improvement. That this improvement to control for DAF ability to decrease stuttering was insufficient was pointed out by Webster and Lubker (1968) who demonstrated that stutterers with enough exposure can learn to withstand DAF disruption and gain fluency from its effect alone and without its operant contingencies. They write that in their laboratory 4 out of 44 stutterers did not show immediate improvement in fluency when they first experienced continuous DAF. These were subjects who were with strong anticipatory struggle response and they could follow instructions to drop out the struggle responses and could then successfully emit words they initiated. They found that if speech was initiated without struggle, DAF permitted fluency (Van Riper, 1973).

With more stutterers Goldiamond gave a set of procedures for shaping their fluency to normal speech. They are: (l) running) subject until prolongation, or instructing subject to prolong under DAF; (2) gradually fading out delay from 0.25 sec. to NAF; and (3) speeding up the reading rate through machine programmed materials. For 30 laboratory subjects during a specified 50-minute period in the programme, he followed the above procedure found a pattern of fluent oral reading. The pattern persisted for other 50-minute periods thereafter under similar laboratory , conditions.

Gross and Nathanson (1967) used a modification of Goldiamond's basic DAF shaping procedures with male stutterers over a 4-week period. They attended three

30-minute sessions and four 15-minute sessions for a total of two and one half hours on the entire sequence. During the first five sessions, the subjects were instructed to establish and use a 'slow blending pattern' under amplified DAF (delay not specified). In the fifth session, the volume of the returned DAF was normalized and later reading rate was gradually increased to a more desirable pattern and this was demonstrated previously to the subjects on a 5-point scale. 1 - represented the subjects initial reading rate under amplified DAF and 5 represented normal rate. The 8 stutterers significantly reduced the frequency of their stuttering. A 6-week and a 6-month recheck revealed that the stutterers were able to maintain a minimal stuttering rate in oral reading.

Soderberg (1969) summarized the long-term studies and said that the frequency of stuttering was greatly reduced when the stutterer was subjected to prolonged DAF or when he was instructed to establish and use a prolonged pattern of talking under DAF. The effect of DAF on the fluency of stutterers seemed to persist after the delay has been eliminated from the feedback and oral reading rate subsequently could be shaped to a more normal pattern.

Another attempt to apply DAF in the treatment of stuttering was made by Curlee and Perkins (1969). They called it Conversational Rate Control Therapy. They gave Instructions to their stutterers to prolong the syllables and to speak slowly in short simple sentences. The stutterers could get a fluent speech at the rate of 30 to 35 words per minute in conversation. The delay was originally set at 250 m.sec. and the stutterer was to try to say his syllables so that they would coincide with the delayed feedback (a procedure that results in a regular rhythmic utterance of words). Later, the delay was progressively decreased in 50 m.sec. steps until simultaneous feedback was attained. Finally, time out procedures were used to punish the stuttering which remained and transfer of the fluency to outside situations was attempted.

Ryan (1968) also applied the Goldiamond procedures described earlier to 6 stutterers over a 9-month period using concurrent programmes of oral reading, monologue and conversation under DAF. His basic conclusions were as follows:

> Comparisons of performances under DAF in the three modes of reading, speaking, and conversation revealed that these situations were independently affected by the DAF procedure. Reading in a fluent, prolonged manner under DAF did not generalize to speaking without DAF. The highest frequency of reoccurrence of dysfluencies under DAF occurred in conversation,

> followed by monologue and then reading. Although it Is possible to dramatically reduce the frequency of stuttering in monologue and conversation concurrently with reading using DAF, it would appear that the increased re-occurrence of dysfluencies makes this a questionable procedure. The use of base periods following each break probably is not necessary and only detracts from the ongoing program. It increases the possibility of dysfluency. (p. 180).

The re-circulation effect described by Chase (1953) may be responsible for this possible therapeutic application. Chase writes:

> It should be noted that facilitation of fe-circulation for speech units may result in obvious repetitions in speech for some cases and prolongations of speech in other cases. For example, if facilitation of re-circulation functioned at the level of vord units, repetitions of words so affected would be noted by the listener. However, if facilitation of re-circulation functioned at the level of a unit of speech smaller than a syllable, it might be heard solely as the prolongation of the syllable, (p. 589).

Van Riper (1973) has made attempts to determine the utility of DAF in stuttering therapy. Early in therapy, they have used it to help the stutterer recognize that other people can be made to stutter too and that their responses to broken words are very similar to the stutterers reactions to his own moments of disruption.

As part of the therapy, the stutterers were taught to "beat the machine" through systematic desensitization. This was done, (l) by inserting brief moments of delay while the stutterer was being fluent and gradually increasing the delay dosages, (2) by beginning with conditions DAF using the delay time which was mast conducive to fluency and then gradually changing the delay interval, until it approximates the delay time which produced maximum disruption, and (3) by starting a delay which caused disruption but by keeping it so low in volume that the delay was barely sensed. Later, gain could be increased in steps up to the threshold of breakdown.(Van Riper (1972) says that the stutterers like the normal speakers find a strong urge to do what they could to bring their utterances under the automatic control of their servo system by their coping mechanism, when they are put for the first time on DAF. In training stutterers, Van Riper found it essential to weaken and prevent the other types of coping reactions, to insist upon and to reinforce somosthetic monitoring. Stutterers proprioceptive-tactile-kinesthetic monitoring transferred very easily, because normal speakers seem to rely primarily upon it rather upon self-hearing for their temporal programming of motoric speech (Van Riper, 1973).

The other uses of DAF are:

1. If we employ very long delay times, a segment of stuttering behaviour could be recycled and during the long delay, the stutterers could attempt to cancel or modify the behaviour thus verifying the contrasts involved.

2. DAF could be used with videotape in stuttering therapy.

8. DAF could be used as an audiometric procedure (Ruhm and Cooper, 1964). Its validity was shown with different types of cases, comparing the thresholds with conventional testing and DAF and the thresholds were found valid.

4. DAF could be used with functional hearing loss patients in their diagnosis.

5. DAF has been tried with mentally retarded by Copeland (1973) to see if it acts as a facilitator to speech production. Free field delayed feedback was administered to 44 high and 44 low verbal level subjects. It was found that feedback condition elicited a significantly greater amount of verbalization for both the groups.

Feedback can be altered by masking noise also. It has been known for a long time that a marked reduction of severity of stuttering follows artificial deafening. Kern (l93l) used the beating of loud drums to produce increments in fluency of stutterers. Cherry and Sayers (1956) performed a series of experiments with puretones and white noise which caused an immediate and in some cases complete reduction in stuttering. These included a further study of shadowing. They found that when stutterers shadowed the speech of another speaker they had nearly normal fluency. Masking noise also has been used in stuttering therapy. Portable maskers have been used (Parker and Christopherson 1963). The masking effect might be possibly related to reported low incidence of stuttering among the deaf (Backus, 1938; and Albright and Malone, 1942). A study by Nataraja and Rathna (l97a) reported different findings. They found 6.6% of 707 stutterers having hearing loss.

Tomatis (1954; 1963) explained stuttering as being due to the same sort of perceptual distortion as that produced by delayed auditory feedback. He said that stutterers monitor their speech with the ear opposite that which should be dominant, and that when this was true, the information (feedback) coming in from their vocal output must be shunted intracerebrally before it could be used. He felt that in stutterers there vas a lag in transit time as the stutterer used the wrong "directing" ear. This lag produced the stuttering disruptions similar to that produced by DAF in normals.

Tomatis (1954) stated that 90% of his stutterers had a hearing loss in the ear which should have been their preferred or directing ear. This forced them to use the non-dominant ear for perception, introducing a trans-cerebral delay time of approximately 0.2 sec., a delay which usually disrupts speech in the adult males. He claimed that the dominant ear could be ascertained by masking one and then the other ear as the subject was talking. When the rate of speech slowed down, it was the directing (dominant) ear that is being masked. To check this, he suggested delaying the feedback to the directing ear until speech slowed down. The delay time then presumably equals the intercerebral transference time. Tomatis claimed that this dominant ear was usually on the same side as the dominant eye.

Tomatis had devised an 'Electronic Ear' which he used for the treatment of stuttering. This device was some-thing like a binaural hearing aid in which appropriate counter delays were built in. Tomatis finding that a unilateral hypacusis existed in stutterers was not corroborated by Moraverk and Langova (1964) or by Aimard, Plaintier and Wittling (1965) nor did the later workers find any evidence of central lateral dominance for auditory perception. Backe (1965) in Norway found that there was less stuttering when DAF was applied only to the preferred ear.

The concept of 'dominant ear' introduces is the concept of cerebral Dominance and to the techniques used in finding out the Dominant or leading hemisphere. Bouillard in 1865 suggested that cerebral Dominance for speech and handedness were in some way interconnected and later Hughlings Jackson introduced the oncept of 'leading hemisphere', implying a physiological rather than any anatomical difference between the two hemispheres. However, recent studies have also shown that the dominant parietal lobe controlling speech, spatial and orientation and prais is slightly larger and contains more nerve cells than the non-dominant parietal lobe.

Penfield and Roberts (1959), Berry and Eigenson (1956), Guazzangia (1970)and Brain (1961) support the findings that there is dominance for speech and one of the cerebral hemispheres control the speech production and speech perception.

Handedness and speech are the two best known brain functions generally regarded as attributes of hemispheric dominance (Rossi and Rossadini, 1967).

It used to be thought that the left cerebral hemisphere vas dominant for speech in right-handers and the right hemisphere in left-handers. However, in 1959, Penfield and Roberts concluded from studies of cortical and stimulation and excision in patients with epilepsy that the left cerebral hemisphere was dominant for speech in nearly everyone, whether left-handed or right-handed, provided that one excluded cases of pathological left-handednesa, i.e., due to trauma or disease of the left hemisphere at birth or during infancy (Espir and Rose, 1970).

The present position regarding the relationship between cerebral Dominance and handedness is that the left cerebral hemisphere is almost always dominant for speech in right-handers with very rare exceptions. The left cerebral hemisphere is also dominant for speech in a proportion (probably 50%) of left-handers. There are other left-handers whose right cerebral hemisphere is dominant and in these cases there is by no means always evidence of trauma or disease to the left hemisphere at birth or during infancy. Confirmation of this view has been obtained from the study of brain wounds (Russell and

Espir, 1961) and cases of post-traumatic epilepsy having an aphasia aura and most recently from the technique of intracarotid arterial injection (Milner, Branch and Rasmussan, 1964). Dichotic listening techniques have been used for the same purpose recently.

Several investigators support the observation that the difference between the left and right lobes of man are functionally different in regard to the kind of auditory events each processes. These investigations have employed a new technique, that of dichotic listening which was devised by D.E. Broadbent (1954) of England. In his study, different digits were presented simultaneously to the listeners ears by means of a dual channel tape recorder with stereophonic earphones. Groups of digits were presented to each ear, simultaneously one sequence to one ear, and the other sequence to the other ear. The subjects was asked to report all the digits he could recall in whatever order. It was observed that normal right-handed persons could recall more number of digits presented to the right ear than to the left ear. The explanation for the dichotic listening findings is that though both ears have neural connections to both sides of the brain, each ear has greater neural representation - more nerve connections in the hemisphere opposite to it than in the Ipsilateral hemisphere.

Kimura (l961a), Milner (1962) and Studdert-Kennedy and Shankweiler (1970) postulate from dichotic stimulation studies that the left temporal lobe is predominant for verbal acoustic functions, especially in the extraction of consonantal features (Studdert-Kennedy and Shankweiler, 1970), but the right temporal lobe predominates for functions related to non-verbal acoustic stimuli like music and sonal pulses (Milner, 1962; and Kimura, 1964).

Kimura (l961a) used Broadbent's dichotic format to study patients with temporal lobe disorder. She demonstrated that when different digits were presented simultaneously to the ears, the following results were obtained:

1. Unilateral temporal lobectomy impaired the recognition of digits arriving at the ear contralateral to the removal.

2. Overall efficiency as measured by the total number of digits reported from both ears was affected by left temporal lobectomy, but not by right temporal lobectomy.

Patients with lesions of the left temporal lobe, before and after surgery were inferior to those with lesions of the right temporal lobe even when the groups had been previously equated for digit span.

Kimura interpreted these facts to mean that the crossed auditory pathways in man were stronger or more numerous than the uncrossed Auditory pathways and that the left hemisphere was more important than the right hemisphere in the perception of spoken material.

DAF has been used with temporal lobe lesion patients. This investigation was reported by Chase (1965). When DAF was given unilaterally to unilateral temporal lobe lesions, the most striking finding was an asymmetry in the effect of DAF on speech as a function of the ear to which DAF was presented. When DAF was given to the other ear, contralateral to temporal lobe lesions there was leas disturbance of the motor organization of speech than when the DAF was presented to the ear on the side of temporal lobe having the lesion. This was observed both in right and left temporal lobe lesions, to much the same degree. The subjects here read a 50-word passage under conditions of unilateral DAF with masking white noise in the other ear. The subjects read under normal conditions and then under DAF. Thus both right and left temporal-lobe patients demonstrated greater disturbance of speech motor activity when DAF is presented to the ear on the side of the lesion. This laterality effect is more marked for patients with left temporal lesions than for right temporal lobe lesions.

DAF has been used as a dichotic listening task in normals by Abbs and Smith (1970). Speech was more disturbed when DAF was given to right ear than when DAF was given to left ear.

In 1965, Tsunoda devised a new objective testing method to find out the dominant cerebral hemisphere, based on DAF tapping. The tapping patterns used were 4 short taps followed by a pause and 2 short taps. The test was a dichotic one with one ear receiving simultaneous tones and the other ear receiving 200 m.sec. delay tone. The intensity level of the tone, where the disturbance in tapping rhythm and time occured was noted down in each ear. The ear which required lower level of Intensity for disturbance was considered to be the dominant ear; and the hemisphere opposite to this formed the dominant hemisphere. In normals, Tsunoda observed a difference of 5 dB between the two ears. 0 dB indicated no dominant tendency. For non-verbal sounds like buzzer sound, white noise and violin A sound, left ear - right hemisphere - was found to be dominant. The left hemisphere - right ear - was found to be dominant for vowel. The functional asymmetry was given in terms of dB.

Carr (1969) has studied the effect of simultaneous dichotic presentations of delayed and non-delayed feedback on oral reading.time. 36 subjects read the passage under 28 conditions of simultaneous delayed and non-delayed feedback and 4 conditions of NDAF. The four conditions of NDAF were at 70, 80, 90 and 100 dB SPL. For simultaneous delayed and NDAF condition, each of 4 NDAF reference levels combined with seven DAF levels, that is, 0 to 30 dB below the reference level in 5 dB steps. Oral reading times increased as the intensity of DAF portion signal approaches that of NDAF portion of signal.

Dichotic presentation of external NDAF, simultaneously with a dichotic presentation of DAF reveals that when DAF was within 10 dB of external applied NDAF, the reception of normal A.C. NDAF and the normal B.C. NDAF apparently was sufficiently impeded to result in speech disruption.

Tsunoda (1969) also made use of DAF as a Dichotic listening task by using key tapping technique - 1 Kc/s puretone bursts were used in a pattern of dots (.....). Meaningful morse code with either 1 Kc/s puretone or white noise as stimulus were used.

Results indicated that the cerebral hemisphere pre-dominant for speech was also predominant for simple vowel sounds and for meaningful morse code using non-verbal sounds, for the morse code operators. The cerebral hemisphere non-predominant for speech was predominant for non-verbal sounds such as 1 Kc/s tone bursts and white noise.

These studies have shown that the left hemisphere - right ear controls linguistic stimuli whereas the right hemisphere - left ear processed the non-linguistic stimuli, indicating the asymmetry of two heaispheres.

The theory that stutterers do not have cerebral dominance and that this creates a mistiming of motor impulses to the bilateral speech muscles and thus produces stuttering was first formulated by Steir (l91l) and by Sachs (1924), but it received its early acceptance through the writings of Orton (1927) and Travis (1931). R.K.Jones (1966), a neurosurgeon, was preparing to operate on four patients who had stuttered severely since childhood, but who had recently developed brain pathology. He used the Wada technique of injecting sodium amytal directly into first right and then left carotid arteries while the patient was conscious and talking. Jones found that all the four stutterers developed transient aphasia when the drug was injected into either the right or left carotid arteries, thus indicating that they had a bilateral cortical control of speech.

Studies by Guillaume, Mazars and Mazars (1957) and by Shtremel (1963) support these findings.

The downfall of Orton-Travis theory came because it was tested in terns of handedness, a peripheral and motor function and because some of its advocates blamed stuttering as a forced shift in handedness, a most irrelevant concept since hemispheric dominance does not always reflect in peripheral sidedness (Van Riper, 1971).

Recently most investigations of laterality in auditory perception have used dichotic listening technique to demonstrate that when competing messages are presented simultaneously to the two ears, persons with left hemispheric cerebral dominance will be able to recall and perceive the message presented to the right (preferred) ear better than the message presented to the other ear. For those with right cerebral dominance for speech, the reverse was found (Van Riper, 1971). These techniques have brought more importance to Orton-Travis theory.

Curry and Gregory (1969) conducted an experiment to study the performance of stutterers on dichotic listening tasks, which were thought to reflect Cerebral Dominance. 20 stutterers and 20 non-stutterers were given one monotic verbal listening task and three dichotic listening tasks. One dichotic task was verbal and two were non-verbal. The non-stuttering adults showed an expected tendency to do better with their right ear in the dichotic word task. The expected right ear superiority on the Dichotic Word Test was much less marked for the stutterers than for the non-stutterers, since 55% of the stutterers actually had higher left ear scores. The stutterers however showed no laterality effect in favour of the left hemisphere or right ear.

Tsunoda and Moriyama (1972) administered Tsunoda's Cerebral Dominance test and standard audiometry on adult stutterers with the aim of examining the central auditory mechanisms of stutterers. On the Cerebral Dominance test 79.3% of normal controls showed dominance for vowel sounds in right ear but this pattern existed for only 38.6% of the stutterers. Among stutterers 29.6% showed dominance for vowel sounds in the left ear and for non-verbal sounds in the right ear (converse from normals), while 20.5% showed dominance for both vowel and non-verbal sounds in the right ear, which is characteristic of an impaired temporal lobe on one side as in aphasia and 4.5% shoved right ear dominance. This relation had no relation to handedness. These results suggest that among stutterers there is a subgroup in which stuttering might be due to abnormal cortical functioning resulting from minimal brain damage.

Sommers, Brady and Moore (1975) conducted a study on

39 stutterers and 39 normal speakers indicating their ear preferences for dichotically presented vords and digits. A single response mode for both dichotic words and digits was selected to study speech perception. Stutterers showed significantly less of the normal right ear preference for dichotic words and digits than non-stutterers. The proportion of stutterers who failed to demonstrate a right ear preference for dichotic words was significantly greater than non-stutterers. 19% of the stutterers and none of the non-stutterers showed reversed or a left ear preference for dichotic digits. Although non-stuttering children and adults performed alike on the dichotic tasks, the right ear dichotic words scores of stuttering children were significantly smaller than those of adult stutterers. The results are related to an early notion that stuttering might be related to mixed dominance and recent evidence showing that large percentages of older stuttering children show spontaneous remission of stuttering.

Nandur (1976) developed a test to find out ear preference for music with dichotic stimuli. It had 13 events. In each event, one ear received a constant piece of tune and the other ear received the distorted version of the constant tune and two other distorted tunes, one at a time. Normals, stutterers and trained musicians were asked to find out as to which one of the 3 distorted tunes resembled the constant tune in the other ear. The results indicated that there was significant difference between the two ears for the perception of masic in normals, left ear - right hemisphere scoring higher percentages. In stutterers there was no significant difference between scores of the two ears. They did not show any clear cut ear preference for music. The study shows that stutterers performed in a different manner from that of normals.

However, contradictory evidence has been reported by Dorman and Porter (1975). In their study, 16 right-handed adult stutterers (12 males and 4 females) and 20 non-stutterers (10 males and 10 females) were presented 60 pairs of synthetic syllables - CVC-syllables - dichotically at an intensity of 75 dB SPL. The results indicated that both the male and female stutterers identified syllables presented to the right ear better than syllables to left ear. The magnitude of the right ear advantage (REA) for the stutterers as a groap was similar to that of controls as a group. The magnitude of REA for female stutterers was smaller than female control (REA). The data failed to lend support to the theory that stutterers suffer abnormality in speech lateralization.

These contradictions lead us to do more research in this area. The present study used DAF as a dichotic listening task by presenting DAF to one ear and simultaneous feedback speech to the other ear, under three time delays of 0.1 sec., 0.2 sec., and 0.3 sec. to normals and stutterers. The speech disturbances were analyzed.

CHAPTER III

METHODOLOGY

In the present study, 30 subjects were exposed to DAF speech in one or both ears and NAF speech in one or both ears. The speech changes were recorded and analyzed.

Subjects

Two groups of subjects, fifteen normals and fifteen stutterers, between the age range of 16 to 25 years were taken for this study. The normals (8 males and 7 females with the mean age of 20.2 years) vere mostly from the student population of the Institute. The stutterers (all males with the mean age of 19.5 years) were from the clinic population of All India Institute of Speech and Hearing.

Normal subjects chosen for the present study satisfied the following criteria:

1. They should have normal hearing. (Screened at 20 dB HTL, at 250 Hz, 500 Hz, 1 KHz, 2 KHz, 4 KHz and 8 KHz, using a calibrated Madsen Z070 clinical audiometer. If they did not respond at 20 dB HTL, at

any of the three test frequencies, they vere not taken for the study.)

2. They should have a minimum education of S.S.L.C. or its equivalent.

3. They should not complain of any present otological problems.

4. they should not have been exposed to DAF before.

5. They should not have any speech problem.

The stutterers were chosen on the basis of the above four criteria and they had to satisfy the definition of stuttering given in introduction.

The objective was to achieve the following conditions:

1. NAF speech to both the ears simultaneously at 95 dB SPL.

2. DAF speech to both the ears simultaneously at 95 dB SPL at 0.1 sec., 6.2 sec. and 0.3 see. delays. And

3. DAF speech to one ear at 0.1 sec., 0.2 sec. and 0.3 sec. delays and NAF speech to the other ear at 95 dB SPL simultaneously.

The above objectives were achieved by using the following instruments:

1. Ahuja hi-fi tape recorder, Model TR-6 with an extra replay head.
2. Remimotor - 1/16 H.P./watt and Rheostat
3. Gores electro-voltmeter
4. Two Arphi speech trainers
5. An Ahuja microphone and an Ampex microphone
6. TDH-39 Earphones in circumaural cushions
7. A selector switch - and
8. An Omega stop watch

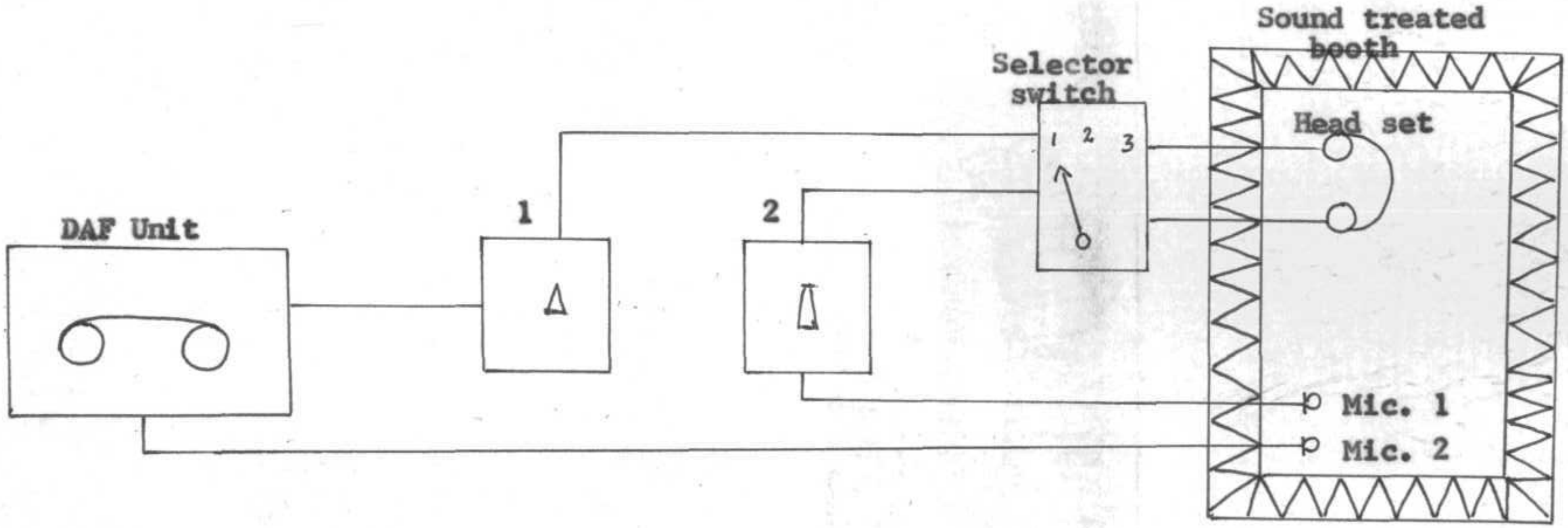
(See Appendix for details.)

A sound treated booth which fulfilled the levels prescribed for audiometric purposes was chosen for this study. The two microphones which were fixed at the same distance from the table and the earphones were kept in the sound treated booth. The other instruments were arranged outside the booth, on a table. The block diagram of the setting has been given in Figure VI.

To achieve NAF speech at 95 dB SPL, the following set UP was used:

An Ahuja microphone was connected to one of the Arphi

Figure VI - Block diagram of the experimental set up



1. Amplifier for DAF Unit
2. Amplifier for direct speech
3. Selector switch- 1 DAF to both ears
   2 NAF to both ears
   3 DAF to right ear NAF to left ear

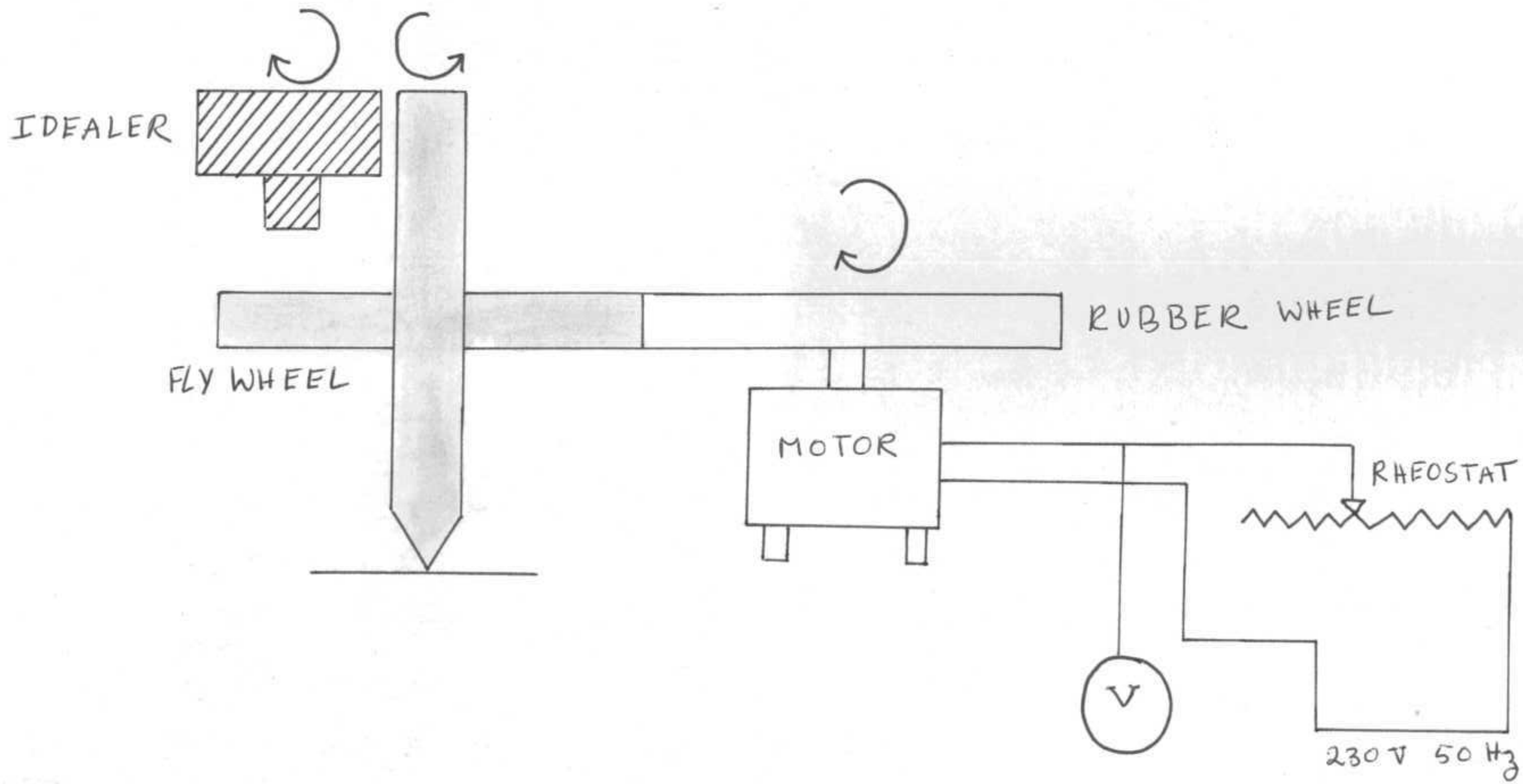


Figure VIII - Electro - Mechanical diagram for different tape speeds

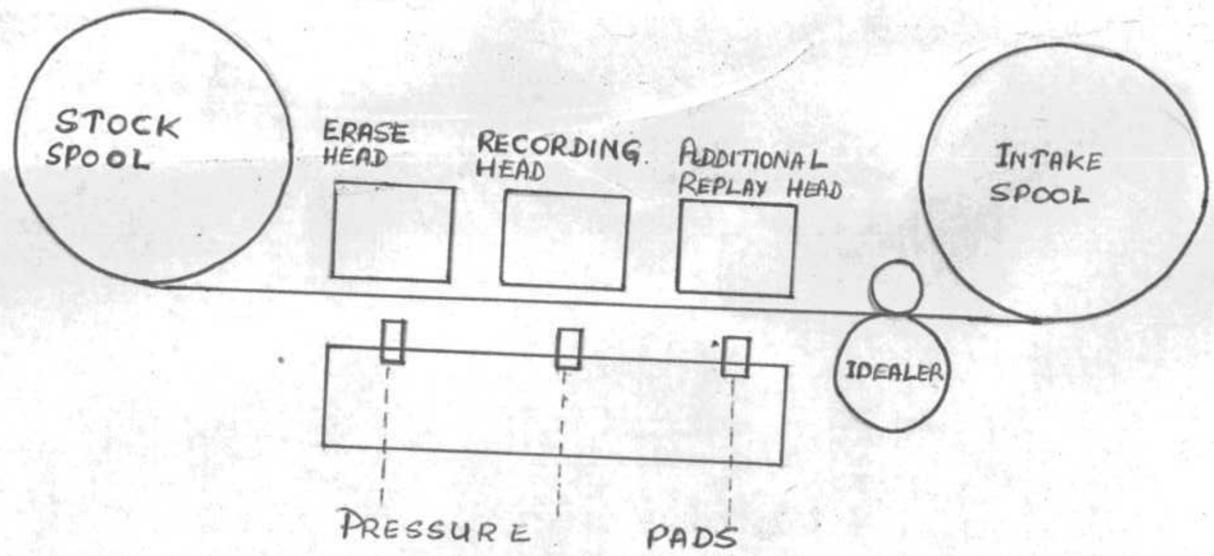
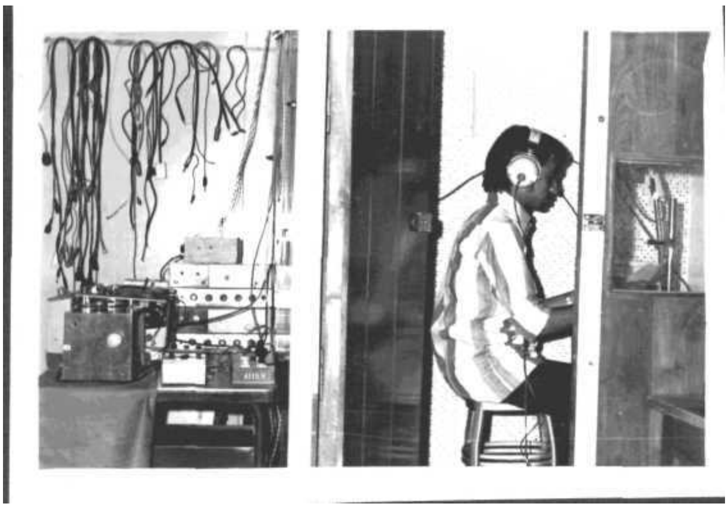


Figure VII - Recording and replay arrangements in DAF apparatus

a. Photograph showing the instruments used in this study.



b. Photograph showing the Experimental set up.

speech trainers which was used as an amplifier and the output was fed simultaneously to the earphones in the sound treated booth.

To achieve DAF speech, calibration of the time delays and calibration of intensity, the following steps were taken:

step 1

An extra motor was connected to the voltmeter from which the voltage of the motor could be read directly. The motor was also connected to a Rheostat and both were kept in a wooden box. The rubber wheel at the top of the motor was in contact with the ply wheel of the tape recorder, and this drove the idler of the tape recorder which let the tape to move at that speed. By adjusting the voltage at the motor, the speed of the tape could be varied. The speech input to the tape recorder was through the Ampex microphone, which picked up the speech and fed it to the tape recorder. The speech was recorded on a magnetic tape and it was replayed after 0.1 sec., 0.2 sec. or 0.3 sec. delays. This delayed speech was amplified to 95 dB SPL by the second Arphi speech trainer, and was fed back to the earphones. The delayed speech could be got only in the right earphone. So, for the left ear DAF - right ear NAF condition, the earphones were reversed.

Step 2

Calibration of time delays

The motor was made to run at different voltages from 60 volts to 90 volts in 5 volt steps. A magnetic tape was made to run for 30 seconds at the above voltages and the length of the tape for 30 seconds was measured in inches. The tape length for one second was calculated. The procedure was repeated six times at each voltage level to get a constant length of the tape for one second. The distance between the recording head and the replay head, that is one inch, which was kept constant throughout the study, was divided by the tape speed for one second to get the time delays.

After many repetitions of this procedure the following time delays were arrived at.

6S volts = 288 m.sec. or 0.3 sec.
70 volts = 189 m.sec. or 0.2 sec.
80 volts = 89 m.sec. or 0.1 sec.

The time delays could not be calculated more accurately; nor could they be adjusted more accurately.

Step 3

Calibration of intensity

An SPL meter (Bruel and Kjaer, Type 2203) and an artificial ear (Bruel and Kjaer, Type 4153) were used for this purpose. The right or the left earphone was placed on the artificial ear, which was connected to the SPL meter. These were kept outside the sound treated booth. A male and a female speaker were asked to phonate the sound at their habitual intensity level, in front of the microphones, at a distance of six inches. The reading of the SPL meter in linear scale was noted. The intensity knob of the Arphi speech trainer-1 was adjusted till the SPL meter showed a reading between 90 and 95 dB SPL. The same procedure was followed for fixing up the intensity level for DAF speech.

The intensity level 95 dB SPL was chosen for two reasons: (l) Previous studies had used intensity levels around 95 dB which was said to be loud enough to mask the subject's bone-conducted feedback. This had to be checked, and (2) To find out if this level was comfortable.

Five subjects were taken and they were asked to read a passage under NAF amplified conditions and under DAF amplified conditions. They were asked to report if the intensity level 95 dB SPL was comfortable enough or not and to gay if that level masked their bone-conducted feed-back of speech. The level was found to be comfortable and loud enough to mask their bone-conducted feedback.

The intensity knob positions of the two Arphi speech trainers were noted down for 95 dB SPL. The V-u meter deflection for 95 dB SPL was also noted down.

Reading Material

The reading material for this study consisted of ten passages. Several books, magazines and newspapers were checked before a long continuous passage was chosen. This was done so that ten different passages could be chosen for all conditions and they had to be of equivalent difficulty.

These English passages were read by five subjects under normal conditions. The passages were marked for one minute. The average number of lines read for one minute was taken as the standard for a one-Minute passage. Ten different one-minute passages were thus chosen from one continuous material. On an average, each passage consisted of 160 words.

Test Environment

Each subject was seated in a sound treated booth comfortably on a chair. The subject faced the two microphones at the same level, as the mouth and at a distance of six inches.

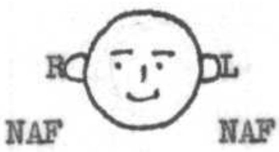
The following instructions were given to the subject:

"You will be given some passages in English to be read. Before reading them aloud, go through them and if you find any word difficult to read, please ask me. After reading each passage, please stop reading. Start only when I tell yon. These earphones will be put on your ears."

Procedure

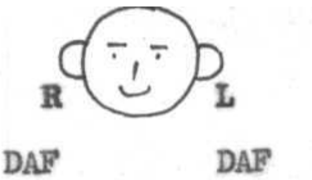
All the 30 subjects underwent the following four conditions separately.

I Condition



Intensity - 96 dB SPL, simultaneously

II Condition



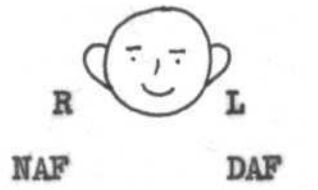
Intensity - 95 dB SPL
Time delays - 0.1 sec, 0.2 sec., and 0.3 sec.

III Condition -

Intensity - 95 dB SPL

Time delays - 0.2 sec., 0.3 sec., and 0.1 sec.

IV Condition



Time delays - 0.3 sec., 0.1 sec., and 0.2 sec.

All subjects read the same passage at a specific time delay. The ten one-minute passages were fixed for the ten different conditions.

All the subjects first underwent the first condition (R_{NAF}-L_{NAF}) and they read the first one-minute passage. The time taken to read the passage, articulatory disturbances and fluency changes were noted down.

Under DAF conditions, the subjects read the other passages, which were recorded and replayed after a time delay of 0.1 sec. or 0.2 sec. or 0.3 sec. under amplified conditions, either to one ear, with the other ear receiving NAF or to both ears simultaneously.

Different conditions were presented with the help of a selector switch.

A Balanced Latin square design was used for both the groups for II, III and IV conditions. This was done in order to rule out the order effect. The subjects were assigned to the three conditions as shown in Table II.

TABLE II

Sl. No.	Subjects 1, 4, 7, 10 and 13	Subjects 2, 5, 8, 11 and 14	Subjects 3, 6, 9, 12 and 15
1	II Condition	III Condi-tion	IV Condition
2	III Condition	IV Condi-tion	II Condition
3	IV Condition	II Condi-tion	III Condition

The time delays for the II, III and IV conditions were also given in a Balanced Latin square design as shown In Table III.

TABLE III

Sl.	$R_{DAF} - L_{DAF}$	$R_{DAF} - L_{NAF}$	$R_{NAF} - L_{DAF}$
1	0.1 sec.	0.2 sec.	0.3 sec.
2	0.2 sec.	0.3 sec.	0.1 sec.
3	0.3 sec.	0.1 sec.	0.2 sec.

In all these conditions the time taken to read the given one-minute passage was noted down by using an Omega stop watch. The other speech changes were analyzed by the investigator by listening to the same tapes which were aged to create the delayed speech. The whole testing procedure took about 30 to 40 minutes.

All the subjects were given an interval of 45 seconds between each time delay in each condition. They used the rest period to become familiar with the next passage to be read.

Analysis of speech errors was done by listening to the tapes as many times as the investigator wanted to. In normals, the number of repetitions, hesitations, prolongations, substitutions, additions and omissions of sounds, syllables, words or phrases were noted down. stutterers, the number of repetitions, hesitations, substitutions, additions, and omissions of sounds, syllables, words or phrases were noted down. Suitable statistical procedures were applied and analysis of the data was

CHAPTER IV

RESULTS AND DISCUSSION

Two groups of subjects, 15 normals and 15 stutterers, were exposed to Normal Auditory feedback (NAF) speech to both ears, DAF to both ears, DAF to right ear with NAF to left ear, and DAF to left ear with NAF to right ear at 0.1 sec., 0.2 sec. and 0.3 sec. time delays at an intensity of 95 dB SPL. The number of speech errors made and the time taken to read the 'one minute' passage under all these conditions, formed the data.

The data was analyzed by the investigator by listening to the tapes. 270 samples of speech were analyzed for speech errors. Repetitions, hesitations, prolongations, substitutions, additions and omissions of sounds, syllables, words or phrases were noted down in the normals. A value of 'one' was given to each of the above speech errors. If some part of the word was repeated and some substituted, 'two' marks were given. In stutterers, prolongations when they were associated with effort were taken as speech errors, and uniform and easy prolongations were considered as changes towards fluency. So, only repetitions, hesitations, substitutions, additions and omissions of sounds, syllables, vords or phrases were taken as speech errors in stutterers under the DAF conditions. No effort was seen in the prolongations of stutterers under DAF. The speech errors vere counted in the same manner as in normals.

Non parametric statistics were applied to analyze the data.

Wllcoxon Matched-Pairs Signed-Ranks Test (Siegel, 1956) was used for finding out,if there was, a significant difference in speech errors and time taken, under the different conditions in the normals and in the stutterers. The Table G, given in the Appendix of "Non parametric Statistics for the Behavioral Sciences" by Siegel, S., was referred for 'T' values.

Kolmogorov-Smirnov two-sample test (Siegel, 1956) was used for comparing normals and stutterers under different conditions for speech errors and durations of reading.

Friedman's test (Conovor, 1971) for related samples was used to see if there were significant differences across the ten different conditions, in the normals and in the stutterers. This test was also used to find an optimal delay for maximum speech disruption in the normals, and to find an optimal delay for fluency among the stutterers.

The data for all items are given in the Appendix A.

SPEECH ERRORS

Normals

Table IV gives the mean and S.D. values for the number of speech errors in normals under -

1. NAF to both ears condition (R_{NAF}-L_{ANF})
2. DAF to both ears condition (R_{DAF}-L_{DAF})
3. DAF to Right ear - NAF to Left ear condition (R_{DAF}-L_{NAF}) - and
4. DAF to Left ear - NAF to Right ear condition (L_{DAF}-R_{NAF})

   at 0.1., 0.2 sec. and 0.3 sec delays.

The mean values shoved that the mean speech errors are highest at 0.2 sec. delay when delay was given to both ears and least in NAF to both ears condition.

The speech errors at 0.1 sec., 0.2 sec. and 0.3 sec. delays under R_{DAF}- L_{NAF} condition were compared with speech

TABLE IV

Mean and S.D values for Speech Errors in Normals

Sl. No.	Value	NAF	R_{DAF}-L_{DAF}			R_{DAF}-L_{NAF}			L_{DAF}-R_{NAF}		
			0.1	0.2	0.3	0.1	0.2	0.3	0.1	0.2	0.3
1	Mean	2.53	19.96	20.40	17.60	12.26	15.00	11.26	10.06	8.13	8.86
2	S.D.	2.85	12.49	11.70	11.79	7.61	10.53	8.60	5.09	4.69	4.35

Note: 0.1, 0.2 and 0.3 are time delays in seconds

errors at 0.1 sec., 0.2 sec. and 0.3 sec. delays under L_{DAF}-R_{NAF} condition separately to test the following hypotheses.

Hypothesis 1.a

There would be no significant difference in speech errors between RDAF-LNAF and LDAF-RNAF condition in normals.

H_1 = The number of speech errors under RDAF-LNAF condition would be more than the number of speech errors made under LDAF-RNAF condition.

When RDAF-LNAF and LDAF-RNAF conditions were compared, the mean speech errors in RDAF-LNAF condition were higher than LDAF-RNAF condition at all three time delays.

The Wilcoxon Matched-Pairs Signed-Ranks Test was used. The level of significance for one-tailed test was noted down.

At 0.1 sec. delay, the observed T value 43.5, (N=15) was greater than Table G value. So, H_0, was accepted.

At 0.2 sec. delay, the observed T value 6.5, (N=14) was less than the Table G value. So, H_0 was rejected and H_1 was accepted at 0.005 level of significance.

At 0.3 sec. delay, the observed T value 21, (N=14) was less than the Table G value. So, H_0 was rejected and H_1 was accepted at 0.025 level of significance.

Under R_{DAF}-L_{NAF} condition, the speech errors were significantly more at 0.2 sec. and 0.3 sec. delays than under L_{DAF}-R_{NAF} condition.

The following hypothesis was also tested in the same way.

Hypothesis l.b

H_0 = There would be no significant difference in speech errors between RDAF-LNAF, LDAF-RNAF and RDAF-LDAF conditions.

H_1 = The number of speech errors under RDAF-LDAF condition would be more than the number of speech errors under RDAF-LNAF or LDAF-RNAF conditions.

a) RDAF-LDAF Vs RDAF LNAF at 0.1 sec., 0.2 sec. and 0.3 sec sec. delays.

At 0.1 sec. delay, the observed T value 5, (N=14) was less than Table G value. So, H_0 was rejected and H_1 was accepted.at 0.005 level of significance.

At 0.2 sec. delay, the observed T value 13, (N=13) was less than Table 6 value. So, H_0 was rejected and H_1 was accepted at 0.025 level of significance.

At 0.3 sec. delay, the observed T value 17.5, (N=14) was less than Table G value. So, H_0 was rejected and H_1 was accepted at 0.025 level of significance.

So, R_{DAF}-L_{DAF} produced significantly more speech errors than R_{DAF}-L_{NAF} condition in normals.

b) R_{DAF}-L_{DAF} Vs L_{DAF}-R_{NAF} at 0.1 sec., 0.2 sec. and 0.3 sec. delays.

At 0.1 sec. delay, the observed T value 11, (N=14) was less than Table G value. So, H_0 was rejected and H_1 was accepted at 0.005 level of significance.

At 0.2 sec. delay, the observed T value 3, (N=15) was less than Table G value. So, H_0 was rejected and H_1 was accepted at 0.005 level of significance.

At 0.3 sec. delay, the observed T value 5, (N=13) was less than Table G value. So, H_0 was rejected and H_1 was accepted at 0.005 level of significance.

Here also the R_{DAF}-L_{DAF} condition produced a significantly greater number of speech errors than the L_{DAF}-R_{NAF} condition.

Hypothesis 7

This was also tested in the same manner.

H_0 = There would be no significant difference in speech errors between NAF to both ears condition and all other DAF conditions.

H_1 = The number of speech errors under all DAF conditions would be greater than the number of speech errors under NAF.

As the observed T value was zero in all conditions, H_0 was rejected and H_1 was accepted at 0.005 level of significance.

So, DAF produced a significant speech disruption in the normals.

Hypothesis 10

This was tested using Friedman's test.

H_1 = There would be an optimal delay for maximum speech disruption among the normals, under all the DAF conditions.

As the T valaes obtained were less than the X Table values, H_0, that there would not be any significant difference among 0.1 sec., 0.2 sec. and 0.3 sec. was accepted under RDAF-LDAF and LDAF-RNAF conditions. Under RDAF-LNAF condition, 0.2 sec. delay was found to be an optimal delay for maximum speech disruption in the normals as the observed T value was greater than Table value at 0.05 level of significance.

From the results it was seen that DAF to the right ear caused more speech disturbances than DAF to the left ear, at 0.2 sec. and at 0.3 sec. delays. This might have been due to the fact that right ear - left hemisphere which is said to be the dominant hemisphere for speech was more affected than the left ear - right hemisphere under DAF conditions. So, the concept of cerebral dominance in normals, that the left hemisphere is dominant for speech was supported. This finding, using DAF as a dichotic listening task agreed with Broadbent (1954), Kimura (1960, 1961), Milner (1962), Studdert-Kennedy and Shankweiler (1970) and many others who have used dichotic listening tests to find out dominance.

This finding agreed with Abbs and Smith (1970) finding, where delay to the right ear caused more speech disturbance than delay to the left ear. The disturbance was significant at 0.2 sec. ana 0.3 sec. delays as in the present study. DAF was used as a dichotic task with masking noise in the other ear.

The present findings agreed with Tgunoda's (1960) study, where DAP was used as a dichotic listening task with vowels or meaningful Morse code in one ear and the other ear receiving non-linguistic stimuli like 1 kc/s tone or white noise. The dominant left hemisphere for speech was also dominant for vowel sounds.

DAF to both the right and the left ears caused more speech disturbance, than DAF to the right ear or the left ear with NAF to the other ear. Binaural DAF caused more speech disturbance than monaural DAF. It might have been because of the NAF speech given to the other ear, simultaneously, which might have counteracted the DAF, thus reducing the speech disturbance.

An optimal delay for maximum speech disruption was found to be at 0.2 sec. delay. This delay time agreed with the findings of Fairbanks (1955), Fairbanks and Guttmann (1958) and Chase, et al, (1958). But this optimal delay existed only under RDAF-LNAF condition, which was contradictory to the earlier studies, where they had used binaural DAF and had arrived at 0.2 sec. as optimal delay.

There was a significant difference between the NAF condition and all DAF conditions, the DAF conditions resulted in significantly greater number of speech errors. This agreed with Lee (1950), Black (1951), Fairbanks (1955] Fairbanks and Guttmann (1958) and all other DAF studies done with normals.

Stutterers

The mean and S.D. values for speech errors under NAF and all DAF conditions for stutterers are given in Table V.

Uniform and 'easy' prolongations were considered as fluency and release from stuttering. These were not taken as speech errors.

The values in the Table revealed that the highest mean speech error was at 0.2 sec. delay under RDAF-LDAF conditic and the least under 0.3 sec. delay in RDAF-LNAF condition.

The mean speech errors under RDAF-LNAF condition at 0.1 sec. and at 0.2 sec. delays were greater than the mean speech errors under LDAF-RNAF condition at 0.1 sec, and at

TABLE V

Mean and S.D. values for Speech Errors in Stutterers

Sl. No.	Value	NAF	RDAF-LDAF			RDAF-LNAF			LDAF-RNAF		
			0.1	0.2	0.3	0.1	0.2	0.3	0.1	0.2	0.3
1	Mean	12.13	10.06	13.13	10.80	9.73	9.66	7.73	8.13	9.00	8.33
2	S.D.	6.32	6.85	4.89	3.16	4.89	4.24	3.87	3.87	3.74	4.12

Note: 0.1, 0.2 and 0.3 are time delays in seconds

0.2 sec.

Wilcoxon Matched-Pairs Signed-Ranks test was applied to test the following hypotheses.

Hypothesis 2.a

H_0 = There would be no significant difference in speech performance between RDAF-LNAF and LDAF-RNAF conditions in stutterers.

H_1 = The speech errors under RDAF-LNAF would be more than LDAF-RNAF condition.

At 0.1 sec. delay, the observed T value 12, (N=11) was greater than Table 0 value. So, H_0 was accepted.

At 0.2 sec. delay, the observed T value 37.5, (N=14) was greater than Table G value. So, H_0 was accepted.

At 0.3 sec. delay, the observed T value 69, (N=15) was greater than Table G value. So, H_0 was accepted.

It was seen that there was no significant difference in speech errors between RDAF-LNAF and LDAF-RNAF conditions.

Hypothesis 2.b

This was also tested in the same manner.

H_0 = There vould be no significant difference in speech performance between RDAF-LNAF, LDAF-RNAF and RDAF-LDAF conditions in stutterers.

H_1 = The number of speech errors under RDAF-LDAF condition vould be greater than the number of speech errors made under RDAF-LNAF or LDAF-RNAF conditions.

a) RDAF -LDAF Vs RDAF-LNAF at 0.1 see., 0.2 sec. and 0.3 sec. delays.

At 0.1 sec. delay, the observed T value 67, (N=15) was greater than Table G value. So, H_0 was accepted.

At 0.2 sec. delay, the observed T value 4.5, (N=14) was less than Table G value. So, H_0 was rejected and H_1 was accepted at 0.005 level of significance.

At 0.3 sec.delay. th6 observed T value 22, (N=15) was less than Table G value. So, H_0 was rejected and H_1 was accepted at 0.025 level of significance.

In stutterers also, RDAF-LDAF condition produced a significantly greater number of errors than RDAF-LNAF condition at 0.2 sec. and 0.3 sec. delays.

b) RDAF-LDAF Vs LDAF.RNAF at 0.1 sec., 0.2 sec. and 0.3 sec. delays.

At 0.1 sec. delay, the observed T value 36, (N=14) was greater than Table 6 value. So, H_0 was accepted.

At 0.2 sec. delay, the observed T value 6.5, (N=13) was less than Table G value. So, H_0 was rejected and H_1 was accepted at 0.005 level of significance.

At 0.3 sec. delay, the observed T value 23.5, (N=14) was greater than Table G value. So, H_0 was accepted.

RDAF-LDAF Condition produced a significantly greater number of speech errors than LDAF-RNAF condition at 0.2 sec. delay.

Hypothesis 8

This was also verified in the same manner.

H_0 = There would be no significant difference in speech errors between NAF to both ears condition and all other DAF conditions.

H_1 = The number of speech errors under NAF condition would be greater than the number of speech errors under all DAF conditions.

a) RNAF-LNAF Vs RDAF-LDAF at 0.1 sec., 0.2 sec. and 0.3 sec. delays.

At 0.1 sec. delay, the observed T value 33.5, (N=15) was greater than the Table G value. So, H_0 waz accepted.

At 0.2 sec. delay, the observed T value 58.5,(N=14) was greater than the Table G value. So, H_0 was accepted.

At 0.3 sec. delay, the observed T value 58, (N=14) was greater than the Table G value. So, H_0 was accepted.

RDAF-LDAF did not differ significantly from RNAF-LNAF condition.

b) RNAF-LNAF Vs RDAF-LNAF at 0.1 sec., 0.2 sec. and 0.3 sec. delays.

At 0.1 sec. delay, the observed T value 40.5, (N=14) was greater than Table G value. So, H_0 was accepted.

At 0.2 sec. delay, the observed T value 44, (N=15) was greater than Table G value. So, H_0 was accepted.

At 0.3 sec. delay, the observed T value 17, (N=13) was equal to Table 0 value at 0.025 level of significance. So, H_0 was rejected and H_1 was accepted.

RDAF-LNAF produced significantly fever speech errors than RNAF-LRAF at 0.3 sec. delay.

c) RNAF-LNAF Vs LDAF-RNAF at 0.1 sec., 0.2 sec. and 0.3 sec. delays.

At 0.1 sec. delay, the observed T value 21.5, (N=14) was greater than Table G value. So, H_0 was accepted.

At 0.2 sec. delay, the observed T value 19. (N=14) was less than Table G value. So, H_0 was rejected and H_1 was accepted at 0.025 level of significance.

At 0.3 sec. delay, the observed T value 9, (N=13) was less than Table G value. So , H_0 was rejected and H_1 was accepted at 0.005 level of significance.

LDAF-RNAF condition did produce significantly fewer speech errors than RNAF-LNAF at 0.2 sec. and 0.3 sec. delays.

Hypothesis 9

This was tested using Friedman's test.

H_1 = There would be an optimal delay for fluency in stutterers among the 3 delays used under the three different conditions.

There was no significant difference in speech errors among three delays, under the II, III and IV conditions. So, an optimal delay for fluency could not be arrived at in stutterers.

It was observed from the results that DAF to the right ear or DAF to the left ear with NAF to the other ear, did not make a significant difference in the number of speech errors. Even though RDAF-LNAF condition caused more speech disturbance than LDAF-RNAF condition the magnitude of difference was not significant. This finding was similar to that of Curry and Gregory (1969) who had used a dlchotic word task with stutterers. The concept of cerebral dominance comes into the picture and stutterers do not seea to have a clear cut dominance for speech like normals.

When RDAF-LDAF condition was compared with RDAF-LNAF condition, a significant difference was seen at 0.2 sec. and 0.3 sec delays, the DAF to both ears condition having significantly more speech errors than RDAF-LNAF. At 0.1 sec. delay RDAF-LNAF might be as effective as RDAF-LDAF. Again, when delay to both ears condition was compared with LDAF-RNAF condition, a significant difference was seen only at 0.2 sec. delay. The optimal delay for normals, in speech disruption might be the same for stutterers under

R_{DAF}-L_{DAF} condition. This delay did not bring about reduction in speech errors, as given by the other authors.

Generally, a reduction in stuttering is said to take place under DAF, for stutterers. It was observed that when speech errors were tabulated on the basis of severity (Table VI), the stutterers having 5 blocks under NAF would increase their blocks to 25 or more. The table showed clearly that severity of the problem was an important factor. The severe stutterers (for example, having 25 blocks under NAF) showed a reduction in their stuttering blocks to 3 or 5 under DAF conditions. So, mild stutterers behaved like normals and in severe stutterers there was a reduction in stuttering behaviour.

Stutterers' speech behaviour under RDAF-LDAF condition was not significantly different from RNAF-LNAF condition. This did not agree with the Nessel (1958), the Soderberg (1959) and the Lotzmann (l96l) findings, where they observed a reduction in stuttering under DAF. This lack of difference might have been because of the high variability seen in the group of stutterers.

A significant difference between R_{NAF}-L_{NAF} and R_{DAF}-L_{NAF} was found only at 0.3 sec. delay. Here, there

TABLE VI

Differences in number of Speech Errors between NAF and DAF condition in Stutterers (arranged according to severity)

Sl. No.	Ss	NAF	RDAF-LDAF			RDAF-LNAF			LDAF-RNAF		
			0.1	0.2	0.3	0.1	0.2	0.3	0.1	0.2	0.3
1	As	5	+24	+12	+ 7	+ 3	+ 3	+ 5	+ 3	0	+ 1
2	Ms	5	+ 1	+11	+ 1	- 1	+ 4	+ 5	+ 5	0	+ 4
3	Os	5	- 2	- 3	+ 1	- 1	+ 1	0	- 1	+ 1	+ 2
4	Js	6	+ 6	+ 8	+ 6	+ 2	+ 3	+ 3	+ 2	+ 1	+ 2
5	Ks	8	+ 6	+ 8	+ 2	+ 4	+6	+ 3	+ 2	+ 1	0
6	Is	9	- 8	- 1	+ 2	- 5	- 3	- 2	- 4	- 6	- 4
7	Ds	10	- 7	0	+18	- 2	- 3	-5	- 7	- 2	- 7
8	Ms	11	- 5	+10	0	- 2	- 2	- 8	- 2	+ 4	4
9	Hs	12	- 2	+ 7	+ 2	+ 6	+ 8	0	- 4	+ 8	- 1
10	Es	15	- 5	- 2	- 1	- 7	- 8	-13	- 8	- 6	0
11	Gs	15	- 4	- 2	- 6	+ 3	- 1	- 9	0	- 2	-12
12	Cs	17	- 1	- 4	- 7	- 2	- 3	- 3	- 4	- 5	- 1
13	Fs	19	- 9	- 7	-11	-10	-13	-14	-14	-12	-11
14	Bs	21	- 7	-11	-10	- 5	- 9	-11	- 6	-10	- 8
15	Ls	25	-18	-15	-15	-19	-20	-20	-22	-15	-14

Note: 0.1, 0.2 and 0.3 are time delays in seconds

vas a significant reduction in the speech errors. This delay might facilitate the stutterers fluency under DAF.

There vas a significant difference between RNAF-LNAF and LDAF-RNAF at 0.2 sec. and 0.3 sec. delays, bringing about a reduction in the stuttering behaviour. This is just the reverse of what is observed in the normals. This finding agreed with the findings of Lotzman (l96l), Nersel (1958) and Soderberg (1959), who reported DAF to be fluency facilitating.

Even though DAF in a dichotic condition, with speech as stimuli has not been used with stutterers previously, this study could be compared with the other studies which have used DAF tapping for a dichotic task or other dichotic word tasks to evaluate cerebral dominance.

The present observations do not agree with Tsunoda and Moriyama (1972), who used DAF tapping test as a measure of finding out cerebral dominance. They found a reversal in dominance with stutterers getting higher scores in the left ear than in the left ear for vowels. Sommers et al. (1975) also found 18% of their 39 stutterers had left ear preference for a dichotic word test. In the present study such reversals were not found. There was no significants difference between the two ears in performance showing that there was no clear cut dominance in the stutterers. This did not go along with the Porter and Dorman (1975) finding also, as they found a significant right ear advantage for synthetic consonants presented dichotically in stutterers.

The present findings agreed with Nandur's (1976) observations, who used music, a non-linguistic stimulus, dichotically to find out ear preference, and thus dominance for music. In stutterers, he did not find a significant difference between the right ear and the left ear scores of the test.

Normals Vs Stutterers

Normals and stutterers were compared on the number of speech errors made under all the DAF conditions. Kolmogorov-Smirnov two-sample test was used for this.

Hypothesis 3 was tested using this method.

H_0 = Normals and stutterers would not differ significantly in speech performance on DAF.

H_1 = Normals have more speech errors under all DAF conditions than stutterers under the same conditions.

The differences in speech errors between RNAF-LNAF and t' -

all other DAF conditions were found for normals and stutterers. This was used for comparison.

As K values were found to be equal to or higher than, '7' at 0.05 level of significance or '9' at 0.01 level of significance (from Table L, Siegel, 1956) in all conditions, Hp was rejected and H^ was accepted. Normals did have significantly greater speech errors than stutterers under DA?.

The present observations do not agree with Nelley (1961), Ham and Steer (1967) and Logue (1962) findings. They also compared normals and stutterers on DAF under different time delays and varied types of speech errors and found no significant differences between the groups. But it is difficult for direct comparisons to be made as these studies have used different experimental designs and have studied different variables. }

Nessel (1958) found substantial differences between the speech patterns of normals and stutterers on DAF. Stutterers made fewer errors under DAF.

The stutterers like normals had more speech errors under RDAF-LNAF condition than under LDAF-RNAF condition, but the magnitude of difference was not significant. So, this lends support to the concept that cerebral dominance is very clear in normals and is not so clear cut among stutterers.

In all, DAF to both ears condition was more effective than the other conditions in normals and stutterers. DAF to right ear with NAF to left ear was more effective than DAF to left ear. In some, RDAF-LNAF condition became as effective as DAF to both ears. LDAF-RNAF condition seemed to be the least disturbing both in the stutterers and in the normals.

Table VII gives a complete picture of speech errors in normals and stutterers.

Graph I shows the mean speech errors in normals and in stutterers under all conditions.

Time taken to read the 'one minute' passage

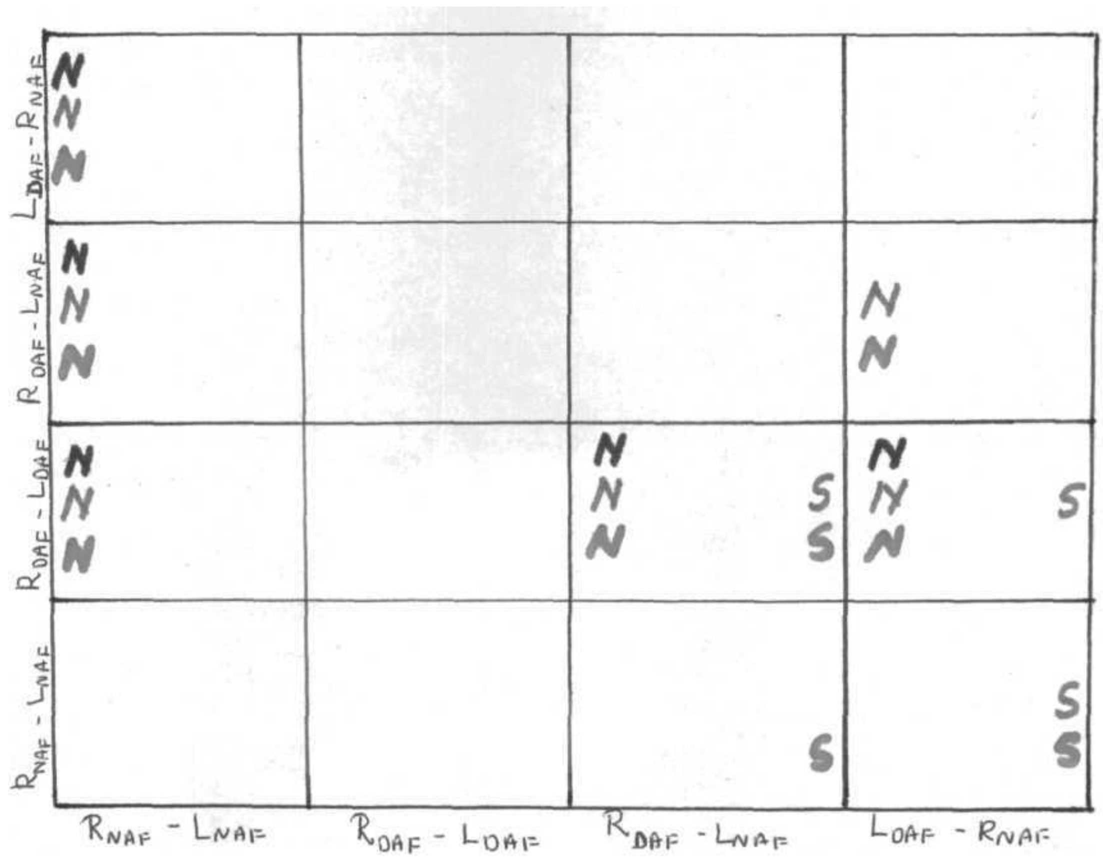
Normals

The mean and S.D. values are shown in Table VIII.

Wilcoxon Matched-Pairs Signed-Ranks test was used to find out if there was any significant difference in the time taken to read the passage under different conditions.

Table VII

Results of Speech errors in normals and in stutterers



N,S - 0.1 sec.
N,S - 0.2 sec.
N,S - 0.3 sec.

N means significant difference in speech errors between two conditions with speech errors on vertical line being greater than speech errors on horizontal line, in normals.

S means significant difference in speech errors between two conditions with speech errors on vertical line being greater than speech errors on horizontal line, in stutterers.

Graph I - showing the Mean Speech Errors in Normals and Stutterers

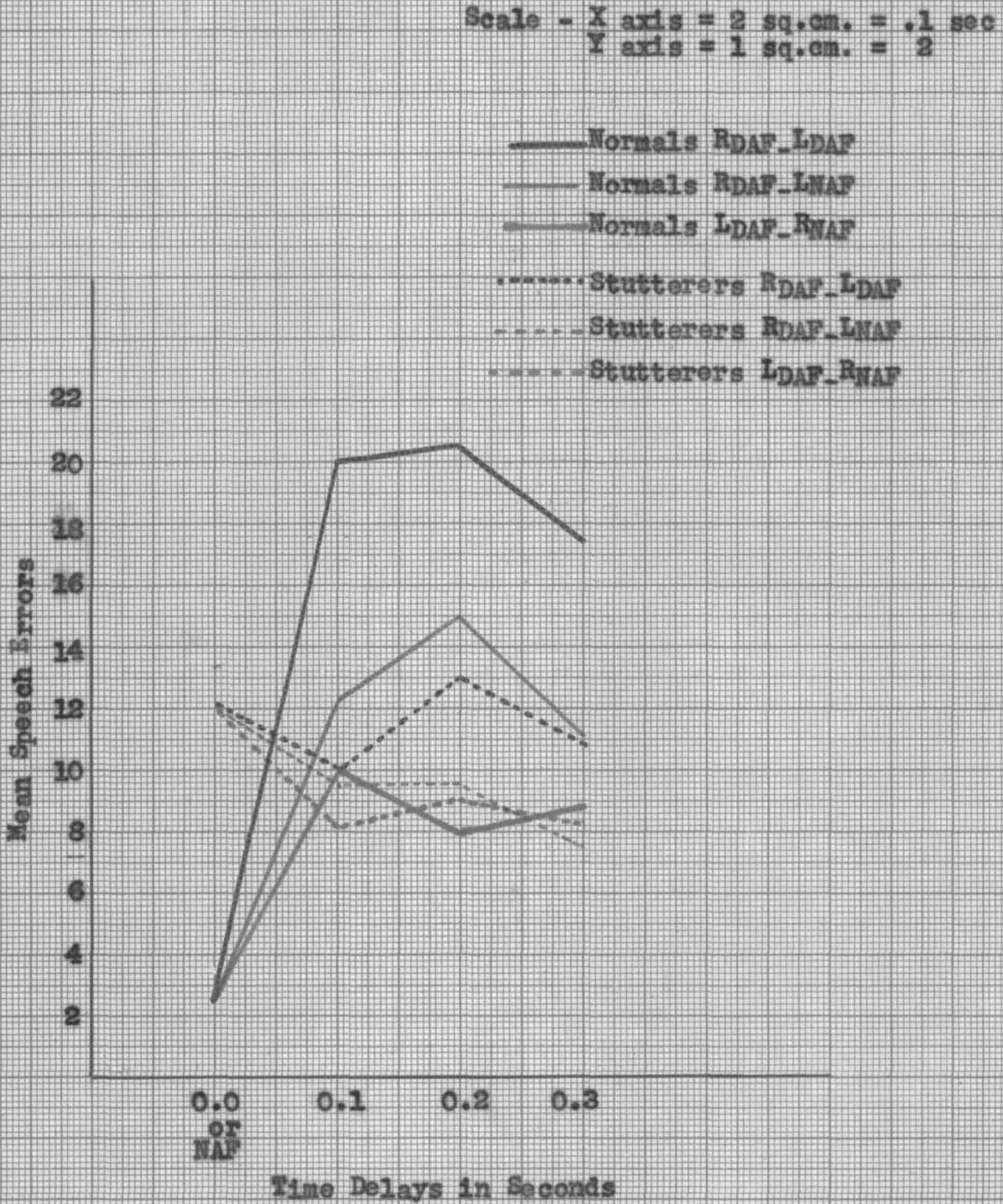


TABLE VIII

Mean and S.D. values for time taken to read the 'one minute' passage in Normals

Sl. No.	Value	NAF	R_{DAF}-L_{DAF}			R_{DAF}-L_{NAF}			L_{DAF} - R_{NAF}		
			0.1	0.2	0.3	0.1	0.2	0.3	0.1	0.2	0.3
1	Mean	60.8 sec.	72.30 sec.	77.00 sec.	77.30 sec.	69.9 sec.	73.5 sec.	67.1 see.	63.4 sec.	65.7 sec.	68.0 see.
2	S.D.	7.14	12.08	18.86	16.21	15.55	13.26	13.15	9	9.89	10.24

Note: 0.1, 0.2 and 0.3 are time delays in seconds

Hypothesis 4.a

This was tested as follows:

H_0 = There would be no significant difference in time taken to read the 'one minute' passage between R_{DAF}-L_{NAF} and L_{DAF}-R_{NAF} conditions in normals.

H_1 = The time taken to read under R_{DAF}-L_{NAF} would be more than under L_{DAF}-R_{NAF} condition.

At 0.1 sec. delay, the observed T value 1.5, (N=14) was less than Table G value. So, H_0 was rejected and H_1 was accepted at 0.005 level of significance.

At 0.2 sec. delay, the observed T value zero, (N=15) was less than Table G value. So, H_0 was rejected and H_1 was accepted at 0.005 level of significance.

At 0.3 sec. delay, the observed T value 47.5, (N=14) was greater than Table G value. So, H_0 was accepted.

At 0.1 sec. and 0.2 sec. delays, normals took more time to read under R_{DAF}-L_{NAF} condition than under L_{DAF}-R_{NAF}.

Hypothesis 4.b

This was tested as follows.

H_0 = There would be no significant difference in time taken to read the 'one minute' passage between R_{DAF}-L_{DAF}, R_{DAF}-L_{NAF} and L_{DAF}-R_{NAF} conditions

H_1 = The time taken to read the 'one minute' passage would be more under R_{DAF}-L_{DAF} condition than under R_{DAF}-L_{NAF} or L_{DAF}-R_{NAF}.

a) R_{DAF}-L_{DAF} Vs R_{DAF}-L_{NAF} at 0.1 sec., 0.2 sec. and 0.3 see. delays.

At 0.1 sec. delay, the observed T value 32.5, (N=15) was greater than Table G value. So, H_0 was accepted.

At 0.2 sec. delay, the observed T value 63.0, (N=14) was greater than Table G value. So, H_0 was accepted.

At 0.3 sec. delay, the observed T value 10.5, (N=14) was le$s than Table G value. So, H_0 was rejected and H_1 was accepted at 0.005 level of significance.

Under RDAF-LDAF condition, normals took more time to read at 0.3 sec. and 0.2 sec. delay than under R_{DAF}-L_{NAF} condition.

b) R_{DAF}-L_{DAF} Vs L_{DAF}-R_{NAF} at 0.1 sec., 0.2 sec. and 0.3 sec. delays.

At 0.1 sec. delay, the observed T value 5, (N=13) was less than Table G value. So, Ho was rejected and H_1 was accepted at 0.005 level of significance.

At 0.2 sec. delay, the observed T value zero, (N=13) vas less than Table G value. So, H_0 was rejected and H_1 was accepted at 0.005 level of significance.

At 0.3 sec. delay, the observed T value 13.5, (N=15) was less than Table G value. So, H_0 was rejected and H_1 was accepted at 0.005 level of significance.

Normals took a longer time to read under R_{DAF}-L_{DAF} condition at 0.1 sec., 0.2 sec. and 0.3 sec. delays than under L_{DAF}-R_{NAF}.

It was also tested if there would be any significant difference in the time taken to read the 'one minute passage between NAF and the DAF conditions.

H_1 = The time taken to read the 'one minute' passage under all conditions of DAF would be more than the time taken under NAF condition.

t

a) R_{NAF}-L_{NAF} Vs R_{DAF}-L_{DAF} at 0.1 sec., 0.2 sec. and 0.3 sec. delays.

At 0.1 sec. delay, the observed T value 1, (N=14) was less than Table G value. So, H_0 was rejected and H_1 was accepted at 0.006 level of significance.

At 0.2 sec. delay, the observed T value 3, (N=14) was less than Table G value. So, H_0 was rejected and H_1 was accepted at 0.005 level of significance.

At 0.3 sec. delay, the observed T value 5, (N=15) was less than Table G value. So, H_0 was rejected and H_1 vas accepted at 0.005 level of significance.

Under R_{DAF}-L_{DAF} condition, normals took more time to read than under R_{NAF}-L_{NAF} condition.

b) R_{NAF}-L_{NAF} Vs R_{DAF}-L_{NAF} at 0.1 sec., 0.2 sec. and 0.3 sec. delays.

At 0.1 sec. delay, the observed T value 3.5, (N=15) was less than Table G value. So, H_0 was rejected and H_1 was accepted at 0.005 level of significance.

At 0.2 sec. delay, the observed T value zero, (N=15) was less than Table G value. So, H_0 was rejected and H_1 was accepted at 0.005 level of significance.

At 0.3 sec. delay, the observed T value 12, (N=13) was less than Table G value. So, H_0 was rejected and H_1 was accepted at 0.025 level of significance.

Normals took more time to read under R_{DAF}-L_{NAF} at 0.1 sec., 0.2 sec. and 0.3 sec. delays than under R_{NAF}-L_{NAF}.

c) R_{NAF}-L_{NAF} Vs L_{DAF}-R_{NAF} at 0.1 sec., 0.2 sec. and 0.3 sec. delays.

At 0.1 sec. delay, the observed T value 39, (N=14) was greater than Table G value. So, H_0, was accepted.

At 0.2 sec. delay, the observed T value 19.5, (N=14) was less than Table G value. So, H_0 was rejected and H_1 was accepted at 0.025 level of significance.

At 0.3 sec. delay, the observed T value 14, (N=15) was less than Table G value. So, H_0 was rejected and H_1 was accepted at 0.005 level of significance.

Normals took more time to read the passage under L_{DAF}-R_{NAF} condition at 0.2 sec. and 0.3 see. delays than under R_{NAF}-L_{NAF} condition.

Stutterers

Table IX gives the mean and S.D. values of time taken to read the 'one minute' passage under different conditions

TABLE IX

Mean and S.D. values for time taken to read the 'one minute' passage in Stutterers

Sl. No.	Value	NAF	R_{DAF}-L_{DAF}			R_{DAF}-L_{NAF}			L_{DAF}-R_{NAF}		
			0.1	0.2	0.3	0.1	0.2	0.3	0.1	0.2	0.3
1	Mean	89.4 sec.	92.2 sec.	103.4 sec.	100.5 sec.	89.6 sec.	96.4 sec.	90.2 sec.	81.8 sec	86.5 sec.	91.3 see.
2	S.D	37.87	21.86	28.77	27.51	22.97	32.45	26.68	18.92	24	25.02

Note: 0.1, 0.2 and 0.3 are time delays in seconds

by stutterers.

Wilcoxon Matched-Pairs Signed-Ranks test was used to test the following hypotheses in stutterers.

Hypothesis 5.a

H_0 = There would be no significant difference in the time taken to read the 'one minute' passage between R_{DAF}-L_{NAF} and L_{DAF}-R_{NAF} conditions.

H_1 = The time taken to read the passage under R_{DAF}-L_{NAF} would be more than the time taken under L_{DAF}-R_{NAF} condition.

At 0.1 sec. delay, the observed T value 14, (N=15) was less than Table G value. So, H_0 was rejected and H_1 was accepted at 0.005 level of significance.

At 0.2 sec. delay, the observed T value 9.5, (N=14) was less than Table G value. So, H_0 was rejected and H_1 was accepted at 0.005 level of significance.

At 0.3 sec. delay, the observed T value 50, (N=14) was greater than Table G value. So, H_0 was accepted.

Stutterers took more time to read under R_{DAF}-L_{NAF} condition than under L_{DAF}-R_{NAF} condition at 0.1 sec. and 0.2 sec. delays.

Hypothesis 5.b

This was tested as follows.

H_0 = There would be no significant difference in time taken to read the 'one minute' passage between R_{DAF}-L_{DAF} L_{DAF}-R_{NAF} and R_{DAF}-L_{NAF} conditions.

H_1 = The time taken to read the passage would be more under R_{DAF}-L_{DAF} condition than under R_{DAF}-L_{NAF} or L_{DAF}-R_{NAF}.

a) R_{DAF}-L_{DAF} Vs R_{DAF}-L_{NAF} at 0.1 sec., 0.2 sec. and 0.3 sec. delays.

At 0.1 sec. delay. the observed T value 59.6, (N=14) was greater than Table G value. So, H_0 was accepted.

At 0.2 sec. delay, the observed T value 34, (N=15) was greater than Table G value. So, H_0 was accepted.

At 0.3 sec. delay, the observed T value 20, (N=15) was equal to Table G value. So, H_0 was rejected and H_1 was accepted at 0.025 level of significance.

Stutterers did not perform significantly differently in the two conditions except at 0.3 sec. delay.

b) R_{DAF}-L_{DAF} Vs L_{DAF}-R_{NAF} at 0.1 sec, 0.2 sec. and 0.3 sec. delays.

At 0.1 sec. delay, the observed T value 16.5, (N=15) was less than Table G value. So, H_0 was rejected and H_1 was accepted at 0.025 level of significance.

At 0.2 sec. delay, the observed T value 3, (N=14) was less than Table G value. So, H_0 was rejected and H_1 was accepted at 0.005 level of significance.

At 0.3 sec. delay, the observed T value 10, (N=14) was less than Table G value. So, H_0 was rejected at 0.025 level of significance and H_1 was accepted.

Stutterers took significantly more time to read the passage under RDAF-LDAF than under L_{DAF}-R_{NAF} at all the 3 time delays.

It was necessary to find out, if there were any significant difference in the time taken to read the 'one minute' passage between R_{NAF}-L_{NAF} and the DAF conditions.

H_1 = The time taken to read under all DAF conditions would be more than the time taken under R_{NAF}-L_{NAF}.

a) R_{NAF}-L_{NAF} Vs R_{DAF}-L_{DAF} at 0.1 sec, 0.2 sec. and 0.3 sec. delays.

At 0.1 sec. delay, the observed T value 39.5, (N=14) was greater than Table G value. So, H_0, was accepted.

At 0.2 sec. delay, the observed T value 22.5, (N=15) was less than Table G value. So, H_0 was rejected and H_1 was accepted at 0.025 level of significance.

At 0.3 sec. delay, the observed T value 26, (N=14) was greater than Table G value. So, H_0 was accepted.

Stutterers did not perform significantly differently under the two conditions except at 0.2 sec. delay.

b) R_{NAF}-L_{NAF} Vs R_{DAF}-L_{NAF} at 0.1 see., 0.2 see. and 0.3 sec. delays.

At 0.1 sec. delay, the observed T value 30, (N=15) was greater than Table G value. So, H_0 was accepted.

At 0.2 sec. delay, the observed T value 16, (N=15) was less than Table G value. So, H_0 was rejected and H_1 was accepted at 0.005 level of significance.

At 0.3 sec. delay, the observed T value was 42.5 (N=14) was greater than Table G value. So, H_o was accepted.

Under R_{DAF}-L_{NAF} condition stutterers did aot differ significantly from R_{NAF}-L_{NAF} condition except at 0,2 sec. delay.

c) R_{NAF}-L_{NAF} Vs L_{DAF}-R_{NAF} at 0.1 sec., 0.2 sec. and 0.3 sec. delays.

At 0.1 sec. delay, the observed T value 57, (N=15) which vas greater than the Table G value. So, H_0 was accepted.

At 0.2 sec. delay, the observed T value 41.5, (N=14) was greater than Table G value. So, H_0 was accepted.

At 0.3 sec. delay, the observed T value 26.6 (N=4) was greater than the Table G value. So, H_o was accepted.

Stutterers did not differ significantly between these conditions under all the 3 time delays.

Normals Vs Stutterers

The normals and stutterers were compared under all the different conditions using Kolmogorov-Smimov two-sample test.

Hypothesis 6

H_o = Normals and stutterers did not differ significantly in the time taken to read the passage under all the conditions.

H_1 = Stutterers would take more time than the normals to read the passage under all DAF conditions.

The K values were equal to or greater than '7' at 0.06 level of significance (for one tailed test) for the following conditions: under RDAF-LDA? at 0.2 sec. and 0.3 sec. delays, under R_{DAF}-L_{NAF} at 0.1 sec., 0.2 sec. and 0.3 sec. delays and under L_{DAF}-R_{NAF} at 0.1 sec., 0.2 sec. and 0.3 sec delays. So, H_0 was rejected at 0.05 level of significance and H_1 was accepted at the above conditions.

It was observed from the results that in normals, delay to the right ear made them take more time to read the passage than delay to the left ear condition at 0.1 sec. and 0.2 sec. delays. This was associated with an increase in speech errors.

This finding did not agree with Abbs and Smith's study where they did not find any significant difference in time taken to read the passage between delay to right or left condition.

The above observation in normals again brings us to cerebral dominance. The fact that the right ear - left hemisphere - control speech is supported as delay to the right ear resulted in a longer duration in reading.

This significant difference between R_{DAF}-L_{NAF} and

L_{DAF}-R_{NAF} condition at 0.1 aec. and 0.2 sec. delays was observed in stutterers also. In stutterers also, this was associated with a change in speech errors.

Normals and stutterers behave similarly under these conditions.

When R_{DAF}-L_{DAF} was compared with R_{DAF}-L_{NAF} condition in normals and in stutterers, there was no significant difference at 0.1 sec. and 0.2 sec. delays, showing that delay to the right ear was as effective as delay to both the ears condition. At 0.3 sec. delay there was a significant difference in time taken between these conditions both in normals and in stutterers.

When R_{DAF}-L_{DAF} was compared with L_{DAF}-R_{NAF} at 0.1 sec, 0.2 sec. and 0.3 sec delays, both normals and stutterers showed a significant difference between both the conditions. They took more time to read under delay to both ears condition than under L_{DAF}-R_{NAF}, L_{DAF}_R_{NAF} condition did not seem to be as effective as the other conditions.

This again reflected on dominance which seemed to be clear cut in normals. In stutterers also, dominance tended to resemble the normals.

When R_{NAF}-L_{NAF} condition was compared with delayed R_{DAF}-L_{DAF} condition at 0.1 sec., 0.2 sec. and 0.3 sec. delays, there was a significant difference in normals with delay to both ears leading to more reading time than R_{NAF}-L_{NAF} condition. In stutterers this difference was significant only at 0.2 sec. delay.

The observation that normals took significantly more time to read under DAF agreed with Fairbanks (1955). Fairbanks and Guttmann (1958), Chase et al (1958, 1959), who also observed longer duration, change in inter-syllable time and increase in the normals under DAF.

When R_{DAF}-L_{NAF} was compared with R_{NAF}-L_{NAF} again & significant difference was found in normals at all time delays. This showed that R_{DAF}-L_{NAF} condition was an effective condition and the subjects took longer time to read the passages under this condition. In stutterers, a significant difference was seen only at 0.2 sec. delay. This might be an optimum delay for stutterers also to bring about more change.

When L_{DAF}-R_{NAF} condition was compared with R_{NAF}-L_{NAF} condition, no significant difference was found in normals and in stutterers except at 0.3 sec. delay in normals. This showed that delay in left ear was similar to R_{RAF}-L_{NAF}

.condition without bringing about much disturbance.

In stutterers, the increase in reading time might have been due to the easy and uniform prolongations observed.

Ham and Steer (1967) and Logue (1962) who compared normals and stutterers did find an increase in total reading time in both groups under DAF.

Normals and stutterers did differ significantly with stutterers taking more time than the normals.

Table X shows the results of time taken to read the 'one minute' passage in normals and in stutterers.

Graph II shows the mean time values under each condition in normals and in stutterers.

The following were the other observations which were made during the analysis of the results, but which vere not studied in detail

1. <u>Types of speech errors</u>

Table XI gives the total number and mean values of different types of speech errors in the normals. In the normals, the number of repetitions were the least (M=2) during the NAF condition. They were maximum at 0.3 sec.

TABLE X

Results of time taken to read the 'one minute' passages in Normals and Stutterers

	$R_{NAF}-L_{NAF}$	$R_{DAF}-L_{DAF}$	$R_{DAF}-L_{NAF}$	$L_{DAF}-R_{NAF}$
$R_{NAF}-L_{DAF}$	N N N			
$R_{DAF}-L_{NAF}$	N N N S			N N S S
$R_{DAF}-L_{DAF}$	N N N 6		N S	N N N S S S
$R_{NAF}-L_{NAF}$				

N,S - 0.1

N,S - 0.2

N,S - 0.3

N - Means., significant difference in time taken to read the passage between two conditions with time taken on vertical line being greater than time taken on horizontal line, in Normals.

S - Means, significant difference in time taken to read the passage between two conditions with time taken on vertical line being greater than time taken on horizontal line in Stutterers.

Graph II - showing the Mean Time taken to read the 'one minute' passage in Normals and Stutterers

Scale - X axis = 2 sq.cm. = .1 sec
Y axis = 1 sq.cm. = 5 sec

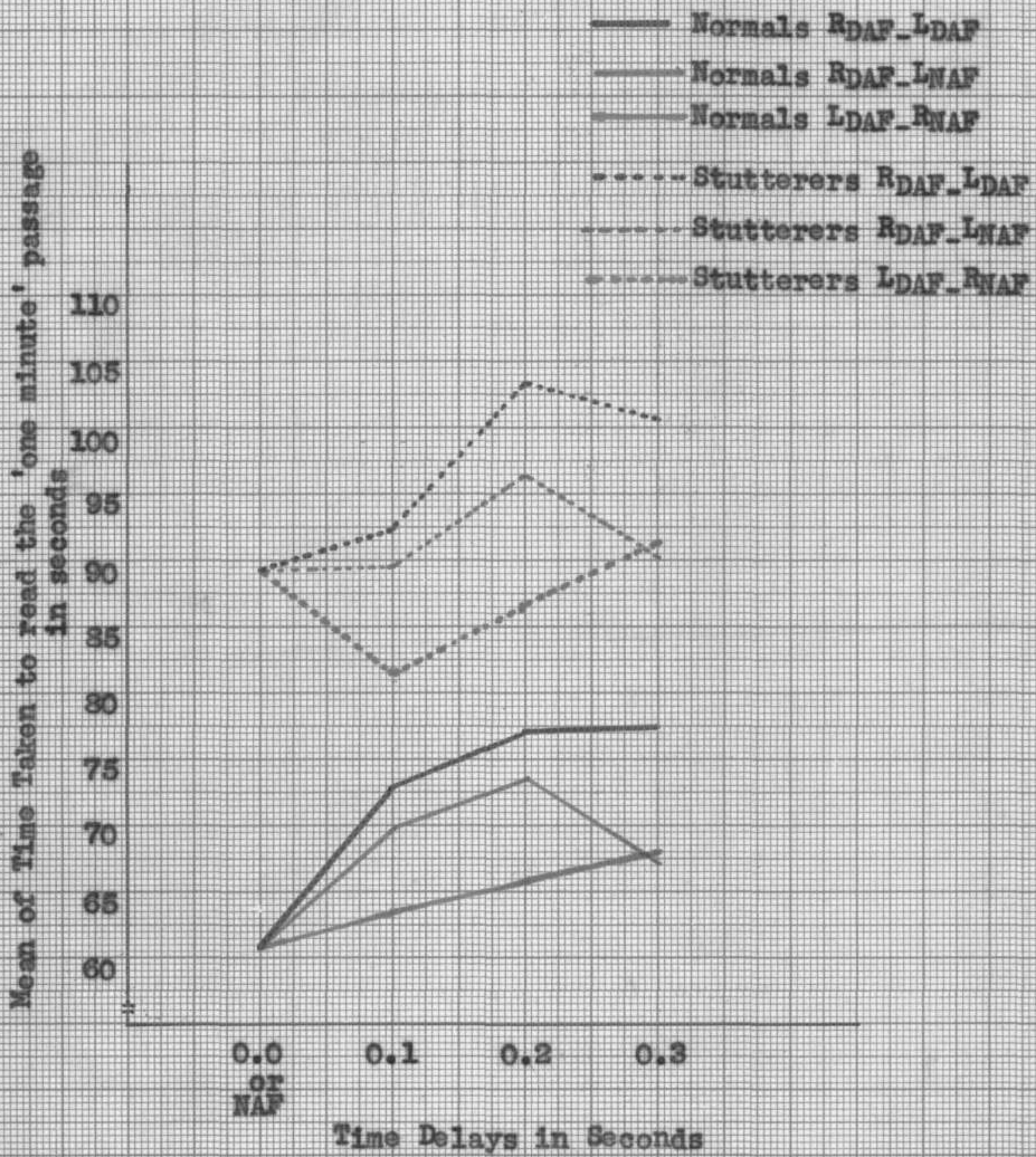


Table XI - Total Number and Mean Values of Different Types of Speech Errors In Normal*

Sl. No.		NAF			$R_{DAF}-L_{DAF}$									$R_{DAF}-L_{NAF}$								
					0.]L			0.2			0.3			0.1			0.2			0.3		
		R	H	P	R	H	P	R	H	P	R	H	P	R	H	P	R	H	P	R	H	P
1	TOTAL	30	6	0	44	25	168	65	15	173	77	20	116	21	17	90	33	24	113	41	13	73
2	MEAN	2	.4	0	2.9	1.6	11.2	4.3	1	11.5	5.1	1.3	7.7	1.4	1.1	6	2.2	1.6	7.5	2.7	.86	4.8

Sl. No		$L_{DAF}-R_{NAF}$								
		0.1			0.2			0.3		
		R	H	P	R	H	P	R	H	F
1	TOTAL	25	16	63	21	24	34	33	21	43
2	MBAN	1.6	1.1	4.2	1.4	1.6	2.2	2.2	1.4	2.8

Table XI - contd.

SI No.		NAF			$R_{DAF}-L_{DAF}$									$R_{DAF}-L_{NAF}$								
					0.1			0.2			0.3			0.1			0.2			0.3		
		S	A	0	8	A	0	S	A	O	8	A	0	S	A	0	S	A	0	S	A	0
1	TOTAL	0	1	1	16	22	16	17	19	17	21	23	7	20	17	17	32	10	14	17	13	
2	MEAN	0	.06	.06	1.1	1.6	1.1	1.1	1.3	1.1	1.4	1.5	.46	1.3	1.1	1.1	2.1	.66	.93	1.1	.86	.6

sl No.		$L_{DAF}-F_{NAF}$								
		0.1			0.2			0.3		
		S	A	0	S	A	O	S	A	0
1	TOTAL	19	12	16	16	17	10	9	16	7
2	MEAN	1.3	.8	1.1	1.1	1.1	.66	.6	1.1	.46

R = Repetitions
H = Hesitations
P = Prolongations

S = Substitutions
A = Additions
0 = Omissions

delay (M=5.l) under R_{DAF}-L_{DAF} condition. The mean values of repetitions showed that they were more under R_{DAF}-L_{DAF} condition than under R_{DAF}-L_{NAF} or L_{DAF}-R_{NAF} condition. There was a gradual reduction in the repetitions.

Hesitations were also the least under R_{NAF}-L_{NAF} (M=.4) condition and were maximum (M=1.6) at 0.2 sec. delay at R_{DAF}-L_{NAF} condition.

Prolongations which were not seen during NAF condition formed most of the speech errors ander the DAF condition. At 0.2 sec. delay in R_{DAF}-L_{NAF} condition, a mean value of 11.5 was noted. Among all the three types of speech , errors, prolongations were more under all conditions and at all the three time delays. This showed that there was a slowing down of speech, which was an important observation made by Lee (l950), Black (1951), Fairbanks (1955), and Fairbanks and Guttmann (1958) and others. This slowing down has been confirmed in the analysis of time taken to read the passages.

The other speech errors like substitutions, additions and omissions of sounds, syllables, words or phrases were analyzed.

In the normals, substitutions were least under the

R_{NAF}-L_{NAF}(M=O) condition. They were maximum (M=2.l) at 0.2 sec, delay under R_{DAF}-L_{NAF} condition.

Additions were also common having 0.06 mean value under R_{NAF}-L_{NAF} and l.5 at 0.3 sec. delay under R_{DAF}-L_{DAF} condition.

Omissions which were the least M=.o6) under R_{NAF}-L_{NAF} were the highest (M=1.1) at 0.2 sec. delay under R_{DAF}-L_{DAF} and at 0.3 sec. delay of R_{DAF}-L_{NAF} condition.

In the normals, repetitions, hesitations and prolongations which resembled stuttering behaviour were observed to be higher than misarticulations, and substitutions, additions and omissions of syllables, words or phrases. Again 0.2 sec. delay seemed to be effective in bringing about the greatest amount of speech disruption. L_{DAF}-R_{NAF} condition brought about the least amount of change in the speech errors, than the other two conditions.

Table XII shows the total number and mean values of different types of speech errors in stutterers.

In stutterers, the repetitions were the highest (M=8.3) at 0.2 sec. delay, under R_{DAF}-L_{DAF}. Other than this, under all the DAF conditions, there was a considerable decrease in repetitions compared to repetitions under R_{NAF}-L_{NAF} (M=7.2).

Table XII - Total Bomber and Mean Values of different types of Speech Errors in Stutterers

Sl. No	NAF			$R_{DAF}-L_{DAF}$									$R_{DAF}-L_{NAF}$								
				0.1			0.2			0.3			0.1			0.2			0.3		
	B	H	P	R	H	P	R	H	P	R	H	P	R	H	P	R	H	P	R	H	P
1 TOTAL	108	82	19	90	32	-	124	28	-	97	32	-	66	31	-	60	23		46	28	-
2 MEAN	7.2	3.5	1.3	6	2.13	-	8.2	1.8	-	6.55	2.1	-	44	2.1	-	4	1.5	-	3.1	1.8	-

Sl. No	$L_{NAF}-R_{DAF}$								
	0.1			0.2			0.3		
	R	H	P	R	H	P	R	H	p
1 TOTAL	55	29	-	64	32	-	58	27	-
2 MEAN	3.6	1.9		4.3	2.1	-	3.8	1.8	-

Table XII - contd

Sl No		NAF			R_{DAF}-L_{DAF}									R_{DAF}-L_{NAF}								
					0.1			0.2			0.3			0.1			0.2			0.3		^
		S	A	0	S	A	0	S	A	0	S	A	0	S	A	0	8	A	0	S	A	e
1.	TOTAL	2	O	0	11	14	14	10	20	IS	12	11	9	22	12	14	26	18	18	16	10	10
2	MEAN	.13	0	O	.73	.93	.93	.66	1.3	1	.8	.73	.6	1.5	.8	.93	1.7	1.2	13	1.1	.66	.66

Sl No		L_{DAF}-R_{NAF}								
		0.1			0.2			0.3		
		∞	A	0	S	A	0	S	A	0
1	TOTAL	10	12	16	21	7	12	17	10	12
2	MEAN	.66	.8	1.1	1.4		.8	1.1	.66	.8

R = Repetitions S = Substitutions
H = Hesitations S = Additions
P = Prolongations 0 = Omissions

Hesitations certainly showed a decrease under all DAF conditions compared to R_{NAF}-L_{NAF} where they had a mean value of 3.6.

There was certainly a change in the speech behaviour of stutterers under DAF.

Substitutions, omissions and additions were not seen under R_{NAF}-L_{NAF} condition in stutterers. They occured only under the DAF condition. A mean value of 1.7 substitutions was found to be the highest at 0.2 sec. delay under R_{DAF}-L_{NAF} condition.

Additions were the highest (M=1.3) at 0.2 sec. delay at R_{DAF}-L_{DAF} condition. The least mean value (M=o.5) for additions being at 0.2 sec. delay under L_{DAF}-R_{NAF} condition.

Omissions were also the greatest (M=l.2) at 0.2 sec. delay under R_{DAF}-L_{NAF} condition and the least (M=o.6) under 0.3 sec. delay of R_{DAF}-L_{DAF} condition.

Comparing the errors under all DAF conditions, the R_{DAF}-L_{DAF} or R_{DAF}-L_{NAF} condition seemed to be more effective than L_{DAF}_R_{NAF} condition. Similarly, the 0.2 gee. delay seemed to be the most effective among all the

3 delays. This finding was true for both stutterers and normals. The total number of different types of speech errors were small.

2. There was an intensity rise in the subject's speech. This was observed during DAF conditions, where the V-u. meter needle deflected 30-5C volume units from 0 volume unit. But this was not studied quantitatively.

3. Two of the normal subjects changed their accent under DAF conditions to overcome its effect.

4. Some of the normals and stutterers used pauses in their speech and click noises in between the words.

5. One of the normal subjects started laughing when he was put on DAF.

Conclusions drawn from the results of this study

1. R_{DAF}-L_{NAF} condition in normals produced significantly more speech errors than L_{DAF}-R_{NAF} condition, supporting the concept of cerebral dominance in normals.

2. The absence of a significant difference in speech errors between R_{DAF}-L_{NAF} and L_{DAF}-R_{NAF} conditions in stutterers supported the theory of cerebral dominance and showed that there was no clear cut dominance in stutterers.

3. In the normals, DAF produced greater speech disturbances than NAF conditions.

4. Blnaural DAF (R_{DAF}-L_{DAF}) and R_{DAF}-L_{NAF} conditions were more effective than L_{DAF}-R_{NAF} condition.in producing speech disturbances in normals.

5. Stutterers with a greater number of blocks under R_{NAF}-L_{NAF} (more than 15/min.) showed a decrease in their number of blocks under DAF. Stutterers with a smaller number of blocks under R_{NAF}-L_{NAF} (less than 15/min.) showed an increase in the number of blocks and behaved like normals under DAF. R_{DAF}-L_{NAF} at 0.3 sec. delay and L_{DAF}-R_{NAF} condition at 0.2 sec. and 0.3 sec. delay showed a decrease in stuttering compared to R_{NAF}-L_{NAF}.

6. Even for stutterers, the binaural DAF was more effective than R_{DAF}-L_{DAF} or L_{DAF}-R_{NAF} at 0.2 sec. delay condition.

7. There was an increase in speech errors in normals under DAF, whereas a general reduction in speech errors was seen in stutterers.

8. In the time taken to read the 'one minute' passage, normals took significantly more time under R_{DAF}-L_{NAF} condition than under L_{DAF}-R_{NAF} at 0.1 sec. and 0.2 sec. delays. This again supported the findings that in the normals, the right ear-left hemisphere was more dominant for speech than the left ear-right hemisphere.

9. In stutterers also, this difference was noticed at 0.1 sec. and 0.2 sec. delays.

10. In normals and in stutterers, R_{DAF}-L_{NAF} condition vas found to be as effective as R_{DAF}-L_{DAF} at 0.1 sec. and 0.2 sec. delays.

11. Normals took significantly greater time to read under DAF than under NAF condition. This was not observed under L_{DAF}-R_{NAF} condition, which almost resembled NAF condition.

12. In stutterers, significant differences between reading times under NAF and other DAF conditions were seen only at 0.2 sec. delay under R_{DAF}-L_{DAF} and R_{DAF}-L_{NAF}

conditions. L_{DAF}-R_{NAF} as in the normals did not bring about a significant difference from the NAF condition in duration of reading.

13. In time taken to read the 'one minute' passages, normals and stutterers behaved similarly when they were compared among themselves. But a significant difference in duration of reading vas seen when the two groups were compared.

14. An optimum delay for maximum speech disruption in normals was observed to be at 0.2 sec. delay under R_{DAF}-L_{NAF} condition. An optimum delay for fluency among stutterers could not be pointed out.

CHAPTER V

SUMMARY AND CONCLUSIONS

In the present study, Delayed Auditory Feedback (DAF) speech was used in a dichotic condition. Fifteen normals and fifteen stutterers between the age range of 16 to 25 years were taken for the study. All the thirty subjects underwent a pre-experimental condition, where they read a 'one minute' passage in English under Normal Auditory Feedback (NAF) condition to both the ears at 95 dB SPL. The time taken to read the passage, articulatory disturbances and fluency changes were noted down for normals and stutterers. After a rest period of 45 seconds, they were exposed to the II, III and IV experimental conditions.

In the II experimental condition, DAF speech was given to both the ears simultaneously at 95 dB SPL. In the III experimental condition, DAF speech was given to right ear and NAF speech to left ear simultaneously at 95 dB SPL. In the IV experimental condition, DAF speech was given to the left ear and NAF speech was given to the right ear simultaneously at 95 dB SPL. The time delays used in II, III and IV conditions were approximately 0.1 a*e., 0.2 sec. and 0.3 sec. The time taken to read the other 'one minute' passages were noted down. Other speech changes were noted down by the investigator by listening to the tapes.

Repetitions, hesitations, prolongations, substitutions, additions and omissions of sounds, syllables, words or phrases were considered as speech errors in normals. In stutterers, uniform and easy prolongations were taken as changes towards fluency. So, repetitions, hesitations, substitutions, additions and omissions of sounds, syllables, words or phrases were considered as speech ewers.

An Ahuja tape recorder with an extra replay head, which had an extra motor, formed the DAF unit. An Ahuja microphone picked up NAF speech, fed it to an Arphi amplifier and to one or both earphones of TDH-39. An Ampex microphone collected DAF speech, fed it to the tape recorder and the speech was replayed after 0.1 sec., 0.2 sec. or 0.3 sec. delays to an Arphi amplifier. The DAF speech was fed back to one or both the TDH-39 earphones.

Non parametric statistics were applied to analyze the data.

The following conclusions were made from the results:

1. DAF could be used as a dichotic listening task to

evaluate cerebral dominance. The delay to right ear with NAF to left ear produced significantly greater number of speech errors than delay to left ear with NAF to right ear, showing a clear concept of dominance in normals.

2. In stutterers, there was no significant difference in speech errors between R_{DAF}-L_{NAF} and L_{DAF}-R_{NAF} conditions. Even though stutterers had more speech errors under R_{DAF}-L_{NAF} than L_{DAF}-R_{NAF} condition, the magnitude of difference was not significant. The lack of a clear cut dominance in stutterers was thus supported.

3. Normals showed a significant increase in speech errors under DAF. In stutterers, there was a general reduction in stuttering.

4. Monaural DAF (R_{DAF}-L_{NAF}) was as effective as binaural DAF (R_{DAF}-L_{DAF}) at certain time delays.

5. L_{DAF}-R_{NAF} condition seemed to be the least disturbing condition.

6. Mild stutterers behaved like normals under DAF and the severe stutterers showed a decrease in stuttering under DAF.

7. An optimal delay of 0.2 sec. under R_{DAF}-L_{NAF} condition was found to cause maximum speech disruption in normals. In stutterers, an optimal delay for fluency could not be found.

8. In the time taken to read the 'one minute' passages, normals and stutterers behaved similarly. Both took longer time to read under DAF conditions than under NAF.

Recommendations for further research

1. Stutterers should be classified on the basis of severity and the effect of DAF on each group should be noted.

2. The DAF equipment needs more precision and calibration.

3. Intensity levels could be varied with different time delays. Other types of speech disturbances and emotional disturbances under DAF could be studied.

4. As normals and stutterers were found to have mis-articulations under DAF, cases with misarticulatlons should be put on DAF to see its effect.

5. The effect of masking noise, anaesthesia of the oral cavity and DAF could be tried on normals and stutterers.

6. DAF with variable time delays could be devised. The point at which the first speech disturbance occurs under each time delay could be noted.

BIBLIOGRAPHY

BIBLIOGRAPHY

Abbs, J.H. "Spectrographic analysis of speech under computed delayed auditory feedback" (Master's Thesis, Uhiv. Wisc., Behavioral Cybernetics Lab, 1968). cited by Abbs, J.H. and Smith, K.U., "Laterality differences in the auditory feedback control of speech," J. Speech Hear. Res.. 13 (l970), 298-303

Abbs, J.H., and Smith, K.U. "Laterality differences in the auditory feedback control of speech," J. Speech Hear. Res., 13 (1970), 298-303

Adamczyk, B. "An wendung des apparatus fur die erzeugung von kunstlichem wider hall beider behandlung dea stotterns," Fol. Phoniatri.. 11 (1959), 216-213. cited by Soderberg, "Delayed Auditory Feedback and the speech of stutterers," J. Speech Hear. Pis.. 33 (1969), p.23

Albright, M.A., and Malone, J.Y. "The Relationship of Hearing Acuity to stammering," J. Exceptional Children. 8 (1942), 186-190

Aimard, P., et al. "Le begaiement contribution a 1'etude de 1'audition et de 1'integration phonetique," Rev. Laryngol. (Bordeauz), 87 (1965), 254-256. cited by Van Riper, C. The Treatment of Stuttering. Englewood Cliffs, N.J.: Prentice-Hall, 1973), p.131

Ainsworth, S. "Integrating Theories of Stuttering", J. Speech Dis.. 10 (1945), 205-210

------ "Methods of integrating Theories of Stuttering", Handbook of Speech Pathology and Audiology (ed) Travis, L.D. (New York, Appleton-Century-Crofts,

Arends, C.J, and Popplestone, J.A. "Verbal Facility and Delayed Speech Feedback", Perceptual & Motor Skills. 9 (1959), 270. cited by Van Riper, C.. The Nature of Stuttering (Englewood Cliffs, K.J.: Prentice-Hall, 1971), p.386

Atkinson, C.J. "Adaptation to Delayed Side tone" J. Speech Hear Dis 13(1953)

Bachrach, D.L. "Sex Differences in Reactions to Delayed Auditory Feedback", Perceptual Motor Skills. 19 (1964), 81-82. cited by Van Riper, C. The Nature of Stuttering (Englewood Cliffs, N.J.: Prentice-Hall, 1971), p.386

Backe, L. "Delayed feedback og Stamming", Nordisk Tidsskrift for Tale og stemme. 25 (1965), 54. cited by Van Riper, C. The Treatment of Stuttering (Englewood Cliffs, N.J.: Prentice-Hall, 1973), 0.131

Backus, 0. "Incidence of Stuttering Among the Deaf", Ann. Oto. Rhino. Larvn.. 68 (1933), 632-635. cited by Van Riper, C. The Nature of Stuttering (Englevood Cliffs, N.J.: Prentice-Hall, 1971), p.392

Berry, M., and Eisenson, J. Speech Disorders (New York: Appleton-Century-Crofts, 1956)

Black, J.W. "The Effects of Delayed Side tone upon Vocal Rate and Intensity", J. Speech Hear. Pis.. 16 (1951), 66-60.

____________ "The Persistence of the effects of Delayed Side-tone", J. Speech Hear. Pis.. 20 (1955), 65-68

Blumel, C.S. "Concepts of Stammering: A century in Review", J. Speech Hear. Pis.. 25 (1960), 24-32

Bohr, J.W.F. "The Effects of Electronic and the other External Control Methods on Stuttering: A Review of Some Research Techniques and suggestions for Further Research", J. South African Logopedic Society, 10(1963), 4-13. cited by Van Riper, C. The Nature of Stuttering (Englewood Cliffs, N.J.: Prentice-Hall, 1971), p.339

Brain, R. "Statement of the Problems", Disorders of Language. CIBA Symposium (eds) De Reuck and Maeve O'Connor (London: Jan Churchill Std. 1961), 5 to 13

Broadbent, D.E. "The role of auditory localization in Attention and Memory Span", J. Expt. Psych.. 47 (1954), 191-196

Brubaker, R. "An Experimental Investigation of Speech Disturbance as a Function of the Intensity of Delayed Auditory Feedback", (Doctoral Dissertation, Univ. Illinois, 1952). cited by Van Riper, C. The Nature of Stuttering. (Englewood Cliffs, N.J.: Prentice-Hall 1971), p.386

Brutten, E.J., and Shoemaker, D.J. The Modification of Stuttering (Englewood Cliffs, N.J.: Prentice-Hall, 1968)

Butler, R.A., and Galloway, F.T. "Factorial Analysis of the Delayed Speech Feedback Phenomenon", J. Acoust.-Soc. Amer.. 29 (1957), 632-635. cited by Van Riper, C. The Nature of Stuttering (Englewood Cliffs, N.J.: Prentice-Hall, 1971), p.386

Butler, R.R. Jr., and Stanley, P.E. "The stuttering problem considered from an automatic control point of view", Folia Phoniatrica, 18 (1966), 33-44. cited by Van Riper, C. The Treatment of Stuttering (Englewood Cliffs, N.J.: Prentice-Hall, 1973), p.117

Buxton, L.F. "An investigation of Sex and Age Differences in Speech Behaviour under Delayed Auditory Feedback" (Doctoral dissertation, Ohio State Univ. 1969). cited by Van Riper, C. The Nature of Stuttering (Englewood Cliffs, N.J.: Prentice-Hall, 1971), p.386

Campbell, W.G. Form and Style in Thesis Writing, Third edition (Boston, Houghton Mifflin Company, 1969)

Carr, B.M. "Effects of simultaneous Dichotic presentations of Delayed and Non-Delayed auditory feedback on Oral reading time", J. Aud. Res.. 9 (1969), 24-31

Chaney, R-B., Jr., and Webster, J.C. "Information in certain multidimensional sounds", J. Acoust. Soc. Amer.. 40 (1966), 447-455. cited by Nandur, S.U.,"A Test for Ear Preference For Music"(unpublished Master's Thesis, Univ. Mysore, India, 1976)

Chase, R.A. "Effect of Delayed Auditory Feedback on the Repetition of speech sounds", J. Speech Hear. Dis.. 83 (1958), 583-590

------, Research report presented on psychological and sensory perceptual deficits resulting from cerebral lesions in man, in Brain mechanisms underlying speech and Language (ed) Darley, L.F. (New York: Grune and Stratton, 1965)

Chase, R.A., et al. "Sensory feedback influences on motor performance", _J. Aud. Res._. 3 (1961), 212-223. cited by Soderberg, 0. "Delayed Auditory Feedback and the Speech of stutterers", _J. Speech Hear. Pis._. 33 (1969)

Chase, R.A., et al. "A comparison of the effects of delayed auditory feedback on speech and key-tapping", Communi- cations lab., Columbia Un0v. and Dept. Biometrics Res., State of N.Y., Res. Report, 1953. cited by Smith, K.U. _Delayed Sensory feedback and behaviour_ (Philadelphia: Sanders, 1962)

__________ "Studies on sensory feedback: The effect of delayed auditory feedback on speech and key tapping", Comm. Lab., Columbia Univ., and Dept. Biometrics Res., State of N.Y., Res. Report, 1969. cited by Smith, K.U. _Delayed Sensory feedback and behaviour_ (Philadelphia: Sanders, 1962)

Chase, R.A., Sutton, S., First, D., and Zubin, J. "A developmental study of changes in behaviour under delayed auditory feedback", _J. Genet. Psvchol._. 99 (1961a), 101-112. cited by Smith, K.U. _Delayed Sensory Feedback and Behaviour_ (Philadelphia: Sanders, 1962)

Chase, R.A., and Guilfoyle, 6. "Effect of Simultaneous and Delayed and Undelayed Auditory feedback on speech J. Speech. Hear. Res., 5 (1962), 144-151

Cherry, E.C., and Sayers, B.M. "Experiments upon the tota inhibition of Stammering by external control and some clinical results", J. Psychosom. Res.. 1 (1956), 233-246. cited by Van Riper, C. The Treatment of Stuttering (Englewood Cliffs, N.J.: Prentice-Hall, 1973), p.117

Coblenz, H., and Agnello, J.G. "The Effects of Delayed Auditory Feedback on the manner of consonant Production", Convention address, A.S.H.A., 1965. cited by Van Riper, C. The Nature of Stuttering (Englevood Cliffs, N.J.: Prentice-Hall, 1971), p.384

Cohen, J.G., and Edwards, A.E. "The Extraexperimental Effects of Random Side tones", Proceedings of the Annual Convention of the American Psychological Association. I (1965), 211-212. cited by Van Riper, - The Nature of Stuttering (Englewood Cliffs, N.J.: Prentice-Hall, 1971), p.389

Gonovor, W.J . Practical Non-parametric Statistics. (New York: John Wiley and Sons Inc., 1971)

Copeland, R.H. "The Effects of Feedback Modification on Verbal Behaviour", J. Speech Hear. Dis.. Monograph, Supplement No.10 (1963), 70-75

Curlee, R.F., and Perkins, W.H. "Conversational rate control therapy for stuttering", J. Speech Hear. Dis. 34 (1969), 245-250

Curry, F.K.W., "A comparison of left handed and right handed subjects on verbal and non verbal dichotic listening tasks", Cortex 3 (1967), 343-352. cited by Nandur, S.U. "A Test of Ear Preference for Music", (unpublished Master's Thesis, Univ. Mysore, 1976) p.15

Curry, F.K.W., and Gregory, H.H. "The Performance of Stutterers on Diehotic Listening Tasks Thought to Reflect Cerebral Dominance", J. Speech Hear. Res. 12 (1969), 73-82

Darwin, C.J. "Auditory Perception and Cerebral Dominance", (unpublished Ph.D. Thesis, Uhiv. Cambridge, England, 1969). cited by Nandur, S.U. "A Test of Ear . Preference for Music" (unpublished Master's Thesis, Univ. Mysore, 1976) p.21

Dorman, M.F., and Porter, R.J. "Hemispheric Lateralization for Speech Perception in Stutterers", Cortex 11 (1975) 181-186

Emerick, L.L., and Hatten, J.T. diagnosis and evaluation in speech pathology (Englewood Cliffs, N.J.: Prentice Hall, 1974), p.175

Eisenson, J. "A Perservative Theory of Stuttering", 1958 in Stuttering: A Symposium. Jon Eisenson (ed) (New York, Harper and Row Publishers, 1958)

Espir, M.L.G., and Rose, F.C. "Cerebral Dominance", The Basic Neurology of Speech (Oxford, Blackwell Scientific Publicationns, 1970)

Fairbanks, G. "Systematic Research in Experimental Phonetics. l.A. Theory of The Speech Mechanism As A Servo System", J. Speech Hear. Dis.. 19 (1954), 133-139

__________ "Selective Vocal Effects of Delayed Auditor Feedback", J. Speech Hear. Pis.. 15 (1955), 142-153

Fairbanks, G., and Guttman, N. "Effects of DAF upon Articulation", J. Speech Hear. Res.. 1 (1958), 12-22

Fillenbaum, S. "Delayed Auditory Feedback with different Delay times at each ear", J. Speech Hear. Res., 7 (1964), 369-371

Fillenbaum, S. "Impairment in performance with delayed auditory feedback as related to task characteristics" J. Verb. Learn. Verb. Rehav.. 2 (1963), 136-141. cited by Rouse, R.O., and Tucker, R.G., "An Effect of Delayed Auditory Feedback on Speech in American and Foreign students", J. Speech Hear. Res.. 9 (1966) p.456

Gauber, I.P. "The Psychoanalysis of Stuttering", cited in Stuttering: A Symposium. Jon Eisenson (ed) (N.Y.: Harper and Row Publishers, 1958)

Goldfarb, W., and Braunstein, P. "Reactions to delayed auditory feedback in schizophrenic children", In Psychopathology of communication. Hoch, P.H., and Zubin, J., Ed. (N.Y.: Grune and Stratton, 1958), quoted by Mysak, E.D. Speech Pathology and Hedback Theory (Illinois, Thomas Books, 1966)

Goldiamond, I. "Stuttering and Fluency as manipulatable Operant Response Classes", cited by L. Krasner and L.P. Ullman (eds), Research in Behavior modification. (New York: Holt, 1965), 106-156

et al. "Stabilization of behaviour and prolonged exposure to delayed auditory feedback", Science. 137 (1962), 437-438. cited by Van Riper, C. The Nature of Stuttering. (Englewood Cliffs, N.J.:Prentice-Hall 1971), p.385

Gross, M., and Nathanson, S.N. "A Study of the use of a DAF shaping procedure for adult stutterers". (Paper presented at the Annual Convention of ASHA, 1966, Chicago, Illinois), cited by Soderberg, 0. "Delayed Auditory Feedback and the speech of Stutterers", J. Speech Hear. Dis.. 33 (1969), p.23

Gruber, L. "Sensory Feedback and Stuttering", J. Speech Hear. Dis.. 30 (1963), 373-390

Guillaume, J., Mazars, 0., and Mazars, Y. "Epileptic Mediation in certain Types of Stammering", Revue Neurologique, XCIX (1957), 59-62. cited by Van Riper, C. The Nature of Stuttering (Englewood Cliffs, N.J.: Prentice-Hall, 1971), p.352

Ham, R.E., and Steer, M.D. "Certain effects of alterations in the auditory feedback", Folia Phoniatr.. 19 (l967), 53-62. Cited by Soderberg, G. "Delayed Auditory Feedback and the speech of stutterers", J. Speech Hear. Pis.. 33 (1969), p.20

Hanley, C.N., Tiffany, W.R., and Brungard, J.M. "Skin resistance changes accompanying the side-tone test for auditory malingering", J. Speech Hear. Res.. 1 (1958) 286-293

Haywood, H.C. "Differential Effects of DAF on palmar Sweating, Heart Rate and Pulse pressure", J. Speech Bear. Res.. 6 (1963), 186-

Jackobovits, L.A., and Lambert, W.E. "Semantic satiation among bilinguals", J. Exp. Psychol.. 62 (1961), 576- 582 eited by Rouse, R.O., and Tucker, R.G., "An Effect of DAF on speech in American and Foreign-students", J. Speech Hear. Res., 9 (1966), p.456

Johnson, W. "Perceptual and evaluatlonal factors in stuttering", In: Handbook of speech Pathology, Travis, L.E. (ed)(N.Y.: Appleton-Century-Crofts, 1957)

Jones, R.K. "Observations on Stammering after localized cerebral injury", J. N-eurology and Neurosurgery. XXXX (1966), 192-195. cited by Van Riper, C. The Nature of Stuttering (Englevood Cliffs, N.J.:Prentice-Hall, 1971), p.352

Kern, A. "Dor Einfluss des Horens aufdas Stottern", Arch. Psychiat.. 97 (1931), 429-449. cited by. Van Riper, C. The Nature of Stuttering (Eaglewood Cliffs, N.J.: Prentice-Hall, 1971) p. 391

Kimura, D. "Some effects of temporal lobe damage on auditory perception", Canad. J. Psychol.. 15 (l961a) 156-165. cited by Nandur, S.U. "A Test of Ear Preference for Music" (unpublished Master's Thesis, gniv. Mysore, 1976), p.

________ "Cerebral Dominance and the Perception of Verbal stimuli", Canad. J. Psychol.. 15 (1961b), 166-171. cited by Nandur, S.U. "A Test of Ear Preference for Music" (unpublished Master's Theais, Univ. Mysore, 1976), p.14

________ "Left right differences in the perception of Melodies", Quart. J. Expt. Psychol., 16 (1964), 355-358. cited by Nandur, S.U. "A Test of Ear Preference for Music" (unpublished Master's Thesis, Univ. Mysore, 1976), p.14.

________ "Functional asymmetry of the Brain in dichotic listening", Cortex. 3 (1967), 163-178.

Lee, B.S. "Some effects of side-tone delay", J. Aconst. Soc. Amer.. 22 (1950a), 639-640

________ "Effects of delayed speech feedback", J. Acoust. Sec. Amer.. 22 (1950b), 824-826. '

Lee, B.S. "Artificial Stutter", J. Speech Hear. Dis., 16 (1951), 53-55

Logue, R.D. "The effects of Temporal Alterations in Auditory Feedback upon the speech output of stutterers and Non-stutterers", (M.A. thesis, Prudue Univ. 1962) cited by Soderberg, G. "Delayed Auditory Feedback and speech of stutterers", J. Speech Hear. Dis.. 33 (1369), p.21.

Lotzmann, G. "Zur anwendung variierter verzogerungszeiten bei balbuties", Folia Phoniatr.. 13 (1961), 276-312. cited by Soderberg G. "Delayed Auditory Feedback and speech of stutterers", J. Speech Hear. Pis.. 33 (1969) p.22

Mackay, D.G. "Metamorphosis of a critical Interval: Age-linked changes in the Delay in Auditory Feedback that produces maximal disruption of speech", J. Acoust. Soc. Amer.. 19 (1963), 811-821

"To speak with ad ascent: Effects of nasal distortions on stuttering under delayed auditory feedback", Perceptual Psychophysics. 5 (1969), 183-188. cited by Van Riper, C. The Treatment of Stuttering. (Englewood Cliffs, N.J.: Prentice-Hall, 1973), p.129

Mahaffey, R.B., and Stransta, C. "Auditory Feedback as a Function of frequency, Intensity, Time and Sex", De Therapia Vocis et Loquellae, 2 (1965), 233-235. cited by Van Riper, C. The Nature of Stuttering. (Englewood Cliffs, N.J.: Prentice-Hall, 1971), p.386

Milner, B. "Laterality effects in Audition" In Mount Castle, V. (ed) "Inter hemispheric Relation and Cerebral dominance. Baltimore, cited by Nandur, S.U. "A Test of Ear Preference for Music" (unpublished Master's Thesis, Univ. Mysore, 1976), p.15

et al. "Lateralized suppresion of dichotically presented digits after commissural section in man", Science. 161 (1968), 184-185. cited by Nandur, S.U. "A Test of Ear Preference for Music" (unpublished Master's Thesis, Univ. Mysore, 1976), p.15

Milncr, B., Branch, C., and Rasmussen, T. Disorders of Language (ed) de Reuck A.V.S. and O'Connor M. Churchill, London, cited in Espir, M.L.E., and Rose, F.C., The Basic Neurology of Speech (Oxford, Blackwell Scientific Publications, 1970)

Moravek, M., and Langova, "Hearing and auditory feedback in stutterers", (Proceedings. Congress of Oto-laryngology, Prague, 1964). cited by Van Riper, C. The Treatment of Stuttering (Englewood Cliffs, N.J.: Prentice-Hall, 1973), p.131

Mysak, E.D. "A Servo Model for Speech Therapy", J. Speech Hear. Dis.. 34 (1960), 144-149

__________ "Servo Theory and Stuttering", J. Speech Hear Dis.. 25 (1960), 188-195

Speech Pathology and Feedback Theory (Illinois, Thomas Books, 1966)

Nandur, S.U. "A Test of Ear Preference for Music" ' (unpublished Master's Thesis, Univ. of Mysore, 1976)

Nataraja, N.P., and Rathna, N. "Stuttering and Hearing Loss", J. All. Ind. Inst. Speech Hear., 3 (1972), 193-197.

Neelley, J.N. "A Study of the speech Behaviour of Stutterers and Non-Stutterers under Normal and Delayed Auditory Feedback", J. Speech Hear. Dis.. Monogragh. Supplement No.7 (1961), 63-82

Nessel, E. "Die verz ogerts Sprachruckk opplung (Lee-effekt) bei der Stotterern", Folia Phoniatr.. 10 (1958), 199-204. cited by Soderberg G. "Delayed Auditory Feedback and the speech of Stutterers", J. Speech Hear. Pis., 33 (1969), p.21

Orton, S.T. "Studies in stuttering", Archives of Neurology and Psychiatry. 18 (1927), 671-672. cited by Van Riper, C. The Nature of Stuttering (Englewood Cliffs, N.J. Prentice-Hall, 1971), p.357

Parker, C.S., and Christophrenson, F. "Electric Aid in the treatment of Stammer", Medical Electronics and Biological Engineering. 1 (1963), 121-125. cited by Van Riper, C. The Nature of Stuttering (Englewood Cliffs, N.J.: Prentice-Hall, 1971), p.392

Penfield, W., and Roberts, L. Speech and Brain Mechanisms (London, Oxford University Press, 1959)

Peters, R.W. "The Effect of changes in side-tone Delay and Level upon rate of oral reading of normal speakers" J. Speech Hear. Pis.. 19 (1954), 483-490

__________ "The Effect of Filtering of Side-Tone upon speaker intelligibility", J. Speech Hear. Pis.... 20 (1955)

Rawnsley, A.F., and Harris, J.D. "Comparative Analysis of Normal Speech and Speech with Delayed Side-tone by means of sound spectrograms", Bureau of Medical Research, Project No. NM 003-041-56-03, 1954. cited by Van Riper, C. The Nature of Stuttering. (Englewood Cliffs, N.J.: Prentice-Hall, 1971), p.384

Rossi, 6.R., and Rosadini, G. "Experimental analysis of cerebral dominance in man", Brain Mechanisms underlying Speech and Language (ed) Darley, F.L, (N.Y.: Gruene and Stratton, 1967), p.167

Rouse, R.O., and Tucker, R.G. "An Effect of Delayed Auditory Feedback on Speech in American and Foreign Students", J. Speech Hear. Res.. 9 (1966), 456-460

Ruhm, H.B., and Cooper, W.A. "Delayed Feedback Audiometry", J. Speech Hear. Dis.. 29 (l964b), 448-455

Russel, W.R., and Espir, M.L.E. Traumatic Aphasia. (London, Oxford Univ. Press, 1961). cited by Espir, M.L.E., and Ross, F.C. The Basic Neurology of Speech (Oxford, Blackwell Scientific Publications, 1970) p.22

Ryan, B.P. "The Use of DAF in the establishment of fluent reading and speaking in six stutterers", (Presented at A.S.H.A. Convention, Denver, 1968). cited by Van Riper, C. The Treatment of Stuttering (Englewood Cliffs, N.J.: Prentice-Hall, 1973), p.130

Sachs, M.W. "Zur Actiologie des Stotterns", Klinische Wochenschrift. 37 (1924), 113-115. cited by Van Riper, C. Nature of Stuttering (Englevood Cliffs, N.J.: Prentice-Hall, 1971), p.351

Shamer, G.H., and Sherrick, C.E. "Discussion of Non-fluency and Stuttering as Operant Behavior", J. Speech Hear. Dis.. 28 (1963), 3-18

Shankweiler, D., and Studdert-Kennedy, M. "Identification of Consonants and Vowels presented to left and right ears", Quar. J. Exp. Psychol.. 19 (1967), 59-63. cited by Abbs and Smith, K.L. "Laterality differences in the auditory feedback control of speech", J. Speech Hear. Res., 13 (1970), 298-303

Sheehan, J. "Conflict Theory of Stuttering", In Stuttering: A Symposium. J. Eisenson (ed), (New York: Harper &Rov, 1958)

Shtremel, A.K. "Stuttering in Left Pareital Lobe Syndrome", Zhurnal Nevropatologii 1 psikhiatrii imeni S S Korsakova, LXIII (1963), 828-832. cited by Van Riper, C. The Nature of Stuttering (Englevood Cliffs, N.J.: Prentice-Hall, 1971), p. 352

Siege1, S. "Non parametric Statistics for the Behavioral Sciences". (New York: McGraw-Hill, 1956)

Sinha, S.P. "The role of the temporal lobe in hearing", (unpublished Master's Thesis, McGili Univ. 1959). cited by Nandur, S.U. "A Test of Bar Preference for Music" (unpublished Master's Thesis, Uhiv. Mysore, . 1976), p.15

Smith, K.U. Delayed Sensory Feedback and Behaviour. (Philadelphia: Sanders, 1962)

Smith, K.U., and Tierney, D. "Delayed Speech Feedback and Age", J. Speech Hear. Res., 14 (1971), 234-219

Soderberg, G. "DAF and Stuttering", J. Speech Hear. Dis.. 33 (1968), 260-267

"Delayed Auditory Feedback and the Speech of Stutterers", J. Speech Hear. Pis.. 33 (1969), 20-29

__________ "A Study of the effects of delayed auditory side-tone on four aspects of stutterer's speech during oral reading and spontaneous speaking", (Ph.D. dissertation, Ohio State Univ. 1959). cited by Soderberg, G. "Delayed Auditory Feedback and the Speech of Stutterers" J. Speech Hear. Dis.. 34 (1969), p.21

Sommers, R.K. et al "Dichotic Ear Preferences of Stuttering Children and Adults", Percept. Motor Skills. 41 (1975), 931-938. cited in dsh abstracts, 1976, No.3, p.479

Spilka, B. "Some Vocal Effects of Different Reading Passages and Time Delays in Speech Feedback", J. Speech Hear. Dis.. 19 (1954), 33-47

______. "Relationships Between Certain Aspects of Personality And Some Vocal Effects of Delayed Speech Feedback", J.Speech Hear Dis.. 19 (l954b) 491-503

Sparks, R., and Geshwind, N. "Dlchotic listening in man after section of neurocortical commissures", Cortex. 4, (1968), 3-16. cited by Nandur, S.U. "A Test of Ear Preference for Music" (unpublished Master's Thesis, Univ. Mysore, 1976), p.15

Stark, R.E., and Pierce, B.R. "The Effects of Delayed Auditory Feedback on a Speech-related Task in Stutterers", J. Speech Hear. Res.. 13 (1970), 245-253

Stetson, R.H. "Motor Phonetics: A Study of Speech Movements in Action", (Amesterdam: N. Holland Publ. Co., 1951). cited by Smith, K.U. Delayed Sensory Feedback and Behaviour (Philadelphia: Sanders, 1962), p.53

Stier, E. Untersuchen uber Linkshandigkeit und die funkionellen Differenzen der Hirnhalften. Jena: Fischer, 1911. cited by Van Riper, C. The Nature of Stuttering (Englewood Cliffs, N.J.: Prentice-Hall, 1971), p.351

Stromsta, C. "Delays associated with certain side tone pathways", J. Acous. Soc. Amer.. 34 (1962), 392-396 cited by Van Riper, C. "The Treatment of Stuttering. (Englewood Cliffs, N.J.: Prentice-Hall, 1973), p.117

Studdert-Kennedy, M., and Shankweiler, D. "Hemispheric Specialization of Speech Perception", J. Acoust. Soc. Amer.. 48 (1970), 579-594

Spuehler, H.E., "Delayed Side-tone and Auditory Flutter", J. Speech Hear. Res.. 5 (1962), 124-132

Spuehler, H.E., and Fulton, R.T. "Effects of Frequency Filtering and Delayed Side-tone on Vocal Responses", J. Speech Hear. Res.. 5 (1962), 382-386

Tiffany, W.R., and Hanley, C.N. "Adaptation to Delayed Side-tone", J. Speech Hear. Dis.. 21 (1956), 164-172

Tomatis, A. L'oreille et le Langage. Paris: Editions du Seuil, 1963

Tomatis, A. "Recherches sur la Pathologie du Begaiement", Journal Francaise ORL. 3 (1954), 384-390. cited by Van Riper, C. The Nature of Stuttering. (Englewood Cliffs, N.J.: Prentice-Hall, 1971), p.359

Travis, L.E. Speech Pathology (New York: Appleton-Century-Crofts, 1931). cited by Van Riper, C. The Nature of Stuttering. (Englewood Cliffs, N.J.:Prentice-Hall, 1971), p.351

Tsunoda, T. Tsunoda's Method: A new objective testing method available for the orientation of the dominant cerebral hemisphere towards various sounds at its clinical use, Indian J. Otol.. 18 (1966), 78-88

__________ "Contralateral Shift Cerebral Dominance for Non-verbal sounds during Speech Perception, J. Aud. Res.. 9 (1969), 221-229

Tsunoda, T., and Moriyamah. "Specific Pattern of Cerebral Dominance for various sounds in adult stutterers", J. Aud. Res.. 12 (1972), 216-227

Van Riper, C. The Nature of Stuttering. (Englewood Cliffs, New Jersy, 1971, Prentice-Hall)

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

Mebster, R.L., and Lubker, B.B. "Masking of auditory feedback in stutterer's speech", J Speech.Hear. Res., 11 (1968), 219-223

Winchester, R.A., Gibbons, E.W., and Krebs, D.F. "Adaptation to sustained Delayed Side-tone", J Speech Hear. Dis., 24 (1959), 25-28

Winchester, R.A., and Gibbons, E.W. "Relative effectiveness of three modes of delayed side tone presentation", Arch. Otolaryngol., 65 (1967), 275-279. cited by Yates, A.J. "Stuttering" Behaviour Therapy. N.T.: John Wiley and Sons, Inc., 1970)

Wiener, N. Cybernatics, (N.Y.; Wiley, 1948). cited by Van Riper, C. The Nature of Stuttering. (Englewood Cliffs, N.J.:Prentice-Hall, 1971), p.383

Wischner, G.J. "Stuttering as Learned Behaviour; A Program of Research", (Doctoral dissertation, Univ. Iowa, 1947). cited by Van Riper, C. The Nature of Stuttering. (Englewood Cliffs, N.J.:Prentice-Hall, 1971), p.303

____ "Experimental Approach to Expectancy and Anxiety in Stuttering Behaviour", J. Speech Hear. Dis.. 17 (1952), 139-154

____________ "Stuttering Behaviour and Learning", J.Speech Hear. Dis.. 15 (1950), 324-335

Wyke, B. "Neurological Mechanisms in stammering: An hypothesis," Britis. J. Dis. Commun.. 5 (1970), 6-15

West, R. "An Agnostic's Speculations About Stuttering", cited in Stuttering: A Symposium, Jon Eigenson (ed) (N.Y.: Harper and Row, 1958)

Wolf, A.A., and Wolf, E.G. "Feedback processes in the theory of certain speech disorders", Speech Pathology and Therapy. 2 (1959), 43-55. cited by Van Riper, C. The Treatment of Stuttering. (Englewood Cliffs, N.J. Prentice-Hall, 1973), p.117

yates, A.J. "Delayed auditory feedback", Psychol. Bull.. 60 (1963a), 213-232. cited by Yates, A.J. Behaviour . Therapy. (N.Y.: John Wiley and Sons, Inc. 1970) p.108

________ "Recent empirical and theoretical approaches to the experimental manipulation of speech in normal subjects and in stammerers", Behv. Res. Ther.. 1 (1963b), 95-119. cited by Van Riper, C. The Nature of Stuttering (Englewood Cliffs, N.J.-Prentice-Hall, 1971), p.388

____________ "Stuttering" in Behaviour Therapy. (N.Y.: John Wiley and Sons, Inc. 1970)

Zerneri, L. ("Attempts to use Delayed Speech Feedback in Stuttering Therapy"), J. Francais d' Oto-Rhino-Larvngo-logie et Chiruraie Maxillo-Facile. 15 (1966), 415-418- cited by Van Riper, C. The Nature of Stuttering, (Englewoof Cliffs, N.J.:Prentice-Hall, 1971), p.389

APPENDICES

APPENDIX A

Table I - Showing Number of Speech Errors in Normals

sL No.	Ss	NAF	$R_{DAF}-L_{DAF}$			$R_{DAF}-L_{NAF}$			$L_{DAF}-R_{NAF}$		
			0.1	0.2	0.3	0.1	0.2	0.3	0.1	0.2	0.3
1	A	2	40	22	23	14	23	9	13	15	15
2	B	7	27	16	10	19	10	16	10	9	16
3	C	0	10	8	7	5	8	20	8	5	12
4	D	9	10	12	12	12	15	13	17	14	12
5	E	0	1	2	2	0	2	1	3	3	2
6	P	0	16	16	17	16	15	14	13	10	7
7	G	0	16	18	15	7	6	5	2	1	6
8	H	1	3	19	13	7	5	5	9	8	6
9	1	6	45	27	33	29	28	12	11	6	14
10	J	3	25	29	17	17	19	10	8	8	5
11	K	2	13	38	33	11	17	5	13	7	11
12	L	4	15	15	9	12	17	6	8	9	5
13	M	0	18	20	19	7	9	8	8	9	7
14	N	1	31	49	46	23	43	37	22	15	11
15	0	3	22	15	8	5	8	8	6	3	4

Note: 0.1, 0.2 and 0.3 are time delays in seconds

Table II - Showing Number of Speech Errors in Sutterers

Sl. No.	Ss	NAF	$R_{DAF}-L_{DAF}$			$R_{DAF}-L_{NAF}$			$L_{DAF}.R_{NAF}$		
			0.1	0.2	0.3	0.1	0.2	0.3	0.1	0.2	0.3
1	As	5	29	17	12	8	8	10	8	5	6
2	Bs	21	14	10	11	16	13	10	15	11	13
3	Cs	17	16	13	10	15	14	14	13	12	16
4	Ds	10	3	10	18	8	7	2	3	8	3
5	Es	15	10	13	14	8	7	2	7	9	15
6	Fs	19	10	12	8	9	6	5	5	7	8
7	Gs	15	11	13	9	18	14	6	15	13	3
8	Hs	12	10	19	15	18	20	12	8	16	11
9	Is	9	1	8	11	4	6	7	5	3	5
10	Js	6	12	20	12	8	9	9	8	7	8
11	Ks	S	14	16	10	12	14	11	10	9	8
12	Ls	25	7	10	10	6	5	5	3	10	11
13	Ms	5	6	14	6	4	9	10	10	5	9
14	Ns	10	5	20	10	8	8	2	8	14	6
15	Os	5	3	3	6	4	6	5	4	6	3

Note: 0.1, 0.2 and 0.3 are time delays in seconds

Table III - Showing Time Taken to Read the "1 Min" Passage
in Normals
(in seconds)

Sl. No.	Ss	NAF	$R_{DAF}-L_{DAF}$			$R_{DAF}-L_{NAF}$					
			0.1	0.2	0.3	0.1	0.2	0.3	0.1	0.2	0.3
1	A	53	66	81	90	70	72	71	64		69
2	B	63	83	73	79	75	84	73	69	72	75
3	C	57	70	68	65	69	80	75	70	68	70
4	D	52	50	52	55	51	58	46	51	47	50
5	E	50	55	58	53	58	58	54	47	50	54
6	F	65	65	76	80	80	81	85	70	76	69
7	G	57	65	71	75	58	64	61	55	58	59
8	H	52	69	76	72	62	60	52	56	60	61
9	1	69	80	75	86	77	80	70	69	68	61
10	J	72	80	70	69	75	73	57	55	64	66
11	K	70	77	105	107	80	84	72	77	76	82
12	L	66	71	64	63	63	67	63	60	62	73
13	M	66	90	90	84	77	81	66	64	65	75
14	N	63	94	128	108	80	109	97	72	85	89
15	0	54	77	69	74	74	72	75	73	64	67

Note: 0.1, 0.2 and 0.3 are time delays in seconds

Table IV - Showing Time Taken to Read the "1 MiN" Passage
in Stutterers
(in seconds)

sl. No.	Ss	NAF	R_{DAF}-L_{DAF}			R_{DAF}-L_{NAF}			L_{DAF}-R_{NAF}		
			0.1	0.2	0.3	0.1	0.2	0.3	0.1	0.2	0.3
1	As	76	95	102	97	82	85	85	77	73	76
2	Bs	85	95	108	100	90	98	92	88	85	86
3	Cs	68	78	80	70	69	74	79	75	73	74
4	Ds	55	71	70	70	61	61	55	52	63	60
5	Es	78	95	99	100	95	101	92	82	86	90
6	Fs	185	132	168	160	143	189	144	134	156	140
7	Gs	58	53	75	80	70	72	56	72	66	69
8	Hs	90	100	105	96	104	100	124	98	101	106
9	Is	63	84	116	113	80	30	71	71	72	87
10	Js	74	89	94	95	70	91	79	65	84	86
11	Ks	80	S3	86	85	90	94	96	79	81	85
12	Ls	145	131	161	167	132	144	150	103	116	151
13	Ms	67	120	119	30	72	70	70	77	70	70
14	Ns	145	80	90	90	95	107	91	75	90	95
15	OS	73	77	79	105	91	80	70	80	85	95

Note: 0.1, 0.2 and 0.3 are time delays in seconds

APPENDIX B

The "1 MINUTE" Passages ased as Reading Material in this Study:

1. **R_{NAF}-L_{NAF}**

I pushed myself out of the chair and started for the door, arriving just as the struggling figures again passed by. I recognized them: one was the physical therapist and the other was Miss Ransom of Room 11. They faced each other with their hands on each other's shoulders, and the therapist walked slowly backwards while Miss Ransom followed, lurching and rolling. Before coming to Brrookhaven, she had been in bed for three years, and the physical therapist was now trying to bring some strength back into her leg muscles. They night have been performing an extremely awkward dance, but it was made chilling by the rhythmic, stereo-typed rotation of her head, and by the gaping mouth, the pleading eyes. These were involuntary motions over which she had no control. The disorder was called "dyskinegia" and was not a basic symptom of Parkinson's disease bat a side effect of some experimental drug she was receiving in the hospital.

3. <u>R_{DAF}-L_{DAF} a± 0.1 sec. delay</u>

In Room 4 was Mr. Kaufmann, a small dapper man of unfailing cheerfulness who had spent years selling ladies' "ready-to-wear" garments. He was the first one out of bed in the morning, taking turns around the rotunda. When he passed my open door he would be leaning far forward, dangerously off balance, taking small, rapid, shuffling steps. This is called "festination," an involuntary increase in the speed of walking in an effort to catch up with a displaced centre of gravity. He never quite caught up. Miss Bramhall occupied Room 7. She was 85, had a master's degree in education, and had been a school teacher of English and American literature. She had severe tremors in both hands. They were in constant, fluttery motion and were at such variance with the quiet dignity of the rest of her that they seemed to have a life of their own.

3. <u>R_{DAF}-L_{DAF} at 0.2 sec. delay</u>

After resting, I tried my left arm, then my legs, with no success. It was as if the force of gravity had triped and was pulling me down hard against the bed. The condition is known as "akinesia," the inability to originate or sustain motion. The mind sends oat an order which is transmitted by nerves to the appropriate muscles, but the message doesn't arrive at the site of the proposed action. It is one of the symptoms of Parkinson's disease. Can will-power force the brain's message through? There is some evidence that it can, spasmodically, at moments of great stress, I shut my eyes and commanded my hand to move upwards and grasp the sheet. And at the same moment I announced the stakes. One part of my brain said to another part, "Either the hand moves now or I give up. If I am defeated in this, I will never again make a demand on you but will remain passively in bed as long as I live."

4- R_{DAF}-L_{DAF} at 0.3 sec. delay

"If you can't get what you want in life, try for something better," he said to his son. "I'm told Harvard University has the best medical school in the country. Apply there. If they are as great as their reputation, they will admit a student like you." George was accepted into Harvard's third-year medical class. Eighteen months later he graduated with distinction, and speaking English. The Brookhaven administration gave him a free hand to search and sow new seeds in any direction he chose. He also discovered he was able to establish a unique relationship with his patients. There was wonder in his voice when he said, "never once have I asked a patient to take a new, potentially dangerous drug and have him refuse. They might hesitate, they might say, 'Let me think it over,' but they always ended by saying 'Yes'". I had already sensed this devotion and loyalty. It lay behind my own desire to establish a "special" relationship with him.

5. R_{DAF}-L_{NAF} at 0.1 sec. delay

A variety of employees had business in my room that morning - all of them professionally cheerful, undaunted by the "Parkinson mark" I wore. Just as my fingers could barely button a shirt, so my face could not portray animation. Even my speech had grown faint. Yet behind this mask I was alert to the events both inside and outside the room. The day shift of nurses came on about 8 a.m., and in the rotunda beyond my open door there had grown a chorus of lively voices. Bach of the 12 wedge-shaped rooms in this wing opened on the rotunda, where two nurses sat at a large, circular desk, busily writing on charts. A third nurse was counting pills and an orderly was arranging tubes and syringes on a chart. At about nine o' clock I was aware of a sudden hush. It all seemed to be a stage, with the actors in place just after the curtain has gone up and before the entrance of the star.

6. R_{DAF}-L_{NAF} at 0.2 sec. delay

The surgeon who would perform the operation that I would see was Dr. Jorge Mendez, a Chilean professor, working under Cotzias for a year. Wearing a long white laboratory coat, he led me to his operation room. It was not the antiseptic area I had expected. There was a clutter of books, filing cases, graphs, reports, bottles. A spiral of plastic tubing led into a transparent container about the size of a shoe box. It was in this that the rat would be anasthetized. On a filing case on the other side of the room was a cage in which the "patient" waited* He regarded me with small, red eyes while his whiskers twitched. His fur was pure white and immaculatley groomed. A notch in the tip of one pink ear indicated his birth-date - he was 36 days old. He was the 176th rat to undergo surgery inducing fake Parkinsonism in this laboratory since the first of the year.

7. R_{DAF}-L_{NAF} at 0.3 sec. delay

The hand began to move slowly, jerkily, up and across.

Crabbed fingers grasped the sheet and pulled it off my body. I tried myself to a sitting position, my legs dangling over the edge of the bed. I was trembling and sweating. After resting a minute or so, I levered myself erect and started towards the bathroom. Placing one foot in front of the other required all the strength that I had. I seemed knee-deep in slowly hardening concrete. Dressing became an obstacle course, each garment presenting new problems. The seemingly simple process of inserting a series of shirt buttons into their appropriate holes required the quick and subtle co-ordination of many nerves and muscles in hands and fingers. On this morning my fingers were as responsive as a bunch of bananas- But at last I was dressed except for shoes. Tying the laces brought defeat. Twice I tried and twice I gave up.

3. L_{DAF}-R_{NAF} at 0.1 sec. delay

In Room 10 was Mrs. Chandler, who I labelled our resident Brahmin. Upon arrival she had announced that her husband was descended from a distinguished and wealthy Boston mercantile family; her daughter had published three volumes of poetry; her son was a post-graduate student in anthropology; she was chairman of the board of a prestigious museum. Mrs. Chandler had postural instability.

Which meant that as long as she was walking or sitting she appeared normal, but when she was standing around (as at a cocktail party or during a cinema intermission) an abnormal motor activity took over. She constantly shifted her weight from leg to leg and her pelvis rotated slightly. This was not unlike the sexy movements of cabaret performers, and it was startling to see them being done by this aristocratic lady.

9. L_{DAF}-R_{NAF} at 0.2 sec. delay

"Bureaucrats'" he would explode. "They seem to think that the only way to advance is by obstruction. They can talk a new idea to death." But in the next breath he would shrug philosophically. "You work where you can accomplish the most. If I had wanted the easy life I would have stayed in the sunshine, and sipped the vines of Greece." George and his family had been refugees from their homeland during the Second World War. His mother, Katherine, was an intellectual with wide literary connection, and her elegant drawing room in Athens was something of a literary salon. His father, Constantin, entered politics and in 1934 was elected mayor of Athens. But when the German army swept down upon the capital in 1941, the family fled, eventually arriving in New York - penniless. Young George had interrupted his medical education to serve with the Greek army's medical corps.

10. L_{DAF}-R_{NAF} at 0.3 sec. delay

I swam upwards out of the blackness of drug-induced sleep. Surfacing, I opened my eyes to find myself on a bed in a wedge-shaped room: curtains at a single window were embroidered with brightly coloured yarn, but the furniture was gray metal. The room seemed part motel and part institution. I was in a hospital, but an unusual one. It was called the Hospital of the Medical Research Centre, Brookhaven National Laboratory, and the only patients were those on whom research was being down. I had signed myself in as a "human guinea pig". As the effect of the sleeping pills receded, I reached to throw off the covers and climb out of bed. But nothing happened. I continued to lie on my back, the sheet and blanket remained over me, my two arms resting on top. Again I decided to throw off the covers and again nothing happened. My breathing became shallow and quick as panic constricted my chest. This was nothing new.

APPENDIX C

TECHNICAL DATA

Ahuja Tape Recorder Model TR-6

The Ahuja TR-6 Tape Recorder is a three speech high quality instrument specially designed to meet the requirements for recording and play back of music, speech and radio programmes. It is foolproof in design and easy to operate. Three separate motors ensure long and trouble free service.

General specifications

Size of Reel	:	7 inches
Track width	:	0.091 inch
Number of tracks	:	2
Number of motors	:	Three 4 pole induction typ
Number of heads	:	8
Operating speeds	:	1 7/8", 3 3/4" and 7 1/2"
Frequency response	:	1 7/8" per sec = 70-4500 c
		3 3/4" per sec = 50-6000 c
		7 1/2" per sec = 50-11000
Wow and flutter	:	Less than .2% @ 7½" per se
Long term speed stability	:	Better than .5%

Input level (for full depth recording)	:	Microphone .003V.RMS
Erase and Bias frequency	:	51 Kc/s approximately
Signal to Noise Ratio	:	Better than 45 dB
Working voltage	:	220-330V AC 50 cycles
Power consumption	:	95 watts
Plane of operation	:	Horizontal
Output (preamplifier)	:	(.025V RMS) for connecting to external amplifier system

Additional Motor for DAF unit

It is a single phase AC motor. Works on 220V - 50 Hz. HP is 1/16. RPM - 1500 revolutions per minute.

Rheostat

It is a 100 watts wire wound Rheostat manufactured by Precision Electronics, Bombay. The variable point is driven by means of rotor mechanism, so that small voltage variations could be achieved, when incorporated in a circuit, as a potential divider.

Voltmeter

It is German make Voltmeter Type Unigor 4 p made by

Goerz Electronics. Sensitivity - 100 K ohm/volt, 20000. Error in measurement ± 1.5%. It is a conventional meter with more accuracy.

Ampex Microphone

The Ampex Microphone is a high impedance, omni-directional dynamic microphone used for recording. Optimum frequency response is provided in the critical range of 60 Hz - 15000 KHz.

Ahuja Microphone

Type	:	AUD-77
Frequency response	:	100-10 KHz
Sensitivity	:	-52 dB (+ 3 dB)
Impedance	:	high impedance 50 K. ohms
General purpose	:	unidirectional, dynamic microphone

Arphi Speech Trainer

It is a valve version amplifier of power output 20W. Input sensitivity is 2 m. volts. Frequency response - 50 Hz - 50 KHz. Distortion - less than 3%.