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HOW DO SPEAKERS PARSE TIME?

PARAMETERS OF RHYTHMIC TEMPORAL PATTERNING IN NATURAL SPEECH OF NORMAL SPEAKERS, FORMER STUTTERERS, AND STUTTERERS

by

FRANCES NASH PODWALL

A dissertation submitted to the Graduate Faculty in Speech and Hearing Sciences in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York.

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ABSTRACT

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Adviser: Professor Louis J. Gerstman

This experiment was designed to investigate rhythmic time patterns of speech in individuals operating at several levels of fluency, and to assess the extent to which disfluent speech is manifested as a timing control disorder. Two five-minute spontaneous speech monologues were recorded from 18 adult male subjects, representing three equal groups of normal speakers, former stutterers and stutterers. Subjects were recorded under two conditions. Condition 1 consisted of a five-minute monologue without a listener; Condition 2 was a five-minute monologue with a receptive listener present. Employing the automated speech analysis system of the New York State Psychiatric Institute, speech samples were segmented into phrases and pauses, the phrases further subdivided into full (stressed) syllables and unstressed transyllabic segments.

From estimated mean durations of these component segments overall articulation rate in syllables per second and a variety of articulatory and phonological measures were derived.

A discriminant analysis identified two parameters -- length of syllabic period and phrase length -- as the major determinants uniquely distinguishing individuals belonging to the three groups. The rhythmic pattern of normal speech which emerged is one of short syllabic periods clustered in long phrases. Results of the investigation confirmed our predictions that 1) Speech of normal speakers is significantly more efficient, i.e., occurs at a higher rate with more accurate timing, than is the speech of former stutterers, while speech of stutterers is least efficient of all on both criteria of rate and timing accuracy. 2) Speaking in the presence of a listener facilitates speech rate in all groups, an increase accomplished primarily by a shortening of syllables and pauses.

A virtually isochronous syllable period was identified for normal speakers. The timing of the syllable period was so accurate that its variance was less than the sum of the variances of its component subsegments in all cases. Greater period variances in stutterers and former stutterers, in association with significantly longer transyllabic segments and shorter phrases, points to the existence of two control modes differing in efficiency. The control mode found among normal speakers is one of discontinuous timing, as rhythms are maintained among segments whose mean durations change in opposite directions. A simpler, less accurate timing mechanism accounts for the behavior of the stutterers.

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CHAPTER I

INTRODUCTION

> Broadly speaking one may say that the sciences derive from pattern-seeking, the arts from pattern-making though there is a much more intimate relation between the seeking and making of patterns than this would suggest.
>
> W. Grey Walter

Speech is a temporal art. The patterns of which it is composed have been compared to those of music because of the importance of time and rhythm to both. In speech, as in music, the sense of time includes the sense of rhythm, timing being the more general concept. Further, rhythm depends on time: a combination of precision and variation in the parsing of time underlies music and underlies speech that is rhythmic as well. In music the primary unit is the motif, a recurring group of durations. The identification of similar primary units is central to study of speech structure.

Statement of the Problem

Unfortunately, the generation of rhythmic speech, the nature of its basic units, and the differential abilities of individuals of varying degrees of fluency to control its timing patterns are areas in which a dearth of experimental investigations exists. The lack is all the more remarkable in view of the recent acceleration of interest in theories of speech timing. In the case of natural speech the customary lag between theory and application is made greater by the technical difficulties presented by the problem of segmenting ongoing continuous speech. Although events are transitory, it is necessary to measure segments accurately, and while boundaries overlap, decisions must be consistent with phonological reality. This will require samples large enough so that believable patterns may emerge such as are there to be found.

Recent studies of speech timing in the literature include reports from diverse disciplinary sources in the United States, while those originating from abroad represent the work done in phonetics laboratories, particularly those of Sweden, Holland, England and the USSR. Much cross-germination occurs among these laboratories and parallel durational investigations are in progress. Unfortunately, none of these durational studies attempt to look at spontaneous speech. Speech timing has been discussed theoretically and extensively in the normal speaker (e.g., Abercrombie, 1964; Allen, 1972; Allen, 1973; Jones, 1956; Kozhevnikov and Chistovich, 1965; Lehiste, 1970; Lennenberg, 1967; Lindblom and Rapp, 1973; NacNeilage, 1970; Martin, 1972; Nooteboom, 1973; Oller, 1973) and rather less extensively in the pathological speaker (e.g., Beech and Fransella, 1968; Van Riper, 1971). Some few studies have experimentally measured durations of standard predetermined vowels or consonants (e.g., Lindbloom and Rapp, 1973; Nooteboom, 1973; Peterson and Lehiste, 1960), repetitions of words or phrases (e.g. Kozhevnikov and Chistovich, 1965; Oller, 1973; Rapp, 1971) or the repeated readings of test sentences (e.g., Cooper and Allen, 1973; Lehiste, 1973) in order to compare durations of segments and reliability of replication. The present study has been undertaken to provide further information in the area, information on the spontaneous speech timing of individuals operating at several clinically defined levels of speech fluency. It will be of particular interest to learn whether a close relationship obtains between the speech timing accuracy exhibited by these subjects and the fluency category in which they have been placed.

Models, Strategies of Analysis, and Literature

Allen and Tingley (1974) distinguish two types of timing models. They describe the "correlational" or "variance" model which looks at correlations between the durations of complementary phonetic segments and examines variances of particular phonetic segment durations. The work of Kozhevnikov and Chistovich (1965) looks at speech segments in this manner, as does that of Lehiste (1970, 1973); Wright (1974) and Allen and his associates (Cooper and Allen, 1973; Tingley and Allen, 1975). The second type of model, the "mean duration" model concentrates on average durations of particular phonetic segments rather than temporal interaction between segments. The classic studies in the field are of this type and recent experimental examples may be found in the work of Lehiste (1973), Lindblom and Rapp (1973), and Nooteboom (1972).

Actually "variance" and "mean" are inseparable parameters if one wants to deal with a customary metric for variation: the squared error about the mean. Accordingly, the present study will include analyses based on both the "variance" and the "mean duration" models in an effort to discover temporal interactions, if such exist in the data, between complementary phonetic segments, as well as evaluating tendencies toward regularity within particular speech units. This approach should yield information relative to the neural mechanism which controls accuracy of speech timing.

The idea of using the variance of a period as a measure of timing accuracy can be traced back to André Classe (1939). Classe proposed an hierarchical scheme of rhythmic units and relations starting with the syllable and extending at least to the sentence level and perhaps beyond;

> It seems highly probable that the sentence is very often a rhythmic unit as well as a grammatical,

> logical and phonetic one. Whether it affects, or is affected by, its neighbours, remains to be seen.
> (Classe, 1939, p.48)

Classe here concurs with Daniel Jones' (1956; also in Leipzig edition originally published 1918) earlier formulation on the rhythmic unity of the sentence and its effect on the duration of stressed and unstressed syllables:

> Vowel-length depends to a considerable extent on the rhythm of the sentence. There is a strong tendency in connected speech to make stressed syllables follow each other as nearly as possible at equal distances.... The usage may be stated more fully as follows: when a syllable containing a long vowel or diphthong is followed by unstressed syllables, that vowel or diphthong is generally shorter than if the syllable were final or followed by another stressed syllable; moreover, the greater the number of following unstressed syllables the shorter is the stressed vowel....
> (Jones, 1956, p. 237)

The present study has been designed to analyze rhythmic patterning at microstructural and macrostructural, that is syllable and phrase levels, as the necessary prerequisite to understanding the more complex rhythmic relations manifested at the supraphrase or sentence level that Classe considers definitive. Classe's principles are, however, accessible to our levels of analysis, for they are set forth in terms of intraphrase as well as interphrase relations. We can go on to consider our results in terms of his prior formulations on stress groups, looking at statistical analyses of our three populations at the syllable and phrase level.

Classe conducted extensive and careful investigations on structure and clustering of linguistic stress groups using examples of rhythmically diversified material. His subjects read the examplars presented three times and beat out the rhythm as they read. Timing of rhythmic schemes was analyzed by means of kymograph tracings, a method in which utterance length is recorded on a revolving cylinder. Among the experiments Classe reports is one in which a group of five subjects read twelve sentences (e.g., 'Two historians never describe events in exactly the same way') aloud. In the main experiment reported a group of thirteen subjects read passages representing English literature selected to sample five levels of presumed rhythmicity, grading from poetic prose to colloquial play dialogue.

Results of the three readings by each subject were averaged and standard deviations for stress groups calculated. Classe discards introductory words of a sentence, such as "There are," considering them to constitute a warm-up period rather than an integral part of the rhythmic scheme. In the sentence "It's a menace, a pitfall, a stumbling-block, etc.) "It's a" is discarded and the onset of the first stress group, "menace," is where measurement is initiated. For purposes of reliability Classe's computations are based on utterances which contain four or more stress-groups. Classe's findings on hierachical levels of rhythmicity both in different levels of reading material and in individuals themselves led him to focus on isochronism as the essential substrate of rhythm in the English language.

Computer Analysis of Rhythm and Rate

Lenneberg (1967) seems to project the development of the type of microsegmental analysis we will attempt. He proposes the existence of a basic time unit which has a duration of one-sixth of a second, as well as the flexibility to pattern these units differentially in order to vary the rate of speech. Lenneberg expects:

> .... within-subject variations [which] would, of course, be subtle and detection would require statistical analysis of the periodic phenomenon involved.
>
> The statistic necessary to prove or reject our hypothesis is quite simple, at present the only obstacle is the necessity of making observations and measurements of hundreds of thousands of events. Suppose we programmed an electronic computer to search the electrical analogue of a speech signal....
>
> (Lenneberg, 1967, p. 119)

Such a speech analysis system has been programmed (Anderson and Jaffe, 1972) and this study was made viable through access to this efficient and economical method of computer processing.

To our knowledge, the only studies in the literature which use and report on computer analysis of speech have been limited preliminary investigations (Anderson and Jaffe, 1972; Jaffe, Anderson and Rieber, 1973; Zeidenberg et.al., 1973) employing earlier versions of the system on which this study was based. The pioneering study (Anderson and Jaffe, 1972) looked at reading conditions in normals and found that the speech of a trained radio announcer showed shorter mean durations of measured vocalic segments than that of the average adult, while the speech of an adult showed shorter mean durations of measured vocalic segments than that of a 5-year-old child. Reading conditions in pathological groups were compared and the mean duration of vocalic segments measured in the speech of stutterers was shown to be greater than that of clutterers. In Zeidenberg et.al., (1973) the effects of delta-9- THC (marihuana) on speech were investigated and frequencies and mean durations of phrases, pauses and vowels, three parameters of speech rate were examined. Results in a spontaneous speech task showed a three-way decrease in speech rate, as evidenced by prolonged vocalic syllables, fewer vocalic syllables per phrase, and increased pausing under the influence of the drug. Jaffe, Anderson and Rieber (1973) compare the results of the above described studies, derive a formula for speech rate and disallow the notion of a single speech-regulating biological clock, based on evidence of opposing movement in relevant speech parameters, namely mean duration of vocalic segment, phrase and pause.

The germinative work of Kozhevnikov and Chistovich

(1965) included the notion of separating rate considerations from those of rhythmic programming as part of an early and exhaustive effort to identify and characterize the nature of the articulatory speech unit. Based on intensive study of the production of several normal speakers, Kozhevnikov and Chistovich found evidence for a rhythmic organization of syllable commands within a unit they term the syntagma. The syntagma is described as an utterance (a sentence or its part), distinguished by meaning and obligatorily pronounced within one articulatory output. Syntagmas are separated from each other by pauses, while syllables within the syntagma are run together, and its length is congruent with man's short term memory. Absolute durational values of syntagmatic elements vary, but constancy may be found in relative durations of the elements, according to these authors, who tell us that if we "consider the syntagma as a sequence of syllables, its rhythmic figure is an invariant and is completely independent of the rate of speech" (Kozhevenikov and Chistovich, 1965, p. 89).

Speech Preplanning, Speech Chaining and the Role of Feedback

Among the goals of the present research will be an effort to view our findings in the light of the unitary speech preplanning model Kozhevenikov and Chistovich propose, the ballistic development of it described by Martin (1972) and Anderson (1975), and also with reference to the combination preplanning and speech chaining model presented by Lindblom and Rapp (1973; Rapp, 1971). Working with Swedish subjects, Lindblom and Rapp derive a recursive model of temporal compression, Rapp using nonsense syllables with the second syllable stressed; the paradigm is extended to phrases and, sentences through use of a reiterative CV framework. Findings indicate the presence of both anticipatory and backward compensation which act together to compress the duration of medial vowels. This bilateral compression is cited as evidence for the working of a central planning mechanism in which anticipatory compensation shows greater effects on vowel contour than does backward compensation.

Rapp's (1971) study supports speech chaining as well as preplanning inasmuch as her results show F_0 contours to be synchronized during the stressed vowel despite considerable variation in durations of preceding constants or clusters. Her results and those of other investigators described below suggest the existence of a time module composed of flexible and inflexible units of duration strung together, that is accented vowel units which are preprogrammed and ballistically controlled (Anderson, 1975; Martin, 1972) and other units (e.g., consonant clusters) which are not. This type of mixed ballistic and monitoring strategy appears to be the likeliest candidate for a model of speech production based on work which supports the existence of each type of mode (e.g., Borden, 1971, Kent and Moll, 1975) and findings such as Rapp's (1971) which indicate duality of mode. Using oscillographic analysis, both Haggard (1973 a,b) and Lindblom and Rapp (1973) report some abbreviation of consonantal durations as a function of clustering. Postvocalic consonants usually being of longer duration than prevocalic, Haggard (1973 b) suggests that it is reasonable to expect them to be more subject to reduction, there being more elasticity in the lengthier sequences. Such consonantal reductions rapidly reach a plateau, however, due to conflict of opposing demands. Cluster compression is necessarily quite limited. An articulatory mechanism at the outset, is working close to the boundary of capability in order to produce a series of sounds with durations long enough so that they seem discrete together with movement patterns coordinated for optimal efficiency and so cannot readily accommodate additional temporal compression.

Further explanatory detail which gives physiological support to this type of model may be obtained from the experimental efforts of Kent and Moll (1975). Kent and Moll report that their ability to measure the brief durations between articulatory closures was dictated by the temporal resolution of the cinefluorographic film used to observe movements of tongue and lips, radiopaquely marked as consonant sequences were produced in various positions within a variety of linguistic contexts, e.g., /spr/. Sequential articulatory gestures were often so brief that only 10 msec separated one from the other. As the authors state, ".... events are timed so closely that their succession is barely resolved by the 10-msec sampling interval provided by the cinefluorographic film"(Kent and Moll, 1975, p. 313). Some support for chaining and probable operation of feedback loops is provided by their report that ".... many subintervals within a given sequence were almost constant in duration even though the total duration of the sequence was variable" (Kent and Moll, 1975, p. 319).

Evidence such as that presented in the foregoing studies continues to accumulate in refutation of Lashley's (1951) argument that there is insufficient time for peripheral feedback loops to operate in rapid skilled movements such as speech, and Lenneberg's (1967) corollary requiring staggered timing of motor commands due to the need to coordinate differential response times of larynx and articulators. Commands to the larynx,for instance, would necessarily have to be given 30 msec earlier than those to the lips. Although reaction times in man are estimated to be on the order of 100-200 msec in response to auditory and tactile stimuli (Kozhevnikov and Chistovich, 1965), much shorter latencies have been reported. These latencies are short enough to make it seem plausible that there is enough time for a round-trip, afferent impulse to brain and efferent impulse to articulators, within the time slot which sequential speech segments occupy.

For example studies by Kugelberg (1952) and Rushwind (1966) are cited by Ohala (1970) to demonstrate the existence of remarkably short facial reflexes in humans (e.g., eyeblink and masseter reflex), reflexes which have latencies on the order of 12-15 msec and less. Kent and Moll (1975) suggest that "....if the neurophysiology of man is like that of monkey, the round trip neural transit time may be as short as 10 msec ...." (Kent and Moll, 1975, p. 306) based on Bowman and Combs' (1968) observation that stimulation of hypoglossal nerves in monkey evoked cerebral potentials with latencies of 4-5 msec.

Borden (1971) studies the role and importance of feedback on speech by attempting to prevent sensory input to the various modalities using several methodologies, including that of mandibular block. After extensive perceptual and electromyographic investigation, she concludes that the elimination of feedback may present insuperable difficulties:

> One possibility we must not fail to consider is that we have never achieved total blockage of the feedback systems. It has been our experience that to block out the bone conducted sound of our own voices is painful if not impossible, in the same way, lingual and palatal anesthetization may leave many other clues from sensory endings in the back of the tongue in addition to sensory information from receptors well below the area of anesthetization. It might be that pronounced effects would result from complete blockage of either system.
>
> (Borden, 1971, p. 125, 126)

Finally, we may not be beyond the long arm of the feedback loop, even in our sleep. Arkin and Brown (1971) give examples of subjects' self-corrections during sleep-talking, e.g. "noked, naked day dreams." Observations such as these may indicate that "auto-speech monitoring mechanisms are capable of functioning during sleep albeit at levels of efficiency which show marked variation" (Arkin and Brown, 1971, p. 1).

In the self-corrections of the child learning to speak we can observe the operation of feedback and appreciate its importance in language acquisition. There is evidence however that the child's reliance on feedback, if not his use of it, has largely disappeared by the time he is four (Borden, 1971), and a central planning mechanism has taken over. In other words, when speech is being learned it functions as a closed loop system, when highly learned it functions in open loop fashion. Of course we may elect to consciously monitor speech for various purposes and give special attention to one or several feedback channels, in effect reinstituting the closed loop system on occasion.

Chase (in House, 1967) discusses the child's growing speech mastery in terms of progressive shifts from a closed-loop to an open loop type of operation. If speech development takes a deviant turn, as it does in children who start to stutter, usually at about four years of age, then it is possible that the necessary sequence of progressive shifts that would make preplanned open loop speech production a viable option may not take place. Thus the child's speech production mode may not move beyond some interim stage of closed loop operation. Various physical and psychological theories have been advanced to account for this anomalous development, theories which run the gamut from those dependent on psychodynamic or learning theory bases (for example, see discussions in Bloodstein, 1969 and Eisenson, 1958) to those which assign causality to neurophysiological deficits such as the lack of lateralization and cerebral dominance (Orton, 1927; Travis, 1931). The controversy over causality is far from resolved. In terms of production models, however, it does appear quite apparent to the observer that the stutterer is monitoring and responding to acoustic and peripheral articulatory feedback in a far more sensitive manner than that of the average speaker.

In any event, the operation of feedback in speech is not an all-or-none phenomenon. While we believe that for the normal speaker speech is largely a preplanned open loop activity, there is such richness and redundancy of feedback systems, auditory, tactile and kinesthetic, that in point of fact, what seems impossible is <u>not</u> to have feedback. Hirsh (in House, 1967) tells us that Helmholtz - - in 1864 - - announced that the source of the feedback signal is the command itself. More explicitly, McCulloch (in Arbib, 1972) describes the close coupling of efferent and afferent systems: "The net is such that every efferent peripheral neuron (i.e., every neuron that controls an effector, be it muscle or gland) can be indirectly affected along several paths through the net by each afferent peripheral neuron (i.e., each neuron that is directly affected by a receptor be it sensory cell or other transducer). Every neuron is traversed by at least one such path." (McCulloch in Arbib, 1972, p. 165).

Studies of Timing Control

Tingley and Allen (1975) in their developmental study of speech timing control in children found no evidence of the use of peripheral feedback in the speech task they used. Motor timing control for speech and tapping did however improve regularly with age. The children ranged in age from five to eleven years old and perhaps, consistent with Borden's (1971) result and Chase's (in House, 1967) thesis, had already made the shift from closed to open loop speech production.

The variance findings reported by Cooper and Allen (1973) in another timing-control study have particular interest for us. These investigators examined relative accuracy of timing control as exhibited in the repetition of stock phrases and sentences sampled from normal and stuttering populations. Although there was overlap in the accuracy of timing control between the group of normal and the group of stuttering speakers, on the whole stutterers were the least accurate timers and individuals identified as "cured" stutterers had an average accuracy rank indistinguishable from that of normal speakers.

Since ours is the first comprehensive study to employ naturally generated spontaneous speech for fluency analysis according to a phonetic paradigm, it will be important to compare our results with these measured under the more artificial conditions needed to obtain controlled speech samples in the phonetics laboratory.

Manipulating Speech Production By Means of a Listener

An effort will be made to investigate the effect of controlled interviewer contact with the subject; presence or absence of an appropriately responsive listener will be correlated with the speech variables employed for the periodic analyses of speech from both normal and pathological subjects. By means of this design it will be possible to investigate whether presence of absence of a listener has an effect apart from the more difficult question of how to interpret the psychological process by which it is brought about. Accordingly then, the temporal patterning of three groups, Normal Speakers, Former Stutterers, and Stutterers will be assessed under two speaking conditions: Condition 1, in which the subject is alone and generates a 5-minute Solo Monologue and Condition 2, in which the subject is joined by a listener, and generates a 5-minute Listener Monologue. Speech is tape recorded for subsequent computer analysis.

The Listener condition is generally supposed to be one of higher anxiety than the Solo condition, although the form this anxiety takes has been variously reported (See a comprehensive review by Rochester, 1973). Because of the more stressful nature of the Listener condition, as described in the literature, it is inadvisable to counterbalance the order effect of the two conditions for the reason that it is not feasible to move from a condition of more to one of less anxiety.

Mahl's (1956) classic paper reports that increased silence accompanies topical anxiety. On the other hand, Pope *et.al.*, (1970) observed a decrease in the silences of psychiatric subjects on days that were designated as "high anxiety" days for them. Admittedly one is often dealing with "situational" anxiety superimposed on "predispositional" anxiety in these subjects. A consensual view of the literature would tend to associate both longer pauses (e.g., Cassota, Feldstein and Jaffe, 1967) and, *mutatis mutandis*, more frequent pauses (e.g., Siegman and Pope, 1965) with stressful topics and conditions of high anxiety.

Apart from content and predispositional considerations, is a listener condition *per se* considered to be one of psychological stress as opposed to a no-listener condition?

If increased pausing is taken as index of increased psychological stress, then there is some evidence that the presence of an audience generates anxiety. Rochester (1973) reports studies (e.g., Lay and Paivio, 1969; Levin and Silverman, 1965; Reynolds and Paivio, 1968) where increased pausing accompanies increased interaction, with children as well as adults.

Increased pausing may take various forms; i.e., pauses may be more frequent; pauses may be considerably longer although somewhat less frequent; finally, pauses may be shorter, but more frequent. This last variety of increased pausing could form part of a pattern of high overall speech rate or productivity, of which more syllables per phrase and shorter syllables are other components. A rationale for such a high productivity pattern is suggested by a model of an "internal clock" of the human organism proposed by Michel Treisman (1963).

Treisman introduces the term "specific temporal arousal" (Treisman, 1963, p. 23) to explain increased rates of response which might be expected to include speaking. He suggests that high anxiety levels tend to maintain specific arousal. Treisman maintains that "specific arousal" is a special case of "general arousal" and shows similar features. Parallels are drawn between the effects of "specific temporal arousal," "general arousal," and performance variables such as "interest," "alertness," "vigilance," "motivation," etc. Using Treisman's characterization then, we may relate presumed "general arousal" to the presence of an audience, and go on to predict that Condition 2, the Listener Condition, will show higher rates of speech response than Condition 1, the Solo Condition, due to "specific temporal arousal."

Studies of the Effect of an Audience on the Stutterer

Stutterers are popularly supposed to show a special vulnerability to the presence of a listener, over and above that shown by the normal speaker. Search of the literature, however, reveals a single relevant example, and that one in Russian (Razdolsky, 1965), of research which supports the often repeated, seldom investigated statement that stutterers speak better when they are alone. The attribution of facilitated speaking ability due to isolation is also traditionally extended to conditions in which the stutterer speaks to babies, pets, etc., as compared to those in which he speaks to an audience, converses with peers or with those of superior status. The manner in which the stutterer is affected by his audience has been reported by various experimenters (See discussion in Bloodstein, 1969, Chapter 5). An example Bloodstein cites is that of Porter (1939) who finds that as audience size increases stepwise from one to eight listeners, stuttering also increases progressively.

It should be noted that this study, as well as most others which investigate the relation between increase in audience size and stuttering, do so with respect to the effect of adaptation on reading material, rather than with respect to natural spontaneous speech. The adaptation effect, as described by Johnson (1955), is "the decrease in stuttering, as measured with reference to its frequency or severity, that occurs when a stutterer reads the same passage a number of times consecutively," (Johnson, 1955, p. 15). The use of adaptation studies is another instance of making comparisons between our spontaneous speech results and reading results of other investigators due to the limitations of the literature.

The Razdolsky (1965) study, however, seems to be one of natural speech production because preschool children unable to read are included in his population. Razdolsky reports on a group of 125 stutterers who spoke in the presence of others and alone. In 32 members of the group speech was markedly facilitated when alone, 30 were somewhat improved, there was very little improvement in 24, and the speech of 28 remained unchanged. Speaking in solitude eliminated all stuttering behavior in 11 subjects and enabled them to talk at a normal rate. While stuttering in the speech of preschool children did not change very much when they were alone, children of school age showed a noticeable improvement. Most of the adolescents and adults in the study spoke much better alone than in the presence of other people.

The literature does contain some studies in which the stutterer is not adversely affected by an audience. Bloodstein (1969, p. 205) speaks of a "startling result" obtained by Young (1965) in which stuttering failed to increase with increases in audience size. This was a study of adaptation effect,as was that of Shulman (1955) who gradually increased audience size and found that adaptation continued to occur. Siegel and Haugen (1964), in the condition where there was a constant audience of one person, seemingly analogous to the condition where only the experimenter is present, found some adaptation taking place in the audience situation but less of it than in a control group.

The Facilitative Effect of Anxiety and Listener on Verbal Productivity

In a series of studies, Kanfer (1958, 1959, 1960) describes and confirms a generalized hypothesis of the facilitating effect of anxiety on verbal productivity. He derives theoretical support for his thesis from the diverse positions of Hull and Skinner,wherein Hull, regarding anxiety as a drive state, relates levels of verbal activity to anxiety levels, while Skinner proposes that as anxiety increases, verbal output increases (Kanfer, 1959). Skinnerian studies (e.g., Salzinger, Portnoy and Feldman, 1964) have shown another view, namely that the delivery of positive reinforcement by a listener also increases the rate of verbal responding behavior. Finally, Matarazzo and Wiens (1972), in their compendium of research into the anatomy and structure of the interview, discuss the role of the listener. They present data which "reveal headnodding and saying mm-hmm, two tactics long suspected by interviewers and other conversationalists as having the capacity to increase utterance durations do, in fact, produce such an increase" (Matarazzo and Wiens, 1972, p. 94). These authors propose an hypothesis of listener stimulation of speaker production, "more human output," increased speaker activity, based on "greater-satisfaction-in-the-presence-of-greater-interviewer-activity." In other words, if someone is present and listening to him with attention and interest, perception of this fact will be positively reinforcing and the speaker will talk more. This reinforcement operates, perhaps, through a state variable similar to that which Treisman identifies with "interest," "alertness," "vigilance," "motivation," etc. Specific temporal arousal is perhaps just such a state variable, maintaining a steady level over a period of time such as the duration of an interview.

Hypotheses of this Investigation

Hypothesis I

The dependent variables of this investigation will distinguish and stratify the three population groups in a manner consonant with their nosological categorizations of "Normal Speakers," "Former Stutterers," and "Stutterers." Normal Speakers will exhibit "more efficient" speech than Former Stutterers, while Former Stutterers will exhibit "more efficient" speech than Stutterers. "More efficient" speech will be determined by means of macrosegmental (phrase and pause) and microsegmental (vocalic and transyllabic) analyses of the five minute samples of the three groups in the two conditions, Condition 1, the Solo Monologue Condition, and Condition 2, the Listener Monologue Condition.

For the purposes of analysis and rank ordering, "more efficient" speech will be defined as speech that is "more productive" and "more accurately timed" than speech that is "less efficient."

Speech that is "more productive" will be operationally defined in terms of the following criteria which are dependent variables of this investigation:

Vocalic and transyllabic segments, the complementary components of the syllable period, will be briefer and more frequent.

Phrases will be longer, both in number of syllables and in mean duration.

Pauses will be briefer, therefore Fluency Ratios (frequency ratios of short to long pauses) will be higher at corresponding fluency cut points, or strata.

Articulation Rates (syllables/sec.) will be higher.

Speech that is "more accurately timed" will be operationally defined in terms of the following criteria which are dependent variables of this investigation:

> Variances of temporal parameters of speech units examined will be smaller in speech that is "more accurately timed." The speech units examined will be: 1) syllable periods and their component parts (vocalic and transyllabic segments); 2) phrase periods and their component parts (phrases and pauses).

Hypothesis II

The two conditions of the experiment, Condition 1, the Solo Monologue Condition, and Condition 2, the Listener Monologue Condition, will be significantly distinguished by all three groups. There will be a heightened response to Condition 2, the Listener Condition, which will take the form of "more productive" speech. "More productive" speech is operationally defined in detail under Hypothesis I and is based on criteria which are dependent variables of this investigation.

Thus, Hypothesis I holds that groups will be distinguished, regardless of condition, on both productivity and timing accuracy, while Hypothesis II holds that conditions will be distinguished for all groups by productivity alone. The prediction that groups will be distinguished by timing accuracy is consistent with findings reported by Cooper and Allen (1973): the prediction that conditions will differ in productivity follows from the previous discussion with respect to specific temporal arousal. The prediction of differential productivity among groups has long been made on the basis of subjective clinical impression but has not heretofore been assessed objectively in continuous speech.

CHAPTER II: METHOD

An Overview

Three groups of 6 subjects each, Normal Speakers, Former Stutterers, and Stutterers, were selected and paid for participating in a spontaneous speech experiment. Subjects were chosen from a male, Caucasian, college-age population by means of a questionnaire which screened for prior speech history, verbal ability test scores, and willingness to participate in the experiment. Potential subjects were then given a screening interview to verify prior speech history and present speech status. Individual experimental sessions for the 18 subjects consisted of two spontaneous speaking tasks of five minutes each. In Condition 1, the Solo Monologue, the subject was left alone in a room after being instructed to speak for five minutes on a selected topic. Condition 2 the Listener Monologue, followed the same format as Condition 1 except that a responsive listener was present in the room. A postexperiment questionnaire provided the subject's own assessment of any emotional stress and concommitant speech disfluencies he may have experienced in the two speaking conditions.

Subjects

A two phase screening procedure was used to select suitable subjects from among a set of volunteers. First, they were screened by their responses on a questionnaire, than given a screening interview. Persons were judged to be suitable subjects for the experiment if they passed both phases, after which they were scheduled for the individual experimental session.

6 male subjects were selected in each of three population categories, normal, stutterer and former stutterer. Normal speakers were obtained from an available pool of college students in the New York City area. The pathological and post-pathological subjects, also of college age, were obtained from cooperating university speech clinics and clinicians in the New York City area. The 18 subjects who met the requisite criteria and indicated their willingness to participate in the experiment were selected as paid volunteers. A more detailed description of the criteria for the respective experimental populations will be found below.

Subject Screening Procedure

Questionnaire

The initial screening procedure for all subjects was the questionnaire which was administered on an individual or a group basis. The 4 parts of the questionnaire are described below and the complete questionnaire can be seen in Appendix I.

1. Personal Information.

This section provided identifying personal information about the subject.

2. Prior and Present Speech and Language History

This section provided information on place of birth, native language, general speech and language background, and the nature of any speech or language problems that the subject may have experienced. The subject was also asked for information on any special speech training he had received.

3. Verbal Abilities Test.

This section consisted of a test adapted by Breskin (1970) from a verbal scholastic apitude test of Brownstein and Weiner (1958). The VAT includes questions which test reading comprehension, skill in sentence completion, and the use of vocabulary and analogy. There is a total of 16 multiple choice items. As this is a relatively difficult instrument, and our purpose was to exclude subjects with a problem in the area of language (as opposed to speech), a score of 70% was established as a criterion for inclusion in the experiment.

4. Participation Information.

The final section briefly explained the purposes of the experiment and the need for volunteers to participate.

Those willing to help with the project were asked to list available free hours in addition to their names and phone numbers.

Potential subjects for the individual experimental session, subject to a subsequent screening interview, were selected from those who successfully met the following criteria based on their responses to the questionnaire.

1. On the basis of the Prior and Present Speech and Language History section, subjects were excluded who reported ever having had a reading problem per se, who were not born in the USA, or whose native language was not English. Speech problems that interfered with communication but were not associated with disfluency were also cause for exclusion. The cooperation of speech clinicians in university, hospital, and private practice settings was instrumental in gaining access to populations of stutterers and former stutterers. Without their professional help and expertise the procurement of requisite and appropriate members of these groups would have presented major problems.

2. The VAT was utilized in order to eliminate any speaking problems that were language connected rather than speech problems specifically connected directly with past or present disfluency. The cut-off point selected those individuals whose reading ability was of high school level or better.

Screening Interview

Subjects passing questionnaire criteria were given a screening interview. Pathological and post-pathological subjects were referred by qualified speech clinicians and were, respectively, presently in therapy for a stuttering disorder which was judged to be within the moderate range, or had been discharged from therapy and had remained essentially free of stuttering symptomatology for the period of at least one year. Screening interviews were conducted by a qualified speech pathologist and only subjects who met all requisite criteria were scheduled for the experimental session. In summary, we can characterize the three groups as follows:

Normal speakers exhibited speech that was free of interfering defects, and reported no history of speech disorder.

Stutterers exhibited disfluent speech patterns containing the following: repetitions and/or interfering blocks and/or prolongations. In every case these constituted a variation of a moderate stuttering disorder which manifested itself during the course of the interview and supported the diagnostic description given by the referring speech clinician. Additionally, a full case history was taken which was found in all cases to be fully congruent with the characterization of the subject as a "stutterer."

Former stutterers had a history of speech disorder, but exhibited speech free of any identifying stuttering symptomatology. The former stutterer would be judged a normal speaker by his listeners, and he no longer routinely characterized himself as a "stutterer," although he might occasionally experience some slight difficulty under stress. Additionally, a full case history was taken which established the developmental and therapeutic course of his stuttering and the pattern of its remission, also the fact that he had been at least a moderate stutterer and had retained stuttering symptomatology through adolescence.

Individual Experimental Session

A final total of 20 subjects were selected as paid volunteers on the basis of the selection procedures described above. 2 additional subjects were chosen in order to replace 2 of the original 18 subjects selected who were unable to produce satisfactory tape recordings. Thus, the required total of 18 subjects remained: 6 Normal Speakers, 6 Former Stutterers and 6 Stutterers. The individual session is described below, procedures listed in the order they were administered. Total time was less than an hour, including instructions and Subject's Self-Report Questionnaire.

1. A release form was signed in which the subject agreed to have his voice tape-recorded and his speech analyzed.

2. Subjects spoke on 2 different topics for a period of at least 5 minutes for each topic. A 5 minute speech sample was chosen because this period is considered to be a reliable representation of the stable structure of pauses and vocalizations (Breskin, Gerstman and Jaffe, 1971). Full standardized oral instructions and an opportunity to ask questions of the experimenter preceded the administration of experimental conditions. Immediately prior to each condition subjects were provided with 3 x 5 index cards which set forth the specific requirements of a particular condition. These cards included a series of optional questions related to the task at hand. The questions were designed to make it easier and more productive to speak on a particular topic for the full 5 minutes required. Subjects were not obliged to answer any of the questions provided on the topic, but had the option of utilizing them at points where such aid might be convenient and helpful. The general instructions for the entire session were given orally by the experimenter at the beginning of the session. Specific instructions for each condition, as well as the questions relating to that topic were read beforehand by the subject and remained accessible to him throughout the time he was speaking. Each condition was followed by a short rest period before having the subject move on to the next task. Recording procedures were the same in each of the experimental conditions. A general description of these recording procedures will be

followed by specific descriptions of each condition.

Recording Procedure

A SONY TC-110A tape recorder with automatic gain control was used to record the experimental session. The on-off switch of the lavalier microphone was under the subject's control. This enabled him to initiate each experimental condtion when he was ready to proceed and without the necessity for the experimenter's presence in the room. Subjects were instructed to turn the microphone on and leave it on until the experimenter informed him that the requisite 5 minute period was over. All subjects complied with these instructions quite easily and cooperatively, despite occasional extraneous distractions, some periods of gross disfluency, and short lapses of material on which to speak. Subjects were paid and appeared motivated to follow all instructions and successfully complete the experiment.

Warm-Up Session

A warm-up session preceded the administration of the experimental conditions. This was designed to accustom the subject to the recording apparatus, speaking requirements, conditions, etc. For the warm-up session subjects were given several comic strips and asked to discuss them. Subjects spoke on the specified topic for at least 5 minutes. The general procedure, as described above, was employed in the warm-up session as it was to be used in the subsequent experimental sessions.

Condition 1

Condition 1 is the Solo Monologue condition. At no time is the experimenter present in the room during this experimental condition.

A 3 x 5 card contains a short philosophical paragraph introducing a discussion topic that requires decision-making, offers options and attempts to stimulate the subject to be imaginative and creative, for he is asked to describe situations that exist only in his mind. The subject's task in Condition 1 is to describe what his respective life style would be if his annual income was $1,000, $10,000, $100,000, and $1,000,000 a year.

Condition 2

Condition 2, the Listener Monologue condition, presents a situation of similar cognitive complexity and demand as that found in Condition 1. A short philosophical paragraph introduces the question of whether the subject is what he watches, that is, do his viewing habits (i.e., theater, concerts, films, TV, etc.) accurately reflect the image he has of himself as a person.

Although cognitive demand level in Condition 2 is equated with that in Condition 1 as closely as could be approximated, an increased social demand is supplied by the presence of the experimenter, whose role is that of silent, but attentive and receptive listener. The experimenter sits facing the subject in a relaxed manner, maintaining appropriate eye contact and facial responsiveness.

<u>Subject's Self-Report Questionnaire</u>

A Subject's Self-Report Questionnaire was administered to all subjects as their final task in the experiment. (See Appendix II). This questionnaire was devised in order to have an independent indicator of whether and in what manner the experimental conditions were affecting the subjects, both in their attitudes toward the tasks and in their perceptions and judgments of their speech performances in the respective task conditions.

The questionnaire probed the subjects' reactions in several ways. The first section asked the subject to look back on the conditions of the experiment in order to compare their effects upon him. Two questions were asked about each condition and a 5 point scale was used in each. The first question asked the subject to judge how he had felt in that situation along a dimension ranging from <u>relaxed</u> to <u>tense</u>. The second question asked the subject how important he thought it was to speak correctly in that situation judged along a dimension of unconcern to importance.

The second section gave a brief description of speech disfluencies and asked the subject to rate his speech in each situation along a dimension of relative fluency ("smooth" to "hesitant and choppy" speech). Again, a 5-point scale was used.

The third section queried the subject as to whether he felt that he had been more fluent in one situation than he had been in the other. An open-ended question asked him to list or describe any factors in the situations or in himself which might account for observed differences from one situation to another. The questionnaire served an ancillary purpose in that it explained the experimental conditions to the subjects in a manner they appeared to find clear, satisfactory and scientifically justifiable.

Processing of Speech Data

Five minute samples of speech generated by means of the procedure described above were processed with speech analysis systems developed and described by investigators (Anderson and Jaffe, 1972; Cassotta, Feldstein and Jaffe, 1964; Jaffe, Anderson and Rieber, 1973; Jaffe and Feldstein, 1970) in the Department of Communication Sciences at The New York State Psychiatric Institute.

This comprehensive speech analysis system yields measurements of processed time in terms of total vocalic time, total intervocalic time, total phrase time, total pause time, as well as duration and frequency of vocalic segments, transyllabic segments, phrases and pauses. From these measured parameters other statistics are derived. These include mean temporal durations of vocalic, transyllabic, phrase and pause segments, which in turn lead to the derivation of measures of mean articulation rate and syllables per phrase (structural complexity). These various units comprise the dependent measures of this study and will be described below.

Dependent Measures

The sophisticated technology of the speech analysis system at the Psychiatric Institute makes possible an efficient and exhaustive study of speech units that are objectively defined. Utilization of these techniques permits a real time scrutiny of the speech process that can provide an adequate description of ongoing speech close to the physiological level. In dealing with diverse populations such as the Normal Speakers, Stutterers and Former Stutterers of this study, a rich armamentarium of analytic speech units is especially useful, and it is believed that the speech units described below, the dependent measures of this study, will, when taken together, provide a basic behavioral model of natural speech in the individuals and the groups studied.

The vocal segments, transyllabic segments, phrases and pauses described here are statistically assessed (See Appendix III for technical references) in terms of frequency and mean temporal duration tallied and calculated from a five minute speech sample. Other measures are derived from the foregoing as indicated in the list below.

Figure 1 presents an hierarchical representation of the levels of temporal patterning: macrostructural and microstructural units. On the macrostructural level we have the Phrase Period which consists of a Phrase and the following Pause. Phrases decompose into strings of Syllable Periods, a Syllable Period containing a Vocalic Segment (Stressed Vowel $>$ 60 msec) and a Transyllabic or unstressed portion of the syllabic unit. A Transyllabic segment consists of a string of one or more of the following: unstressed vowels ($\leq$ 60 msec) and subvocalic elements. Subvocalic elements, necessarily less than 200 msec in length, may take the form of continuant consonants, stop consonants or nonconsonantal gaps. The various speech measures enumerated and described below are derived from the decision processes and measurements of these basic units.

1. fV

fV is the frequency of vocalic segments, that is, the

Fig. 1: Levels of Temporal
Patterning

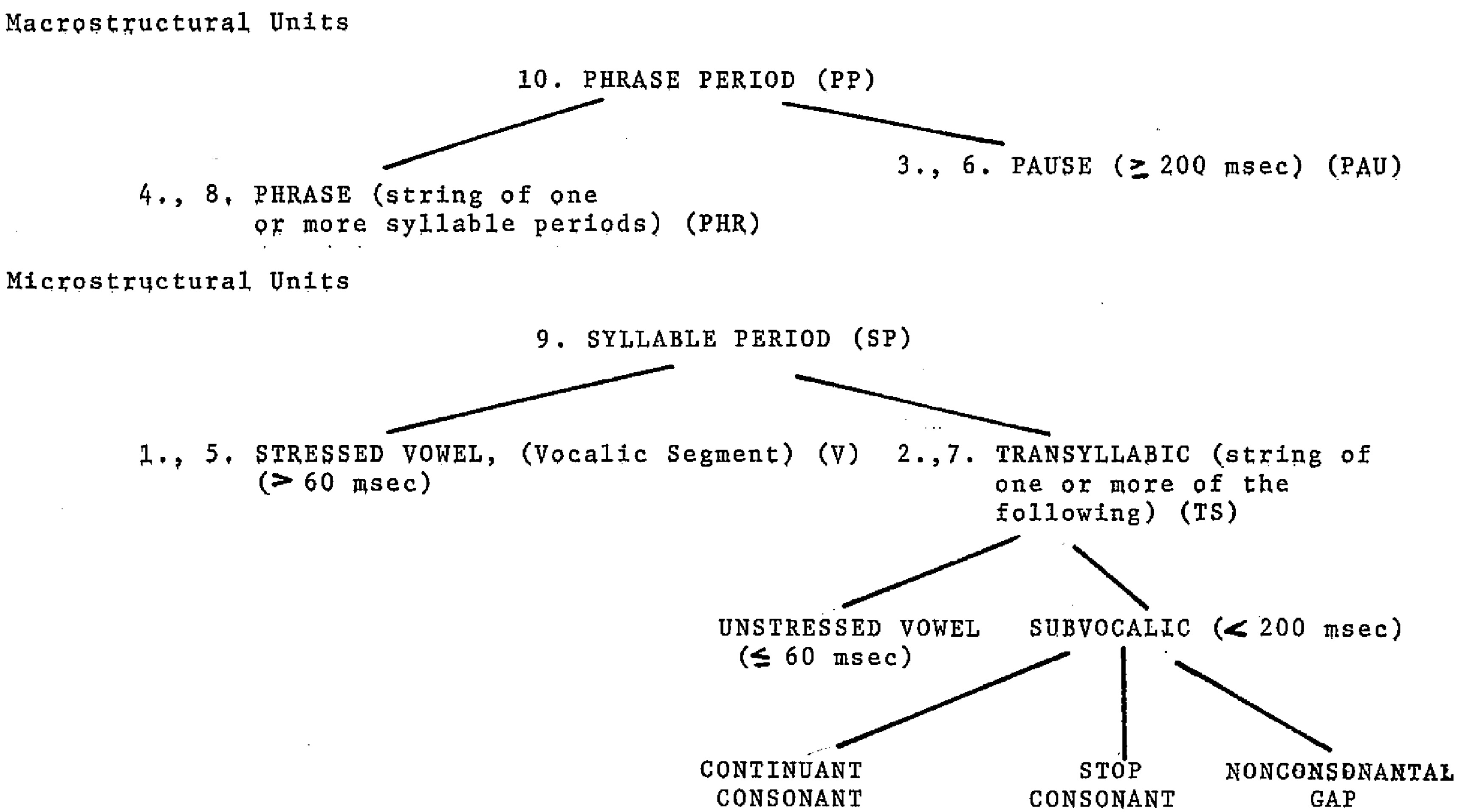

Fig. 1. LEVELS OF TEMPORAL PATTERNING

number of vocalic nuclei whose amplitude rises high enough above threshold and whose duration is long enough to make the determination that a new vocalic peak has occurred (See further technical description under LV).

It should be noted that the syllable, by most definitions, contains one and only one vocalic nucleus. Hence, the terms "vowel" and "syllable" will be used interchangeably with "vocalic segment" as is appropriate to facilitate comparisons between direct and derived measures and between results of this study and reports in the literature.

More technically, the vocalic segments identified by this procedure are considered to be the nucleii of stressed or heavy syllables as opposed to the vocalic nucleii of unstressed or light syllables. Vanderslice and Ladefoged (1972, p. 819) characterize such a distinction in the following manner: "If a syllable is heavy, it will have its full vowel quality; if it is light, it will be completely unstressed and will often have a reduced, centralized vowel."

2. fTS

fTS is the frequency of transyllabic segments. A transyllabic segment is a continuous unit of speech time containing neither vocalic segments nor pauses (See pause description under fPAU). Transyllabic segments include all periods of nonvocalic time that are more than 200 msec long, and contiguous combinations of these. Nonvocalic time includes silence and subvocalic sound, which is defined as sound possessing signal energies that rise above noise, but fail to meet the vocalic time and amplitude thresholds. (See LV.) Since every vocalic is terminated by either a transyllabic or a pause, the frequency of transyllabic segments in a speech sample equals the frequency of vocalic segments minus the frequency of pauses.

3. fPAU

fPAU is the frequency of pauses. A pause is a nonovocalic period of time that is 200 msec or longer (Jaffe and Feldstein, 1970).

4. fPHR

fPHR is the frequency of phrases. A phrase is defined as a sequence of consecutive vocalic segments which are connected only by transyllabic segments; a phrase is always terminated by a pause.

5, LV

LV is the mean duration of a vocalic segment. It is obtained by dividing total vocalic time in a speech sample by the number of vocalic segments, fV. Identification and measurement of individual vowel durations is accomplished by means of a PDP-12 computer which monitors the amplitude envelope of ongoing speech at 400 microsec intervals and codes as a vocalic segment any period of time between 0.060 and 1.630 sec that begins when the speech signal (full-wave rectified and low-pass filtered at 2 kHz) rises to a point at least 6 dB above background noise, and continues until the signal drops at least 6 dB from a momentary value to remain below that level for at least 0.020 sec. (Jaffe, Anderson and Rieber, 1973). For a more complete technical description see Appendix IIIa, excerpted from Anderson and Jaffe, 1972. A similar algorithm for vowel measurement has been used in conjunction with automatic speech recognition by Lea and Klocker (1975).

6. LPAU

LPAU is the mean pause duration. It may be obtained from the frequency distribution of pauses or from the product of two factors: the reciprocal of the conditional probability of speaking given previous silence, and the sampling interval of the system.

7. LTS

LTS is the mean transyllabic duration. It is obtained by subtracting vocalic time plus pause time from total time and dividing the remaining time by fV - fPAU.

8. LPHR

LPHR is the mean phrase duration. It is obtained by dividing total phrase time by fPAU.

9. LSP

LSP is the mean syllable period duration. It is simply the sum of LV + LTS. A single syllable period is defined as the time between a vowel onset and the next vowel onset within a phrase.

10. LPP

LPP is the mean phrase period duration. It is the sum of LPHR + LPAU. Analogous to the syllable period, a phrase period lasts from one phrase onset to the next phrase onset.

11. N

N is the number of syllables per phrase, referred to alternatively as <u>structural</u> <u>complexity</u>. It is obtained by dividing the number of vowels by the number of phrases.

12. ARW

ARW is Articulation Rate-Within Phrase, expressed in syllables per second. It is obtained by dividing fV by total phrase time.

13. ART

ART is Articulation Rate-Total, expressed in syllables per second. It is simply defined as fV divided by total time, but can be obtained by means of the following formula which both derives the measure and describes the relative contributions of the temporal parameters which make it up:

$$ART = \frac{LPHR}{(LSP)} + \frac{LTS}{(LPP)}$$

A variant form of this equation appears in Jaffe, Anderson and Rieber (1973, p. 231).

14. VLV

VLV is the variance of LV. It is measured in this study between Condition 1 and Condition 2, for a particular individual or group.

15. VLTS

VLTS is the variance of LTS. It is measured in this study between Condition 1 and Condition 2, for a particular individual or group.

16. VLV + VLTS

VLV + VLTS is the sum of the variances of a mean vocalic segment and a mean transyllabic segment between Conditions 1 and 2, for a particular individual or group.

17. VLSP

VLSP is the variance of LSP. It is measured in this study between Condition 1 and Condition 2, for a particular individual or group.

18. VLPHR

VLPHR is the variance of LPHR. It is measured in this study between Condition 1 and Condition 2, for a particular individual or group.

19. VLPAU

VLPAU is the variance of LPAU. It is measured in this study between Condition 1 and Condition 2, for a particular individual or group.

20. VLPHR + VLPAU

VLPHR + VLPAU is the sum of the variances of mean phrase and mean pause between Conditions 1 and 2, for a particular individual or group.

21. VLPP

VLPP is the variance of LPP. It is measured in this study between Condition 1 and Condition 2, for a particular individual or group.

22. FLS

FLS are Fluency Strata, extracted by a method of scoring relative fluency based on partitions of all pauses in a speech sample. A fluency stratum is defined by a cut off time point that partitions the distribution of pauses into "shorter" and "longer." Fluency cuts are made and thus define strata at each 200 msec interval with that interval and all below it constituting "shorter" pauses while those above it are considered "longer" pauses. The <u>fluency ratio</u> of a stratum is the ratio of the frequency of short pauses divided by the frequency of long pauses. For example, if we examine the first Fluency Stratum, at the initial 200 msec interval, then the fluency ratio would consist of the "shorter" pauses, in this case the number of pauses that are at least 200 msec long but are less than 400 msec, divided by the "longer" pauses, in this case the number of pauses that are 400 msec and longer. This strategy is considered to be more sensitive to pauses of different lengths than that employed by Goldman-Eisler (1972) who employs a single cut point at the 500 msec interval in order to obtain a ratio of "fluent" to "hesitant" transitions. Fluency cuts made at each 200 msec interval, (200 msec being the minimum pause criterion), should provide flexibility to characterize populations at diverse levels of fluency, flexibility that would be unavailable if only a single cut point were used.

23. SSRQ

SSRQ is Subject's Self-Report Questionnaire. This is a form designed to elicit subjects' evaluations of the effects of the experimental conditions. Subjects respond to a series of questions (These have been described previously under <u>Procedure</u>, and a copy of the questionnaire can be found in Appendix II). Responses to each question are scored on a 5 point scale and overall scoring determinations are made on the bases of self-perceived psychological stress and self-perceived disfluency in the experimental conditions. The purpose of the questionnaire is to obtain an independent measure of situational diversity, one that is guided by the subjective experience of the individual. Previous experimenters (e.g., Lay and Paivio, 1970) report the use of such instruments as the Subject's Self-Report Questionnaire as a relatively direct and independent method of ascertaining whether the subject apprehends task difficulty hierarchically and in a manner congruent with the experimenter's intention.

Independent Measures

1. Groups

Group differences were assessed by comparing the three groups, Normal Speakers, Former Stutterers and Stutterers, by means of the variables described above.

2. Conditions

Differences between conditions were assessed by comparing Condition 1, Solo Monologue, and Condition 2, Listener Monologue, by means of the variables described above.

CHAPTER III: RESULTS

Results of this study consist of individual dependent variable measures for each of the 18 subjects in the experiment. These were computed as indicated for the two spontaneous speech monologue conditions: Condition 1, the Solo Monologue Condition and Condition 2 the Listener Monologue Condition. Statistical analysis was performed on the six dependent variables relating to frequency of occurrence and the five variables relating to mean duration. Variances of mean durations were compared across subjects and conditions for four macrosegmental (Phrase and Pause) and four microsegmental (Vocalic and Transyllabic) speech units (See Tables I-XII).

As hypothesized at the outset, rank ordering of the variables constitutes the minimal type of scale that can distinguish the three groups.

For example, under equivalent speaking demands a higher Articulation Rate is more efficient than a lower, a shorter mean pause duration more efficient than a longer, and so on with respect to vocalic and transyllabic segment lengths. The Articulation Rate formula described previously (Jaffe, Anderson and Rieber, 1973), demonstrates the consistency of these assumptions. Most important, ranking the magnitudes of results from the three groups permits testing of Hypotheses I and II.

TABLE I

TOTAL FREQUENCIES OF VOCALIC SYLLABLES (fV) BY GROUP AND CONDITION

Group	Condition 1	Condition 2	
Normal Speakers	2975	3186	6161
Former Stutterers	2947	3001	5948
Stutterers	2444	2719	5163
	8366	8906	17,272

	Chi^2	df	P
I. Between Groups			
A. Within Conditions			
Condition 1	64.05	2	$<.001$
Condition 2	37.26	2	$<.001$
B. Across Conditions	95.98	2	$<.001$
II. Between Conditions			
A. Within Groups			
Normal Speakers	6.63	1	$<.01$
Former Stutterers	.49	1	ns
Stutterers	14.65	1	$<.001$
B. Across Groups	1688.28	1	$\ll .001$

TABLE II

MEASURED RANKING OF GROUPS ON MEAN FREQUENCIES OF SPEECH UNITS

Speech Unit	Condition	A. Normal Speakers	B. Former Stutterers	C. Stutterers	Predicted Ranking	Measured Ranking	P
Frequency of Vocalic Segments (fV)	1	496	491	407	A>B>C	A>B>C	<.05
	2	531	500	453			
Frequency of Pauses (fPAU)	1	165	165	171	A>B>C	C>B=A	ns
	2	179	185	188			
Number of Syllables per Phrase (N)	1	2.686	2.484	2.098	A>B>C	A>B>C	<.05
	2	2.720	2.429	2.078			
Articulation Rate, - Within Phrase, in Syll./sec (ARW)	1	2.862	2.863	2.644	A>B>C	B>A>C	ns
	2	2.859	2.939	2.701			
Articulation Rate - Total, in Syll./sec (ART)	1	1.653	1.638	1.358	A>B>C	A>B>C	<.05
	2	1.770	1.667	1.510			
Fluency Ratio, Stratum #1	1	.623	.604	.536	A>B>C	A>B>C	<.05
	2	.698	.622	.571			

TABLE III

(DURATIONAL COMPONENTS OF PRODUCTIVITY)
MEASURED RANKING OF GROUPS ON MEAN DURATIONS OF SPEECH UNITS
(Values in msec)

Speech Unit	Condition	A. Normal Speakers	B. Former Stutterers	C. Stutterers	Predicted Ranking	Measured Ranking	P
Vocalic Segment	1	211	214	222	C>B>A	C>B>A	<.05
(LV)	2	204	207	209	C>B>A	C>B>A	
Transyllabic Segment	1	228	245	385	C>B>A	C>B>A	<.05
(LTS)	2	237	240	354	C>B>A	C>B>A	
Syllable Period	1	440	460	607	C>B>A	C>B>A	<.05
(LSP)	2	441	460	563	C>B>A	C>B>A	
Phrase	1	943	873	792	A>B>C	A>B>C	<.05
(LPHR)	2	956	806	778	A>B>C	A>B>C	
Pause	1	772	763	894	C>B>A	–	ns
(LPAU)	2	644	704	727	C>B>A		
Phrase Period	1	1715	1636	1686	C>B>A	–	ns
(LPP)	2	1600	1510	1505			

TABLE IV

(ACCURACY OF TIMING)
MEASURED RANKING OF GROUPS ON VARIANCES OF MEAN DURATIONS OF SPEECH UNITS
(Values in $msec^2$)

Speech Unit	A. Normal Speakers	B. Former Stutterers	C. Stutterers	Predicted Ranking	Measured Ranking	Agreement of Predicted and Measured Rankings
Vocalic Segment (VLV)	79	148	189	A<B<C	A<B<C	yes
Transyllabic Segment (VLTS)	200	547	4,845	A<B<C	A<B<C	yes
Sum of Voc and Trans. Segments (VLV + VLTS)	279	695	5,034	A<B<C	A<B<C	yes
Syllable Period (VLSP)	132	538	5,398	A<B<C	A<B<C	yes
Phrase (VLPHR)	2,768	5,451	11,606	A<B<C	A<B<C	yes
Pause (VLPAU)	17,090	10,714	17,978	A<B<C	B<A<C	no
Sum of Phrase and Pause (VLPHR + VLPAU)	19,858	16,165	29,584	A<B<C	B<A<C	no
Phrase Period (VLPP)	14,371	22,082	24,467	A<B<C	A<B<C	yes

TABLE V

(PARAMETRIC ANALYSIS OF DURATIONAL COMPONENTS OF PRODUCTIVITY)
MEAN DURATIONS OF VOCALIC SEGMENTS (LV) BY SUBJECT, GROUP AND CONDITION (Values in msec)

	Normal Speakers		Former Stutterers		Stutterers	
Subject	Condition 1	Condition 2	Condition 1	Condition 2	Condition 1	Condition 2
1	170	182	241	202	194	182
2	236	217	194	204	210	209
3	200	192	231	220	127	125
4	203	200	255	256	273	272
5	228	217	196	194	252	214
6	230	214	169	163	274	250
Group Means	211	204	214	207	222	209

ANALYSIS OF VARIANCE OF VOCALIC SEGMENTS (LV)

Source	df	MS	F	P
Conditions(I)	1	.00080	7.4176	<.05
Groups(J)	2	.00019	<1	ns
Interaction(IJ)	2	.00003	<1	ns

TABLE VI-Parametric Analysis continued

MEAN DURATIONS OF TRANSYLLABIC SEGMENTS (LTS) BY SUBJECT, GROUP AND CONDITION
(Values in msec)

Subject	Normal Speakers Condition 1	Normal Speakers Condition 2	Former Stutterers Condition 1	Former Stutterers Condition 2	Stutterers Condition 1	Stutterers Condition 2
1	298	281	293	260	213	239
2	245	250	202	186	330	379
3	207	251	182	177	599	375
4	227	228	254	276	174	216
5	183	194	203	269	387	360
6	210	219	338	355	606	555
Group means	228	237	245	254	385	354

ANALYSIS OF VARIANCE OF TRANSYLLABIC SEGMENTS (LTS)

Source	df	MS	F	P
Conditions(I)	1	.00019	<1	ns
Groups(J)	2	.06670	3.7322	$<.05$
Interaction(IJ)	2	.00157	<1	ns

TABLE VII-Parametric Analysis continued

MEAN DURATIONS OF SYLLABLE PERIODS (LSP) BY SUBJECT, GROUP AND CONDITION
(Values in msec)

Subject	Normal Speakers Condition 1	Normal Speakers Condition 2	Former Stutterers Condition 1	Former Stutterers Condition 2	Stutterers Condition 1	Stutterers Condition 2
1	467	463	534	462	407	421
2	481	466	396	390	540	588
3	407	443	412	397	726	500
4	430	428	509	532	447	488
5	410	412	399	463	639	574
6	441	433	508	518	881	805
Group Means	440	441	460	460	607	563

ANALYSIS OF VARIANCE OF SYLLABLE PERIODS (LSP)

Source	dF	MS	F	P
Conditions(I)	1	.00307	1.5303	ns
Groups(J)	2	.07676	4.2964	ns
Interaction(IJ)	2	.00160	<1	ns

Tests of Hypothesis I

Hypothesis I refers to the relative efficiency of the three groups, Normal Speakers, Former Stutterers and Stutterers, as judged by criteria of productivity and accuracy of timing.

Efficiency

Tables I, II and III summarize findings on measures which assess productivity. Table I presents information on total frequencies of vocalic syllables (fV) collected and results of Chi^2 analysis by group and condition. Table II presents information on measured ranking of the three groups on frequency of speech units. Recall that fTS = fV - fPHR and fPHR = fPAU. Table III presents information on measured ranking of the groups on mean duration of speech units.

Table IV summarizes findings on measures which assess accuracy of timing; it presents information on measured rankings of the groups as determined by variances of mean durations of speech units. Tables V-VII present mean durations of Vocalic segments (LV), Transyllabic segments (LTS) and Syllable Periods (LSP) by subject, group, and condition, as well as analysis of variance results on these measures.

Chi^2 analysis, rank orderings, and analysis of variance of the three groups, as seen on Tables I - VII, confirm predictions made in Hypothesis I, that is, speech of

Normal Speakers is more efficient than speech of Former Stutterers- -efficiency being judged by criteria of productivity and accuracy of timing- -while speech of Stutterers is least efficient of all. A detailed description of results presented in Tables I - VII follows.

a. Productivity

Table I summarizes frequency information which confirms significant productivity differences among the three groups, as determined by Chi^2 analysis. As predicted by Hypothesis I, Normal Speakers produced more Vocalic syllable segments than Former Stutterers, Stutterers producing fewest of all. These differences were highly significant ($p < .001$) both across and within experimental conditions.

Table II summarizes productivity in terms of frequency of speech units. Predicted and measured rank orderings of productivity related speech measures of the three groups were compared. The confirmation of hypothesized results on productivity of Vocalic segments (fV) has already been reported, and it also reaches significance nonparametrically by the binomial test (Hoel, 1958) across both conditions. Significance ($p < .05$) was established for three of the five remaining measures of speech frequency also by means of the binomial test. The predicted rank ordering with Normals most productive, Stutterers least, held for the following measures: Number of syllables in a phrase (N), overall Articulation Rate (ART) and the Fluency Ratio for Stratum #1.

(See Table XIII.) Two frequency measures proved non-significant, those of pause frequency (fPAU) and within phrase Articulation Rate (ARW).

Table III summarizes productivity measures in terms of mean durations of speech units. The productivity hypothesis predicts that Normals produce briefer syllables (LV) than Former Stutterers, with the LV of Stutterers being predicted longest of all. This rank ordering is also predicted for Transyllabic segments (LTS), Syllable Periods (LSP) Pauses (LPAU) and Phrase Periods (LPP). Expectations were that phrases would prove to be longest in Normals and shortest in Stutterers, with Former Stutterers occupying the intermediate position.

Measured rankings matched predicted rankings ($p < .05$, binomial test) on all mean durations of speech units except Pauses (LPAU) and Phrase Periods (LPP). Subsequent analysis of variance (See Table VI) found Transyllabic segments (LTS) to significantly distinguish groups parametrically ($p < .05$) across conditions.

In regard to the failure of LPAU to show significance, we should note that Former Stutterers seen in this study maintained a consistent pause pattern over changing conditions. This pattern differed from that of the other groups and affected all measures to which pausing contributed.

Implications of this will be discussed in the following section, Chapter IV.

b. Accuracy of Timing

Table IV summarizes accuracy of timing measures in terms of variances of mean durations of eight speech units. These unitary and combinational variances have been expressed in milliseconds for purposes of consistency with values presented elsewhere. For all measures, Hypothesis I predicts that Normal Speakers would show less variance than Former Stutterers with Stutterers being most variant of all. Measured rankings match predicted rankings on six of the eight speech units: Vocalic segments (VLV), Transyllabic segments (VLTS), their sum (VLV + VLTS), Syllable Period (VLSP), Phrase (VLPHR) and Phrase Period (VLPP); however the number of cases is insufficient for statistical comparison. The relative invariance of pausing patterns in Former Stutterers has been pointed out previously; this finding gains further support from the emergence of two discrepant measures, pause variance (VLPAU) and the sum of phrase and pause variances (VLPHR + VLPAU). On both these indices Former Stutterers rank higher than Normal Speakers.

In Table III we may observe particular constancy of Syllable Period duration (LSP) across conditions in the case of the group of Normal Speakers. Group means for Condition 1 and Condition 2 vary by only a single msec in this population. Variance for the Syllable Period (VLSP) is less than half that of its component parts in the Normal Group (See Table IV). An examination of changes in LV (Table V) and corresponding changes in LTS (Table VI) shows that they always change in opposite directions for all Normal subjects. These negatively correlated changes appear to operate in a manner which is effective in maintaining a degree of regularity in the Syllable Period unit. Former Stutterers maintain isochronous Syllable Periods across conditions but they are lengthier than those of the Normals and temporal interactions do not occur on a significant basis.

Tests of Hypothesis II

Chi^2 analysis was significant between conditions for frequency of Vocalic syllables (Table 1). We find that there is indeed a highly significant ($p < .001$) increase in productivity across groups as we move from Condition 1 to Condition 2. And when we break our population down into the several categories, we find that the between conditions difference remains significant for Normals ($p < .01$) and for stutterers ($p < .001$). But while there is a tendency for Former Stutterers to produce more syllables in Condition 2 than Condition 1, the difference is not significant.

Former Stutterers examined in this study show neither the increment in syllable frequency nor the decrement in pause length that distinguishes Condition 1 from Condition 2 in the other groups. Former Stutterers demonstrate rather consistent patterning of individual parameters across changing conditions, although general productivity increases. Support for this statement is provided by the increase of Articulation Rate in Condition 2 (both ART and ARW) together with the previously reported relative invariance of pause patterns and syllable frequencies for the Former Stutterers (See Tables I, II, IV, XI).

Recall that Hypothesis II refers to the productivity of all three groups and predicts that productivity of Normal Speakers, Former Stutterers and Stutterers will increase significantly in the Listener Monologue Condition, Condition 2. This increase in productivity is operationally defined, as it was in Hypothesis I, in terms of the following dependent measures: Vocalic segment (fV, LV) Transyllabic segment (LTS), Syllable Period (SP), Phrase (N, LPHR), Pause (LPAU), Phrase Period (PP) Fluency Strata (FLS) and Articulation Rates (ARW, ART).

A 3 x 2 (groups by conditions) analysis of variance with repeated measures (BMD 08V) was performed on eight main variables: LV, LTS, LSP, N, LPHR, LPAU, ARW, and ART. (One of these measures, LTS, significantly distinguished the groups across conditions as was reported above.)

TABLE VIII-Parametric Analysis continued

MEAN DURATIONS OF PAUSES (LPAU) BY SUBJECT, GROUP AND CONDITION
(Values in msec)

Subject	Normal Speakers Condition 1	Normal Speakers Condition 2	Former Stutterers Condition 1	Former Stutterers Condition 2	Stutterers Condition 1	Stutterers Condition 2
1	988	890	602	675	494	410
2	695	515	931	786	867	569
3	482	388	570	640	711	630
4	1.052	661	780	843	918	838
5	801	773	719	576	1.036	839
6	615	639	974	704	1.336	1.075
Group Means	772	644	763	704	894	727

ANALYSIS OF VARIANCE OF PAUSES (LPAU)

Source	df	MS	F	P
Conditions(I)	1	.12484	14.2034	$<.01$
Groups(J)	2	.03390	<1	ns
Interaction(IJ)	2	.00900	1.0242	ns

TABLE IX-Parametric Analysis continued

MEAN DURATIONS OF PHRASES (LPHR) BY SUBJECT, GROUP AND CONDITION
(Values in msec)

	Normal Speaker		Former Stutterers		Stutterers	
Subject	Condition 1	Condition 2	Condition 1	Condition 2	Condition 1	Condition 2
1	655	694	789	701	885	776
2	905	1.016	859	809	771	802
3	945	819	1.138	1.190	563	587
4	992	1.048	950	869	1.270	994
5	1.169	1.153	929	716	696	916
6	992	1.004	574	553	566	594
Group Means	943	956	873	806	792	778

ANALYSIS OF VARIANCE OF PHRASES (LPHR)

Source	df	MS	F	P
Conditions(I)	1	.00458	<1	ns
Groups(J)	2	.08402	1.1733	ns
Interaction(IJ)	2	.00491	<1	ns

TABLE X-Complexity

NUMBER OF SYLLABLES PER PHRASE (N) BY SUBJECT, GROUP AND CONDITION

	Normal Speakers		Former Stutterers		Stutterers	
Subject	Condition 1	Condition 2	Condition 1	Condition 2	Condition 1	Condition 2
1	2.038	2.107	2.026	2.081	2.695	2.408
2	2.392	2.713	2.678	2.548	2.038	2.010
3	2.832	2.416	3.199	3.445	1.602	1.923
4	2.832	2.983	2.367	2.154	3.230	2.477
5	3.294	3.273	2.837	2.126	1.694	2.225
6	2.728	2.826	1.797	1.753	1.331	1.427
Group Means	2.686	2.720	2.484	2.059	2.099	2.078

ANALYSIS OF VARIANCE OF NUMBER OF SYLLABLES PER PHRASE (N)

Source	df	MS	F	P
Conditions(I)	1	.01420	< 1	ns
Groups(J)	2	1.1344	2.3180	ns
Interaction(IJ)	2	.02166	< 1	ns

TABLE XI–Total Productivity Per Second

ARTICULATION RATE–TOTAL (ART) BY SUBJECT, GROUP AND CONDITION
(Values in syllables per sec.)

Subject	Normal Speakers Condition 1	Normal Speakers Condition 2	Former Stutterers Condition 1	Former Stutterers Condition 2	Stutterers Condition 1	Stutterers Condition 2
1	1.237	1.243	1.573	1.720	2.093	2.183
2	1.547	1.827	1.580	1.673	1.413	1.702
3	2.077	2.110	2.037	1.987	1.260	1.590
4	1.463	1.800	1.507	1.350	1.593	1.420
5	1.757	1.800	1.920	1.807	1.090	1.253
6	1.837	1.837	1.210	1.477	.697	.913
Group Means	1.653	1.770	1.638	1.667	1.358	1.510

ANALYSIS OF VARIANCE OF ARTICULATION RATE – TOTAL (ART)

Source	df	MS	F	P
Conditions(I)	1	.08918	6.5536	.05
Groups(J)	2	.25589	1.1292	ns
Interaction(IJ)	2	.01202	<1	ns

TABLE XII -Total Productivity Per Second Within Phrases

ARTICULATION RATE - WITHIN PHRASE (ARW) BY SUBJECT, GROUP AND CONDITION
(Values in syllables per sec.)

Subject	Normal Speakers Condition 1	Normal Speakers Condition 2	Former Stutterers Condition 1	Former Stutterers Condition 2	Stutterers Condition 1	Stutterers Condition 2
1	3.112	3.035	2.568	1.720	3.046	2.183
2	2.642	2.670	3.119	1.673	2.643	1.702
3	2.996	2.949	2.811	1.987	2.844	1.590
4	2.855	2.848	2.491	1.350	2.542	1.420
5	2.817	2.839	3.055	1.807	2.436	1.253
6	2.750	2.814	3.132	1.477	2.351	.913
Group Means	2.862	2.859	2.863	2.939	2.644	2.701

ANALYSIS OF VARIANCE OF ARTICULATION RATE - WITHIN PHRASE (ARW)

Source	df	MS	F	P
Conditions(I)	1	.01703	1.4579	ns
Groups(J)	2	.17828	1.4518	ns
Interaction(IJ)	2	.00516	<1	ns

TABLE XIII

FLUENCY RATIOS (RATIOS OF RELATIVE FREQUENCIES, SHORT/LONG PAUSES) IN STRATA COMPUTED AT 200 MSEC INTERVALS

	Condition 1				Condition 2		
Strata Cut Points	Normal Speakers	Former Stutterers	Stutterers	Strata Cut Points	Normal Speakers	Former Stutterers	Stutterers
1. 200 msec	.623	.604	.536	200 msec	.698	.622	.571
2. 400	1.108	1.038	.962	400	1.400	1.147	1.196
3. 600	1.704	1.829	1.414	600	2.349	1.756	2.082
4. 800	2.408	2.678	2.100	800	3.634	2.821	3.068
5. 1.0 sec	3.270	3.797	2.466	1.0 sec	5.761	4.059	4.360
6. 1.2	4.621	4.911	3.039	1.2	8.513	6.338	5.772
7. 1.4	6.158	6.638	3.794	1.4	11.216	9.453	7.767
8. 1.6	7.578	8.280	4.516	1.6	15.538	12.190	10.310
9. 1.8	9.585	11.110	5.535	1.8	20.939	16.312	13.138
10. 2.0	12.630	13.391	6.381	2.0	25.220	20.308	16.672
11. 2.2	15.864	17.055	7.550	2.2	28.054	26.024	20.340
12. 2.4	18.510	20.587	10.152	2.4	32.594	30.657	25.302
13. 2.6	23.875	28.206	10.793	2.6	37.393	43.320	32.267
14. 2.8	31.097	34.464	12.500	2.8	37.393	51.762	39.393
15. 3.0	40.458	38.720	15.031	3.0	40.346	68.250	40.889

Three measures proved significant for condition differences: LV, LPAU and ART. Tables V through XII summarize these results. Condition 2 was found to be significantly ($p < .05$) more productive than Condition I for all groups in terms of briefer vocalic segments (LV) as seen in Table V. The decrease of pause length (LPAU) was another predicted determiner of productivity which was significantly confirmed ($p < .01$) as seen in Table VIII. As would have been expected from these results and others to be subsequently reported, overall Articulation Rate (ART) increased significantly ($p < .05$) in Condition 2, as seen in Table XI.

There were no significant interactions, and results for the other five dependent measures were nonsignificant for condition differences, as tested by the analysis of variance.

Fluency Strata are displayed in Table XIII. Fifteen cut points were selected at intervals 200 msec apart. For each Fluency Stratum the frequency ratio of short/long pauses was obtained in terms of that cut point. Increases in productivity, as measured by increases in Fluency Ratios, occurred in Condition 2 for all groups at nearly all Fluency Strata. Results were highly significant (binomial test, $p < .01$). Recalling that only the first Stratum (#1) distinguished groups, it appears that this measure is more sensitive to situational differences in fluency than to clinically defined differences in fluency.

ADDITIONAL RESULTS

SSRQ

The Subject's Self-Report Questionnaire, Appendix II, was designed to elicit subjects' impressions of the relative psychological stress placed upon them in the two conditions: Condition 1 in which they spoke about life-styles and were alone, and Condition 2 in which they spoke about entertainment they had watched with a listener present. Questions 1-E and 2-E posed these questions. Questions 1-F and 2-F inquired into the subject's estimation of how important it was to speak correctly in that situation, while questions 1-G and 2-G asked about the subject's opinion of the fluency of his speech in each situation. Subjects responded to these six questions along a 5 - point scale. In addition they answered an open - ended section of the questionnaire in which they were asked to werite descriptive statements on aspects of the situations.

Subjects' responses to the objective questions (1-E 2-E, 1-F, 2-F, 1-G 2-G,) were analyzed and those that had been scaled above item number 3 on the negative end of the 5-point scale were considered to be negatively evaluated. These were collected and expressed as a percentage for each question, condition, and population group. (See Table XIV). For example, the item scaled as number 4 in question I-E reads "I felt somewhat tense." Number 5, the higher negative value in that question, reads "I felt pressured."

Table XIV tells us that no Normal Speakers responded to question 1-E with either of these negative statements, nor were there any such negative responses to questions 1-F and 1-G among the Normal group. In Condition 2, however, 50% of the Normal Speakers responded negatively to question 2-E, and 16% responded negatively to questions 2-F and 2-G respectively. The direction of this pattern of responding, a pattern which points to Condition 2 as the more pressured condition, was only found in the Normal group. This trend was not upheld in the other two groups. Results of the questionnaire did not, therefore, significantly distinguish conditions, nor were there sufficient cases to establish reliable group distinctions.

In response to the open-ended section of the questionnaire, 50% of the subjects made descriptive comments pertaining to increased tension in Condition 2, pointing out the presence of the experimenter as the cause. It is of interest to note that such comments were equally distributed among the three subject populations.

TABLE XIV

PERCENTAGE OF NEGATIVELY EVALUATED RESPONSES ON SUBJECT'S SELF-REPORT QUESTIONNAIRE

Condition	Question	Normal Speaker	Former Stutterers	Stutterers
1. Solo Monologue	1-E "Tension"	0%	33%	67%
	1-F "Importance"	0%	16%	33%
	1-G "Fluency"	0%	16%	33%
2. Listener Monologue	2-E "Tension"	50%	67%	33%
	2-F "Importance"	16%	33%	50%
	2-G "Fluency"	16%	0%	67%

CHAPTER IV: DISCUSSION

An Overview of Main Findings: Topics for Discussion

Results of this investigation confirm predictions that 1) Speech of normal speakers is significantly more efficient, i.e., occurs at a higher rate with more accurate timing, than is speech of former stutterers. Speech of stutterers is found to be least efficient of all on both criteria of rate and timing accuracy. 2) Speaking in the presence of a listener facilitates speech rate in all groups, tending to improve rather than inhibit productive performance in the two nonnormal groups contrary to results reported in the literature. This overall increase in articulation rate is accomplished primarily by compression of syllables and pauses, with expansion of phrases occurring also in normals.

Variances of mean durations across subjects and conditions were compared. An isochronous interstress interval was identified for the nonstuttering groups. The timing of the interstress interval in each of the Normal Speakers was so accurate that its variance was much less than that of its subsegments. Lack of significant temporal compensation in the other groups, in association with significantly incremented transyllabic length, points to the existence of two control modes differing in efficiency.

The discussion section will consider the following topics arising from these findings in turn: the nature of temporal patterns which distinguish groups and conditions; the assignmentof individuals to nosological groups on the basis of speech measures; primary units for rhythmic speech; the fit of these data to appropriate models of speech production; the question of speech-regulating biological clocks; some consideration of neurophysiological differences between stutterers and nonstutterers; and finally, implications for future research.

The Nature of Temporal Patterns Which Distinguish Groups and Conditions

We can conclude from the results thatthere is support both for Hypothesis I - - characterizing differences between groups of subjects varying in fluency, and for Hypothesis II - - which attempts to account for differences between Solo and Listener Conditions. Groups and conditions are both distinguished by all measures of speech productivity except those that concern pausing with reference to groups. As predicted, groups were distinguished by measures of timing accuracy - - the variances. Again, exceptions are limited to variances of measures of which pausing is a part.

Accuracy of timing control was used to index rhythmicity as well as efficiency of speech exhibited by the groups. Rhythmic patterning was found to be strikingly represented in a particular group, the Normal Speakers and by a particular microstructural speech unit, the Syllable Period. Not only are the groups in our study distinguished by measures of timing accuracy, as indicated by variances of means between conditions,but Normals universally show two indices of syllabic isochrony or equality of interstress interval. Normal Speakers not only show the lowest variation in mean length of Syllable Period, varying as it does by only a single msec, but in each individual normal subject the period variance is less than the sum of its subcomponent variances, VLV and VLTs. This suggests the operation of some form of temporal compensation across one or more syllables in a phrase that tends to minimize the variance of the rhythmic period below the value (VLV + VLTS) which would be predicted by chance. A preplanning open loop model of speech production such as that described by Kozhevnikov and Chistovich (1965) fits the facts of these data.

Not only did Normal Speakers produce more of the salient speech units than the other groups, and with the lower variances, but mean durations of such units were shorter, thereby contributing to more efficient speech; phrases, syllables and their components significantly stratified the groups in the predicted hierarchical manner, although pauses did not.

Thus it can be concluded that the measures distinguishing groups belong to the domain of ongoing articulatory movements alone, while conditions are distinguished both by the microstructural measures of articulation and the pausing phenomenon as well. Since Jaffe et.al., (1970) have found pause length to be a social interaction variable in dyadic conversation, it is not surprising that pause distributions changed in this experiment with the presence or absence of a listener.

The absence of any significant interactions between groups and conditions in the analysis of variance leads to the conclusion that all three groups responded to a perceived social partner in the same manner. Thus, contrary to views (See, for example, Bloodstein, 1969, Chapter 5) which hold that stutterers are more vulnerable to an audience than normals, the present results suggest that basic timing phenomena are not involved in any such special vulnerability. While psychopathology could sometimes accompany speech disorders, no support for this view was apparent from either the screening interviews which preceded this experiment, or from the self-rating questionnaire which followed it. The questionnaire, in fact, failed to elicit any indication that the groups differed from each other in psychological stress reactions to either condition.

Fluency Ratio Measures established the Listener Condition as one of greater fluency for all three groups based on greater proportions of short to long pauses, indicative of less hesitant transitions. This determination used only pause units as criteria and was made on a group basis. The usefulness of obtaining further classificatory information on an individual basis, taking all speech units into account, was evident.

Classifying Individuals on the Basis of Speech Measures

In order to pursue several lines of inquiry, among them the question of whether the presence of a listener is more or less diagnostic of a particular individual's clinically categorized fluency level than speaking with no one present, a Stepwise Discriminant Analysis (BMD 07M) was performed on the 18 subjects in each of the experimental conditions. This procedure also provides information on the differential importance of each speech unit used in the study and weights its relative contribution to the measured variation among the individuals in the three groups.

Analyses of both conditions classified subjects into the three groups quite well - - results for each condition being significantly greater than chance assignment at the 1% level or better. For each condition discrimination of the individuals into the three groups was accounted for to a large degree by the same two variables: the speech units of Syllable Period (LSP) and Phrase (LPHR) length.

The complete results of these analyses are presented in Appendix IV, but their significance may be assessed from an inspection of Figure 2. This figure presents a series of 3 x 3 matrices, wherein each row describes the three groups of 6 subjects and each column describes their assignment following the discriminant analysis. Perfect discrimination would be expressed by three entries of 6 along the main diagonal, whereas no discrimination would be observed if there were equal numbers of subjects in every cell. In Figure 2, the succeeding matrices display the assignment of subjects after each succeeding variable is introduced into the discriminant function, the run concluding when no significant improvement is achieved.

Although seven variables were introduced, namely the six variables specified in Table III plus the first variable in Table II, in both runs the computer program ran only six steps. In both runs it is observed that the principal discrimination is achieved by Syllable Period length, such that thereafter no Normal Speaker is misclassified as a stutterer. The next improvement in discrimination is achieved by adding a knowledge of Phrase length, after which 11 subjects are now correctly classified.

By the end of the runs, 12 subjects have been correctly classified under Condition 1 (Solo Monologue) and 13 subjects have been correctly classified under Condition 2

Fig. 2: Stepwise Discriminant Analysis of Three Groups. Rows define actual group membership, columns define computer assignments. N, F, S, refer respectively to Normal Speakers, Former Stutterers and Stutterers.

Condition: 1
Solo Monologue

Step			N	F	S
1	LSP	N	4	2	0
		F	3	2	1
		S	2	0	4
	+				
2	LPHR	N	5	1	0
		F	3	3	0
		S	1	2	3
	+				
3	LTS	N	4	2	0
		F	2	4	0
		S	1	2	3
	+				
4	fV	N	3	3	0
		F	2	4	0
		S	1	2	3
	+				
5	LPP	N	4	2	0
		F	1	5	0
		S	1	2	3
	+				
6	LV	N	4	2	0
		F	1	5	0
		S	1	2	3

Condition: 2
Listener Monologue

Step			N	F	S
1	LSP	N	4	2	0
		F	3	1	2
		S	1	2	3
	+				
2	LPHR	N	4	2	0
		F	1	4	1
		S	1	2	3
	+				
3	LV	N	4	2	0
		F	1	4	1
		S	0	2	4
	+				
4	LPAU	N	5	1	0
		F	1	4	1
		S	0	2	4
	+				
5	fV	N	4	1	1
		F	1	4	1
		S	0	2	4
	+				
6	LTS	N	5	1	0
		F	1	4	1
		S	0	2	4

Fig. 2; <u>Key</u>

Rows: Actual Group Membership
Columns: Computer-Assigned Classification

(Listener Monologue). Employing either that criterion or the criterion of misclassification of Stutterers as Normals (4 in Condition 1, 0 in Condition 2), it may be said that Stutterers are discriminated from Normals at least as well under dyadic conditions as when speaking alone. In fact optimal discrimination is accomplished on the basis of five variables in Condition 1 while only four are required in Condition 2.

Primary Units for Rhythmic Speech

We have seen that almost all the variance among the three groups is accounted for by durations of two primary speech units - - Phrases and Syllable Periods - - while temporal compensation between subsegments of Syllable Periods underlies rhythmic patterning as we understand it. Dimensions emerging as important for distinguishing between groups in the present study, although independently derived, prove comparable to those Classe (1939) uses to assess rhythmicity across the gamut of styles of written speech and between individual speakers of varying ability.

Classe's detailed studies of stress groups (analogous to metric feet and to the Syllable Period of this study.) and distribution of stress groups (analogous to stress groups per phrase or N, the measure of complexity in this study) lead to trenchant guidelines for rhythmic analysis:

(a) A low standard deviation will not necessarily concide with a strong continuous rhythm if the groups are distributed in short series.

(b) But everything else being about equal, a lower standard devaiation will coreespond to a stronger rhythm ....

[with] the corollary (c) that a more regular distribution may compensate for a decrease in the size of the larger rhythmic unit.

(Classe, 1939, p. 98, 99)

Classe goes on to discuss isochrony and compensation in the service of rhythm.

(a) A certain irregularity of syllabic distribution will disturb 'objective' isochronism, but not necessarily 'subjective' isochronism.

(b) The phonetic and logical composition of the groups may help to compensate for such irregularities.

(Classe, 1939, p. 99).

The agreement of our findings on spontaneous natural speech with those of Classe on rhythmically graded material read aloud extends and generalizes the scope of Classe's conclusions.

Although the three groups followed similar courses in response to a listener, a close comparison of performance under the varying conditions causes subtle distinctions between the Normals and the other groups to emerge. The differences lie in the area of complexity of rhythmic structure. This is expressed in the clustering of stress groups, a finding of longer phrases with more accented syllables per phrase and therefore a more pronounced beat among the Normal Speakers. Rhythm is more continuous, paced by regular accents of highly stressed vowels contrasting with subtle patterns of lightly stressed and unstressed elements, the whole suggestive of a contrapuntal mode. Phrases of Stutterers and Former Stutterers show an opposite effect, a decrease in clustering of the accented elements, as well as in the absolute length of the phrase. It seems that these two groups are able to achieve greater production - - and with a listener present - - but at a price, the price being shorter, simpler, less rhythmic phrases.

Timing-Dominance and Articulation-Dominance

The temporally compensative unit and the contrapuntal type of processing we have described for our Normal Speakers could be accounted for in a most comprehensive manner by a combined model of speech production such as that described by Lindblom and Rapp (1973; Rapp, 1971). Due to our method of measuring which begins with the onset of the stressed vowel, it is the more powerful anticipatory compensation that would account for the phonological interactions we find between stressed vowel segments and unstressed other segments in our data. The Lindblom and Rapp model has components of both speech preplanning and speech chaining, as discussed in our introductory chapter. The Normal Speakers of this study give ample evidence of speech preplanning in the microstructural analysis of their Syllable Periods and sufficient experimental evidence of feedback operation exists (e.g., Haggard,1973, a, b; Kent and Moll, 1975) so that its influence must be acknowledged even in essentially preprogrammed models of production.

Stutterers and Former Stutterers, on the other hand, do not maintain the temporally interactive unit which would indicate preplanned speech production. Stutterers, in particular, present a picture in which speech chaining appears to predominate. This implies much greater activity of feedback loops than is evidenced in the case of the Normals. Some support for this hypothesis is indicated in data of the present study which show incremented durations for speech units of the pathological and postpathological groups as compared to the Normals. Discrepancies are particularly striking in the case of segments containing postvocalic consonants.

Ohala (1970) proposed a dichotomy between "Timing-Dominant" and "Articulation-Dominant" systems which closely resembles the two modes of functioning we find in this study. Although Ohala did not intend that this distinction serve to identify normal and abnormal speech processes, the present findings strongly indicate that Timing-Dominance is a normal phenomenon. Among earlier investigators, evidence of Timing-Dominance was taken as support for an open loop or "comb" model of speech timing, and evidence for Articulation-Dominance as support for a closed loop or "chain" timing model. Following this inference, the open loop model, which does not depend upon feedback, better fits Normal Speech as observed in this study. Speech of Stutterers and Former Stutterers, on the other hand, is perhaps best understood as a closed loop Articulation-Dominant system of timing, wherein preset central rhythm plays a subordinate role.

Can we draw any more specific conclusions from our results about open vs, closed loop production in the normal as compared to the pathological groups? Recall that the criteria proposed by Ohala (1970) for Timing-Dominance are met by each of the normals as individuals in this study (See Tables IV-VI) but not by either of the other two groups.

If we assume that stutterers have a degree of motoric control for speech more characteristic of that seen in young children (See discussion in Jaffe, Anderson and Rieber, 1973), and then go on to accept Chase's hypothesis (in House, 1967) that young children have not completed the shift to open loop speech production, then we should see stutterers as individuals somehow arrested at an unsophisticated stage of motoric speech. We should not then be surprised to learn that closed loop mechanisms predominate in their speech. What is unexpected, however, is the finding that Former Stutterers may sound like Normals, maintain a lengthy but isochronous Syllable Period unit, but share many of the stutterers' other limitations.

Assuming that the timing pattern shared by Stutterers and Former Stutterers is endogenous rather than the result of therapeutic intervention, it is suggested that the role therapy plays in the improvement of the Former Stutterer is not to normalize his timing mode, but rather to bring about a successful accommodation of his speaking pattern -- as manifested by the consistency with which he regulates pausing for example -- superimposed upon the timing limitations of the stutterer which he continues to retain.

Speech-Regulating Biological Clocks

If there were a single clock responsible for timing of all types of segments then a change in articulation rate would produce a proportional shortening or lengthening of each type of segment. The figures in Tables V-IX indicate that there is no case among any of the three groups of proportional changes in mean durations of the various types of speech units. Thus the conditions for a strong hypothesis of a single neural clock are not met.

However a minimal criteria for whether it is reasonable to hypothesize that speech rate changes are under the control of a single continuous clock is the finding of segment changes in the same <u>direction</u> for all types of units. Stutterers show general continuous retardation and acceleration of speech. This type of unified psychomotor expression, when observed, has often been assumed to be under the control of a single process such as metabolic activity. There is inadequate evidence to argue that speaking in any of the groups is under the control of such a unitary timing process, but Stutterers do meet the weak condition that we have suggested might indicate it.

Only speculative conclusions can be drawn, but one can assume that the timing complexity available to normal speakers involves the alternating influence of different timing parameters from segment type to segment type where timing of each component of Syllable and Phrase Period is handled relatively independently, perhaps through elastic coupling of oscillators (See discussion in Pavlidis, 1973). In contrast an explanation for the simpler more tightly coupled timing rate pattern of stutterers, a pattern in which rates mutually synchronize across all types of segments, is more difficult to explain. It seems to represent a strategy of simplification of the temporal repertoire for this disfluent group. We should note however that therapy given to stutterers frequently includes practice in just such a metronomic fashion. Since, unlike the Normals, both the Stutterers and the Former Stutterers have all had considerable speech therapy, there is a possibility that timing inflexibility observed in these two groups is iatrogenic.

Another possible explanation could lie in the fact that the wealth of feedback information received and being acted upon by the pathological groups might bring about asynchrony of the master oscillators which control speech-timing mechanisms and thus disrupt the accuracy of the clock. A simplification in the complexity and coordination of outgoing motor commands might be one result. Another might be prolonged duration of speech units; evidence of such prolongation is in fact recoverable from the data and can be described as a strong effect, particularly in the case of transyllabic segments in which the difficulty of sequencing consonant clusters could be a factor.

Consideration of Neurophysiological Differences Between Stutterers and Normal Speakers

To summarize briefly then, subjects in this study appeared to be stimulated rather than stressed by the presence of a listener, as judged by the fact that more speech and briefer hesitations characterized encounters with a listener for all threee groups. This study therefore fails to provide support for a psychogenic view of differences in speech production between normal and stuttering speakers when in similar situations. Hypothesized differences that received confirmation were those involving consistency of temporal patterning, a characteristic of all individuals in the Normal Group, but one which failed to be maintained uniformly in the other groups.

Lack of precision and control with resultant mistiming of speech measures could be considered as nothing more than the unfortunate effect of stuttering episodes. In this view mistiming is the consequence rather than the cause of interrupted articulatory gestures. This explanation, however, fails to account for the timing limitations of Former Stutterers whose speech is free of disruptions but deviant in temporal patterning.

Another view to consider is one which holds that there are differences in neurophysiological organization between normal and stuttering speakers, differences important enough to preclude Timing-Dominance as a viable option and to impose Articulation-Dominance as the speech production mode of these individuals. Anomalies in the stutterers' perceptual processing have been hypothesized to coexist with deviant production. It seems likely for such modal differences to be associated due to close coupling between systems of perception and production (See, for example, discussions throughout Arbib, 1972).

Early and influential statements made by Orton (1927) and Travis (1931) suggesting the possibility of a lack of cerebral dominance in individuals who stutter have received renewed attention lately. A number of experiments have been conducted over some forty years investigating dominance and lateralization in the stutterer as compared to the normal speaker. The writer was unable to locate a central reference for these investigations and therefore assembled a summary chart for purposes of informal evaluation. The chart(Table XV) presents entries of studies which look at neurophysiological organization in normals and stutterers through various means. Positive and negative findings are reported on the chart, as well as the nature of the study. Studies charted were those available from accessible resources. Assuming that these are representative of results in the area in general, that is positive findings outweigh negative - - studies unfortunately,

TABLE XV

STUDIES OF DIFFERENCES IN THE NEUROPHYSIOLOGICAL ORGANIZATION OF NORMAL SPEAKERS AND STUTTERERS

Year		Perception	Findings		Production	Findings
1935				E	Travis & Knott	Mixed
1936				E	Travis & Knott	Mixed
1939				E	Hamstra	Negative
1940				E	Lindsley	Positive
1943				E	Douglas	Positive
1943				E	Knott & Tjossem	Positive
1943				E	Scarborough	Negative
1946				M	Kopp	Positive
1957	A	Stromsta	Positive			
1966				S	Jones	Positive
1969	D	Curry & Gregory	Positive			
1969	D	Perrin	Positive			
1972	D	Quinn	Negative			
1973	D	Slorach & Noehr	Negative	S	Cooper & Allen	Positive
1974				E	Zimmerman and Knott	Positive
1975	D	Brady & Berson	Positive			
1975	D	Dorman and Porter	Negative			
1975	D	Sommers, *et. al*.	Positive			
1975	D	Sussman & MacNeilage	Negative	SP	Sussman & MacNeilage	Positive

Key:

A - Auditory Monitoring Task
D - Dichotic Listening Task
E - Encephalographic Speech-Related Task
M - Motor Task
S - Speech Production Task
SP - Pursuit Auditory Tracking Task

are too disparate to allow for more detailed comparisons - - then there does seem to be evidence for differences in perceptual and productive modes of stutterers when compared with normal speakers. These differences typically manifest themselves as reversals in usual patterns of lateralization, lack of significant lateralization, or deficiencies in motor activities which rely on timing.

Brown and Jaffe (1975) present a provocative hypothesis which holds that dominance is not completely established in childhood but is a lifelong process. These authors develop their thesis in terms of aphasia, a language disorder, but a theory of delayed ongoing lateralization has exciting implications for stuttering, a speech disorder, as well. Perhaps the child who stutters is a delayed lateralizer, and there is a certain level of lateralization of language function required (but not yet achieved) in order for him to maintain effective control over the timing of the short fluent speech sounds that are considered appropriate for him by the time he reaches four or five. Such a child might speak rhythmically - - but slowly. With the necessity to speed up he becomes internally desynchronized and a stuttering speech response results. Temporal ordering of short sequential sounds is difficult for a child, particularly one who is late in lateralizing, or whose pattern of hemispheric dominance is best described as bilateral in nature, perhaps an adaptation for something other than speech.

According to Robinson and Solomon (1974) speech stimuli and nonspeech stimuli which are rhythmic are both processed in the same left hemisphere. Thus, individuals with divergent or inadequate hemispheric specialization could be disadvantaged for speech timing and rhythmicity. Their phrase structure, therefore, might reflect a lack of the organizing principle rhythm affords (Neisser, 1967, p. 262 - 263).

Most children do, however, grow out of their stuttering problem, at least by the time they reach high school. In fact a study of 8,000 school children shows that practically all are reported to have recovered from stuttering by the age of eight (Milisen and Johnson, 1936, cited in Bloodstein, 1969, p. 78). Recovered stutterers taking part in the present study had all stuttered until at least early adolescence and had received therapy for their stuttering problem. Their timing patterns remained deviant, although less so than those of stutterers. We could make the following speculation: If the Brown - Jaffe hypothesis is correct, and if timing behavior and strength of lateralization are associated, a relation that has been established for rat (Glick, et.al., 1975) but not for man, then stutterers who make spontaneous recoveries should show commensurate development in lateralization of language function and accuracy of timing control.

Implications for Future Research

Stutterers in the dissertation study showed higher articulation rates in the presence of a responsive listener than when alone. A preliminary pilot study shows that this higher articulation rate is evidenced even under adverse conditions, when the listener is programmed not to listen attentively but to appear bored and distracted, showing no behavioral responsiveness. An increase in reduplications could not account for this effect, since Stutterers produced the smallest number of unstressed syllables of any of three groups in this condition and reduplicative syllables fall into the unstressed category. Former Stutterers and Normal Speakers, on the other hand, did show a decrease in articulation rate in the unresponsive interview situation. A full scale follow-up study to explore facets of the effect of the interviewer on time patterns of speech in various populations is planned.

Further work should concentrate more heavily on linguistic studies of phrase structure and relations among phrases, a logical second level of analysis necessary in order to study the phrase patterns which obtain in natural speech. Comparisons should be made to stock paradigms investigated by Abercombie, (1973), Jones (1956), and Lehiste (1973). This includes analysis of patterns of metric feet, a metric foot being a unit comparable to the stress group of this study, and identification and durational measures of the various foot types - - disyllabic, trisyllabic, etc. - - according to position in phrase and sentence.

It is likely that there are similarities between the motif of music and the phrase of human speech. Individuals may be prone to use certain phrase structures for habitual reasons or a great variety of patterns for stylistic reasons. From the results of the present study we can expect a simplification of phrase structure, a skeletonizing of the motifs of stutterers and former stutterers when confronted with an audience whereas normal speakers tend to elaborate their phrase structure under similar circumstances. In fact, normals may tend to show generally more complex phrase structure than the other groups in all conditions.

In a similar manner, it would not be surprising to find schizophrenics and apathetic depressives using restricted and stereotyped phrase structures, while those of manics and agitated depressives might show expanded and interative configurations. It is possible that the same individual might reveal very different phrasal patterning in the manic than in the depressive stage of a bipolar psychosis; his speech in fact might signal transitional states. Along the same lines, analysis of aphasic speech in this manner - - in cases where collection of adequate speech samples is feasible - - could have diagnostic and prognostic value.

In order to explore our speculations on the possibility of delayed lateralization in stutterers, a study of recovered stutterers of two types could be undertaken. Timing patterns of recovered stutterers who had undergone therapy should be compared with those who have made a spontaneous recovery. The prediction would be that stutterers who have had spontaneous remission without therapy should show more temporal interaction and timing patterns more like those of normal speakers than those who recovered with the aid of speech therapy. The argument for such a prediction would assert that lateralization for speech has matured in the stutterer who recovers spontaneously and with it his timing control, accuracy and propensity for rhythmic speech.

A longitudinal study could be designed to explore the ongoing development of lateralization and speech behavior. Does the child who stutters become more lateralized with passing time? Does his stuttering symptomatology improve as lateralization progresses? Studies in the literature report that from 42 to 81 per cent of stutterers recover spontaneously (Bloodstein, 1969, p. 78 - 81), usually by high school age, so there is a foreseeable time span which such a study could encompass. We know from the Tingley and Allen (1975) study of timing as a developmental process that motor timing for speech and tapping do improve with age and in a congruent fashion in the normal child. Does this pattern hold for the child who stutters? If his pattern is deviant then the nature of the deviances will have special interest for us.

Invariant tempos delivered by a metronome have long been used as a therapeutic tool to assist the stutterer in establishing a more isochronous interstress interval. Such pacemaker devices are, of course, one of the earliest forms of rhythmic therapy, but the beat of the metronome is not the beat of the individual.

The criteria for normality of speech timing established in this study are clearly not simply metronomic, and were derived as purely descriptive measures. However their mathematical properties could guide the behavior of a device which delivers rhythmic cues to a stutterer, displaying both the structure of regularity and the variety of expressiveness that are missing from his speech on most occasions. If he were to be supplied with feedback of just those portions of his speech which approach normal timing patterns, the probability of producing such patterns might increase,possibly to the point at which rhythmic patterns are produced without further reliance on feedback.

APPENDICES

APPENDIX: I

Participation Questionnaire

Participation Questionnaire

Name ______________________________

Sex __________ Major or Area of Interest ______________

Age __________ Telephone Number ______________

1. Is English your native language? Yes ___ No ___
2. Have you ever had a reading problem? Yes ___ No ___
3. Have you ever had an oral reading problem? Yes ___ No ___
4. Have you ever had any speech problems? Yes ___ No ___
5. What kind of problem? Voice ___ Problem Sounds ___
   Stuttering ___ Other (describe) ______________________
6. Have you ever received special training in speech? (e.g. acting school, speech therapy, radio announcing, voice or other speech lessons) Yes ___ No ___
7. Do you have any speech problems at the present time? Yes ___ No ___
8. What kind of problem? Voice ___ Problem Sounds ___
   Stuttering ___ Other (describe) ______________________
9. Is your birthplace in the USA? Yes ___ No ___

DO NOT TURN PAGE UNTIL INSTRUCTED

VAT

Directions: Read the following paragraph and answer the questions based on this paragraph.

Only twice in literary history has there been a great period of tragedy, in the Athens of Pericles and in Elizabethan England. What these two periods had in common, two thousand years and more apart in time, that they expressed themselves in the same fashion, may give us some hint of the nature of tragedy, for far from being periods of darkness and defeat, each was a time when life was seen exhalted, a time of thrilling and unfathomable possibilities. They held their heads high, those men who conquered at Marathon and Salamis and those who fought Spain and saw the Great Armada sink. The world was a place of wonder; mankind was beauteous; life was lived on the crest of the wave. More than all, the poignant joy of heroism had stirred men's hearts. Not stuff for tragedy, would you say? But on the crest of the wave one must feel either tragically or joyously; one cannot feel tamely. The temper of mind that sees tragedy in life has not for its opposite the temper that sees joy. The opposite pole to the tragic view of life is the sordid view. When humanity is seen as devoid of dignity and significance, trivial, mean and sunk in dreary hopelessness, then the spirit of tragedy departs.

1. The title that best expresses the ideas of this paragraph is:

   1. Two thousand years of tragedy
   2. Periclean Athens
   3. The tragedy of war
   4. The psychology of happiness
   5. Mainsprings of tragic drama

2. The mental attitude that finds tragedy is characterized by

   1. sordidness
   2. indifference
   3. exaltation
   4. triviality
   5. hopelessness

3. The two periods in which great tragedies were written were periods of

   1. gloom
   2. serenity
   3. defeat
   4. confusion
   5. valor

4. In an age of glory one

   1. is not indifferent
   2. usually feels tragic
   3. feels happy
   4. is apathetic
   5. feels mean and hopeless

Directions: Each of the questions below consists of an underlined word, followed by five words numbered 1 to 5. Choose the numbered word which is most nearly opposite in meaning to the underlined word.

5. ribald 1. refined 2. scurrilous 3. insignificant
4. impolite 5. impolitic

6. diatribe 1. monologue 2. hypocrisy 3. praise
4. clan 5. autocracy

7. pithy 1. epigrammatic 2. anecdotal 3. verbose
4. fancy 5. plain

8. furtive 1. nearer 2. stealthy 3. apathetic
4. open 5. affable

Directions: Select the word or words which best complete the sentence.

9. Disturbed by the ______ nature of the plays being presented, the Puritans closed the theaters in 1642.

1. mediocre 2. fantastic 3. moribund
4. salacious 5. witty

10. The columnist was very gentle when he mentioned his friends, but he was bitter and even ______ when he discussed people who irritated him.

1. laconic 2. splenetic 3. remorseful
4. militant 5. stoical

11. ______ with the waters of melting snow, the rivers threatened to overflow their banks.

1. Ineffable 2. Chilled 3. Turgid
4. Filled 5. Berserk

12. To be ____ is to be ______ .

1. pugnacious-supercilious 2. obsequious-servile
3. contradictory-hostile 4. puerile-strong 5. effete-violent

Directions: Select the best relationship

13. chauvinism:country :: 1. frugality:money 2. patriotism: country 3. gluttony:food 4. jingoism:loyalty 5. criticsm:book

14. frugal:parsimonious :: 1. joy:ecstasy 2. caution:wisdom 3. honor:loyalty 4. poor:miserly 5. eager:anxious

15. convention:mores :: 1. antics:caprice 2. corruption: maggots 3. popularity:ephemeral 4. books:library 5. honesty:falsity

16. automobile:gasoline :: 1. fire:fuel 2. man:energy 3. airplane:propeller 4. man:food 5. disease:germs

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This booklet has contained the first part of research for a doctoral dissertation on individual and general patterns of speech behavior. We need various kinds of people on different levels of fluency to participate in the second part of the experiment. This experimental session will take place in a few weeks. It will be an individual session and will last about an hour. Perhaps you would be able to help us in our research, have a new experience, and earn some money at the same time.

If you are selected for the project, you will be notified by telephone and an appointment will be set up at your convenience. Please fill out the information below if you wish to participate. Add any comments about yourself which might be useful to us in our selection procedures.

Please circle free hours

M	T	W	Th	F	S
9	9	9	9	9	9
10	10	10	10	10	10
11	11	11	11	11	11
12	12	12	12	12	12
1	1	1	1	1	1
2	2	2	2	2	2
3	3	3	3	3	3
4	4	4	4	4	4
5	5	5	5	5	5

Name ______________________________

Phone Number _______________________

Comments:

Thank you for your cooperation,

Frances Podwall

APPENDIX: II

Subject's Self-Report Questionnaire

SUBJECT'S SELF-REPORT QUESTIONNAIRE

For your final task, I would like you to look back on the conditions of the experiment in order to judge one against the other in terms of their effect on you. Please circle the number that best applies to you in that particular situation.

1-E How did you feel when you were talking about life-styles that were possible with various annual incomes?

1. Overall I felt relaxed.
2. I was fairly relaxed.
3. I was not tense.
4. I felt somewhat tense.
5. I felt pressured.

1-F Did you think it was important to speak correctly in that situation?

1. It did not concern me at all.
2. It was not very important.
3. I thought it was fairly important.
4. I thought it was important.
5. I thought it was very important.

2-E How did you feel when you were talking about either the program or the movie you watched?

1. Overall I felt relaxed.
2. I was fairly relaxed.
3. I was not tense.
4. I felt somewhat tense.
5. I felt pressured.

2-F Did you think it was important to speak correctly in that situation?

1. It did not concern me at all.
2. It was not very important.
3. I thought it was fairly important.
4. I thought it was important.
5. I thought it was very important.

In any situation where people are speaking disfluencies such as pauses, repetitions, or extra little sounds like "ah" or "um" can occur. I would like you to rate your speech in terms of its fluency, as you remember it, for each situation.

1-G When I was talking about the various life-styles

1. I spoke smoothly.
2. I spoke smoothly most of the time.
3. My speech was sometimes smooth and sometimes choppy.
4. I spoke hesitantly much of the time.
5. My speech was generally very hesitant and choppy.

2-G When I was talking about the program or movie

1. I spoke smoothly.
2. I spoke smoothly most of the time.
3. My speech was sometimes smooth and sometimes choppy.
4. I spoke hesitantly much of the time.
5. My speech was generally very hesitant and choppy.

H Do you think your level of fluency varied somewhat throughout this experimental session, that is, do you think that you were more fluent in one situation than the other?

Yes _______ No _______

O Please list and/or describe any factors in the situations, or in you yourself, which might account for differences from one situation to the other.

APPENDIX: III

Technical Information

APPENDIX IIIa

THE DEFINITION, DETECTION AND TIMING OF VOCALIC SYLLABLES IN SPEECH SIGNALS

Scientific Report #12

1972

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Department of Communication Sciences
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It has long been known in acoustic phonetics, that amplitude (and hence energy) level across the entire speech spectrum flucuates in a quite discrete fashion between two states or phases. One phase is characterized by a high level of energy that is not only intense but widely dispersed across the high-boosted human speech spectrum. This we refer to as the "High Energy Dispersion" (HED) phase, within which the position of spectral formants is always visible. The other phase we shall term the "Low Energy Dispersion" (LED) phase possessing either too little energy or too little dispersion for identifiable formants to appear in the spectrogram. Not only have we observed the HED phase always occurring once in monosyllabic spectrograms and twice in disyllabic ones in a manner that perfectly matched the number of syllables judged by subjects, but also that the HED phase always lasted longer during stressed syllables than during unstressed ones. Therefore,we adopted the HED phase as an acoustic tag for the occurrence and duration of syllables. A HED phase recognition program was written for a Digital Equipment Corporation PDP-12 computer that would monitor the speech signal for occurrences of the HED phase and time the discrete durations of what constitute the HED segments of running discourse. We shall report the acoustic specifications and results of testing this program below. But in developing it we found it necessary to evolve a more explicit notion of segment.

It is known that the HED phase is a clear correlate of the oral sonorant sounds--vowels, liquids and glides--e.g., [ae] [r] [y], respectively. Nasal sonorants [m] [n] [n] belong to the LED phase, for although their energy level is relatively high, it is not widely dispersed due to the fact that these sounds strongly resonate only through the single nasal resonant cavity. Non-sonorants, (all the remaining sounds) are not subject to spontaneous voicing by the Bernouilli effect, and possess too little energy for the generation of visual formants. The role of two resonating oral cavities in producing the spectral spread observed during the HED phase is also well known, and supplies a corroborating articulatory basis for the conclusion that the HED phase only occurs during vowels.

Although graphically "obvious," finding an explicit acoustic detection routine for the onset and offset of HED segments is not simple.

Rise and decay phenomena are more easily visualized in oscillograms than in spectrograms, so we looked to see if visual detection and timing of HED segments was possible here too.

We formulated a simple vocalic segment geometry in terms of which the computer was to be instructed to monitor the amplitude envelope, segment it, and time the segments.

The speech signal was low pass filtered at 2000 Hertz prior to analog to digital conversion (every 400 microsec) effectively high pass filtered at 50 Hertz afterward by the following segment boundary detection routine.

Vocalic segment onset is defined as the occurrence of a rise of the speech signal above background noise by an amount of 6 dB, provided that it is maintained at this level or higher for 60 msec without meeting the offset criterion. Vocalic segment offset is defined as a drop in the speech signal of 6 dB or more that is maintained for at least 20 msec. See Table I for details.

TABLE I

RECOGNITION CRITERIA FOR VOCALIC SEGMENTS

(I) ENVELOPE CONTINUITY. The amplitude envelope is determined by the absolute values of the maximum signal amplitudes 6 dB or higher above background noise within each time epoch of 20 msec or "window" following onset. Thus, the envelope is set to zero (or to some value, X) if and only if the signal remains at zero (or at X) for as long as 20 msec. The envelope remains nonzero throughout any signal containing a nonzero component at least 6 dB above background at any frequency higher than 50 Hz. The window timer is set to zero at t_o = time of onset.

(II) AN INTERVOCALIC SEGMENT (IVS) is defined as any nonvocalic period following the offset or preceding the onset of a vocalic segment, or both.

(III) MINIMUM VOCALIC THRESHOLD (MVT) is fixed at 6 dB above background. Background includes system noise plus all nonvoiced components below 2000 Hz.

(IV) VOCALIC TRANSITION (VT) CUES.

A. ONSET: Envelope amplitude above MVT, persisting for at least three windows (60 msec) after the end of an intervocalic segment.

B. OFFSET:

1) Decay of envelope at a rate equal to or greater than 6 dB per window (half-life of 20 msec) persisting for at least one window.

or:

2) A drop of the envelope below MVT, persisting for at least one window.

APPENDIX IIIb

A BRIEF DESCRIPTION OF THE ACOUSTIC SPECIFICATIONS OF THE CONVERSATIONAL SPEECH DETECTOR COMPLETED AT THE NEW YORK STATE PSYCHIATRIC INSTITUTE ELECTRONICS LABORATORY IN MARCH 1971

1/26/73
M. Tobin

A BRIEF DESCRIPTION OF THE ACOUSTIC SPECIFICATIONS OF THE CONVERSATIONAL SPEECH DETECTOR COMPLETED AT THE NEW YORK STATE PSYCHIATRIC INSTITUTE ELECTRONICS LABORATORY IN MARCH 1971

The CONVERSATIONAL SPEECH DETECTOR is a two channel speech detector interfaced to a PDP 8/1 computer. Each channel contains an amplifier whose "effective Dynamic Range"* is greater than 30 dB, and whose gain for "average speech"** is flat to ± 4 db from 100 Hz to 4000 Hz. At higher frequencies the gain falls 10 db per octave. The equalized speech is rectified, then fed into an integrator whose time constant is 10 ms, and is detected by means of a dual level comparator. The delay between onset of speech and detection is a maximum of 10 ms for the full dynamic range. The delay between the termination of speech and continued detection varies between 10 ms for threshold speech levels to 50 ms for sustained speech above saturation. In addition a constant 180 ms delay is added to the end of detected speech.

*The CSD amplifiers saturate at input levels of 10 volts peak to peak. The gain of the external preamplifiers must be set so that "normal speech" yields 3.5 volts peak to peak at the inputs to the CSD. 1000 Hz 50 millisecond bursts 20 db below and 10 db above this level will be detected by the CSD. Wider tone bursts yield dynamic ranges greater than 30 db. A 10 ms tone burst is the narrowest signal that the CSD recognizes.

**The "average speech" spectra as measured by Dunn and White (1940) and Rudmose et.al., (1944 and plotted on page 1042: Handbook of Experimental Psychology - edited by S.S. Stevens - John Wiley and Sons, 1951.

APPENDIX: IV

Stepwise Discriminant Analyses

of the Three Groups:

Condition I and Condition 2

Stepwise Discriminant Analyses of the three groups for both Condition I (Solo Monologue) and Condition II (Listener Monologue) as provided by Program BMD 07M. In these printouts the entering variables are coded as follows:

1. fV - Frequency of Vocalic Segments
2. LV - Mean Duration of Vocalic Segments
3. LTS - Mean Duration of Transyllabic Segments
4. LSP - Mean Duration of Syllable Periods
5. LPHR - Mean Duration of Phrases
6. LPAU - Mean Duration of Pauses
7. LPP - Mean Duration of Phrase Periods

Condition 1

```
******************************************************************************************

STEP NUMBER          1
VARIABLE ENTERED     4

VARIABLES INCLUDED AND F TO REMOVE - DEGREES OF FREEDOM    2   15

  4    4.0527

VARIABLES NOT INCLUDED AND F TO ENTER - DEGREES OF FREEDOM    2   14

  1   0.4121        2   0.0186        3   0.0187        5   0.4689        6   0.0680        7   0.1727

U-STATISTIC             0.64920    DEGREES OF FREEDOM    1    2   15
APPROXIMATE F           4.05266    DEGREES OF FREEDOM    2   15.00

F MATRIX - DEGREES OF FREEDOM    1   15

              GROUP
              NORMAL        FORMST
GROUP
FORMST        0.10049
STUTTR        6.60546       5.25204

              FUNCTION
              NORMAL           FORMST          STUTTR
VARIABLE
  4           0.03559          0.03724         0.04915

CONSTANT
            -8.91723         -9.65770        -16.00739

              NUMBER OF CASES CLASSIFIED INTO GROUP -
              NORMAL FORMST STUTTR
GROUP
 NORMAL        4       2       0
 FORMST        5       2       1
 STUTTR        2       0       4

******************************************************************************************

STEP NUMBER          2
VARIABLE ENTERED     5

VARIABLES INCLUDED AND F TO REMOVE - DEGREES OF FREEDOM    2   14

  4    3.4299         5    0.4689

VARIABLES NOT INCLUDED AND F TO ENTER - DEGREES OF FREEDOM    2   13

  1   0.2771        2   0.3788        3   0.3791        6   0.0615        7   0.0615

U-STATISTIC             0.60844    DEGREES OF FREEDOM    2    2   15
APPROXIMATE F           1.97403    DEGREES OF FREEDOM    4   28.00

F MATRIX - DEGREES OF FREEDOM    2   14

              GROUP
              NORMAL        FORMST
GROUP
FORMST        0.15734
STUTTR        3.38634       3.07677

              FUNCTION
              NORMAL           FORMST          STUTTR
VARIABLE
  4           0.11276          0.11214         0.12945
  5           0.06091          0.05912         0.06238

CONSTANT
           -54.58603        -52.68164       -65.45682

              NUMBER OF CASES CLASSIFIED INTO GROUP -
              NORMAL FORMST STUTTR
GROUP
 NORMAL        5       1       0
 FORMST        3       3       0
 STUTTR        1       2       3

******************************************************************************************
```

Condition 1

```
STEP NUMBER         3
VARIABLE ENTERED    5

VARIABLES INCLUDED AND F TO REMOVE - DEGREES OF FREEDOM    2   13

   3   0.3791         4   0.1973          5   0.6203

VARIABLES NOT INCLUDED AND F TO ENTER - DEGREES OF FREEDOM    2   12

   1   0.2811         2   0.0859          6   0.0874        7   0.0874

U-STATISTIC              0.57492     DEGREES OF FREEDOM    3    2   15
APPROXIMATE F            1.38171     DEGREES OF FREEDOM    6   26.00

F MATRIX - DEGREES OF FREEDOM     3   13

              GROUP
              NORMAL        FORMST
GROUP
FORMST        0.23075
STUTTR        2.13275       2.21676

              FUNCTION
              NORMAL         FORMST          STUTTR
VARIABLE
   3          0.10727        0.09321         0.11471
   4          0.03430        0.04396         0.04554
   5          0.08099        0.07657         0.08486

CONSTANT
            -59.06821      -56.06633       -70.58287

               NUMBER OF CASES CLASSIFIED INTO GROUP -
              NORMAL FORMST STUTTR
GROUP
 NORMAL         4        2       0
 FORMST         2        4       0
 STUTTR         1        2       3


STEP NUMBER         4
VARIABLE ENTERED    1

VARIABLES INCLUDED AND F TO REMOVE - DEGREES OF FREEDOM    2   12

   1   0.2811         3   0.3755          4   0.4166        5   0.6846

VARIABLES NOT INCLUDED AND F TO ENTER - DEGREES OF FREEDOM    2   11

   2   0.0685         6   0.2193          7   0.2193

U-STATISTIC              0.54919     DEGREES OF FREEDOM    4    2   15
APPROXIMATE F            1.04818     DEGREES OF FREEDOM    8   24.00

F MATRIX - DEGREES OF FREEDOM     4   12

              GROUP
              NORMAL        FORMST
GROUP
FORMST        0.25499
STUTTR        1.63769       1.54315

              FUNCTION
              NORMAL         FORMST          STUTTR
VARIABLE
   1          0.16121        0.16777         0.16973
   3         -0.00037       -0.01080         0.00140
   4          0.21384        0.23080         0.23456
   5          0.04041        0.03433         0.04213

CONSTANT
           -107.04945     -108.02983      -123.76422

               NUMBER OF CASES CLASSIFIED INTO GROUP -
              NORMAL FORMST STUTTR
GROUP
 NORMAL         3        3       0
 FORMST         2        4       0
 STUTTR         1        2       3
```

Condition 1

```
**************************************************************************************************

STEP NUMBER          5
VARIABLE ENTERED     7

VARIABLES INCLUDED AND F TO REMOVE - DEGREES OF FREEDOM    2   11

  1   0.4012          3   0.3440          4   0.4822          5   0.2581          7   0.21

VARIABLES NOT INCLUDED AND F TO ENTER - DEGREES OF FREEDOM    2   10

  2   0.0644

THE FOLLOWING VARIABLES DID NOT PASS THE TOLERANCE TEST    6
  THEY WILL NO LONGER BE PRINTED

U-STATISTIC           0.52813    DEGREES OF FREEDOM    5    2   15
APPROXIMATE F         0.82727    DEGREES OF FREEDOM   10   22.00

F MATRIX - DEGREES OF FREEDOM    5   11

           GROUP
          NORMAL      FORMST
GROUP
FORMST    0.20136
STUTTR    1.33625     1.19311

          FUNCTION
           NORMAL          FORMST         STUTTR
VARIABLE
   1      0.93102         0.94327        0.95700
   3     -0.00044        -0.01887        0.00132
   4      0.41878         0.43726        0.44415
   5     -0.32710        -0.33589       -0.33372
   7      0.27507         0.27711        0.28132

CONSTANT
       -405.52490      -410.93677     -435.94116

           NUMBER OF CASES CLASSIFIED INTO GROUP -
          NORMAL FORMST STUTTR
GROUP
  NORMAL      4      2      0
  FORMST      1      5      0
  STUTTR      1      2      3
**************************************************************************************************
```

Condition 1

STEP NUMBER 6
VARIABLE ENTERED 2

VARIABLES INCLUDED AND F TO REMOVE - DEGREES OF FREEDOM 2 10

1	0.3609	2	0.0644	3	0.0647	4	0.0638	5	0.2226

THE FOLLOWING VARIABLES DID NOT PASS THE TOLERANCE TEST 6
THEY WILL NO LONGER BE PRINTED

U-STATISTIC 0.52142 DEGREES OF FREEDOM 6 2 15
APPROXIMATE F 0.64143 DEGREES OF FREEDOM 12 20.00

F MATRIX - DEGREES OF FREEDOM 6 10

GROUP	NORMAL	FORMST
FORMST	0.15255	
STUTTR	1.01311	0.90433

F LEVEL INSUFFICIENT FOR FURTHER COMPUTATION

VARIABLE	FUNCTION NORMAL	FORMST	STUTTR
1	0.96806	0.98039	0.99439
2	9.27369	9.29423	9.36115
3	9.21354	9.21552	9.30220
4	-8.78521	-8.78711	-8.84663
5	-0.35723	-0.36608	-0.36413
7	0.28434	0.28640	0.29067
CONSTANT	-417.72290	-423.18848	-448.37329

GROUP / CASE	GROUP WITH LARGEST PROB.	SQUARE OF DISTANCE FROM AND POSTERIOR PROBABILITY FOR GROUP - NORMAL	FORMST	STUTTR
GROUP NORMAL CASE				
1	NORMAL	7.239 0.507,	7.494 0.447,	12.042 0.046,
2	NORMAL	2.930 0.471,	3.042 0.446,	6.394 0.083,
3	FORMST	3.560 0.323,	2.520 0.544,	5.347 0.132,
4	NORMAL	3.734 0.607,	5.414 0.262,	6.802 0.131,
5	NORMAL	3.419 0.620,	5.439 0.226,	6.206 0.154,
6	FORMST	5.275 0.405,	4.983 0.469,	7.614 0.126,
GROUP FORMST CASE				
1	FORMST	5.547 0.276,	4.060 0.575,	6.773 0:149,
2	FORMST	2.290 0.457,	2.133 0.494,	6.725 0.050,
3	NORMAL	4.452 0.417,	4.815 0.348,	5.602 0.235,
4	FORMST	2.026 0.409,	2.017 0.411,	3.675 0.179,
5	FORMST	3.814 0.331,	2.890 0.525,	5.463 0.144,
6	FORMST	6.914 0.400,	6.359 0.528,	10.340 0.072,
GROUP STUTTR CASE				
1	FORMST	5.501 0.250,	3.693 0.618,	6.769 0.132,
2	FORMST	1.306 0.306,	0.840 0.366,	1.290 0.308,
3	STUTTR	15.818 0.042,	20.343 0.020,	12.616 0.938,
4	NORMAL	5.965 0.619,	5.413 0.182,	8.255 0.199,
5	STUTTR	5.716 0.157,	4.340 0.312,	3.279 0.531,
6	STUTTR	23.300 0.001,	20.985 0.004,	10.181 0.994,

NUMBER OF CASES CLASSIFIED INTO GROUP -

GROUP	NORMAL	FORMST	STUTTR
NORMAL	4	2	0
FORMST	1	5	0
STUTTR	1	2	3

Condition 2

BMD07M - STEPWISE DISCRIMINANT ANALYSIS - REVISED FEBRUARY 2, 1973
HEALTH SCIENCES COMPUTING FACILITY, UCLA

PROBLEM CODE STEPDS

NUMBER OF VARIABLES 7

NUMBER OF GROUPS 3

NUMBER OF CASES IN EACH GROUP 6 6 6

PRIOR PROBABILITIES 0.3333 0.3333 0.3333

VARIABLE FORMAT (7F5.0)

DATA INPUT FROM CARDS

MEANS (THE LAST COLUMN CONTAINS THE GRAND MEANS OVER THE GROUPS USED IN THE ANALYSIS)

VARIABLE	GROUP NORMAL	FORMST	STUTTR	
1	531.00000	500.16650	453.16650	494.77759
2	203.66666	206.50000	203.66666	206.27777
3	237.16666	253.83333	354.00000	281.66650
4	440.83325	447.00000	562.66650	483.50000
5	955.66650	806.33325	778.16650	846.72217
6	644.33325	704.00000	726.83325	691.72217
7	1600.00000	1510.33325	1505.00000	1538.44434

STANDARD DEVIATIONS

VARIABLE	GROUP NORMAL	FORMST	STUTTR
1	85.13283	69.03659	128.81819
2	14.70601	30.68385	51.85319
3	30.18219	65.57257	121.46765
4	70.91324	66.83705	133.46707
5	167.65378	216.59506	165.29765
6	179.68811	97.13034	235.99396
7	236.41986	236.60820	282.48389

WITHIN GROUPS COVARIANCE MATRIX

VARIABLE	VARIABLES 1	2	3	4	5	6	7
1	9538.22266						
2	-1033.47705	1263.21021					
3	-4993.77734	-342.67676	6655.03906				
4	-6250.89844	1007.19995	6227.73428	7572.66797			
5	5691.55078	3640.70947	-9859.47266	-5727.85547	34118.19922		
6	-15993.23906	2907.46682	5735.90234	9343.25761	-1374.73486	32522.91797	
7	-10301.74219	6546.19531	-4123.57031	3615.39966	32743.46484	31146.17188	63891.65234

WITHIN GROUPS CORRELATION MATRIX

VARIABLE	VARIABLES 1	2	3	4	5	6	7
1	1.00000						
2	-0.29541	1.00000					
3	-0.62679	-0.11726	1.00000				
4	-0.73550	0.32510	0.87726	1.00000			
5	0.31550	0.55023	-0.65431	-0.35835	1.00000		
6	-0.90805	0.45006	0.38988	0.59536	-0.04127	1.00000	
7	-0.41731	0.72319	-0.19998	0.16437	0.70131	0.68331	1.00000

Condition 2

```
STEP NUMBER          1
VARIABLE ENTERED     4

VARIABLES INCLUDED AND F TO REMOVE - DEGREES OF FREEDOM    2   15

  4    3.7318

VARIABLES NOT INCLUDED AND F TO ENTER - DEGREES OF FREEDOM    2   14

  1   0.5831        2   0.1678        3   0.2143        5   0.9871        6   0.7152        7   0.4145

U-STATISTIC            0.66774     DEGREES OF FREEDOM    1    2   15
APPROXIMATE F          3.73185     DEGREES OF FREEDOM    2   15.00

F MATRIX - DEGREES OF FREEDOM    1   15

              GROUP
            NORMAL       FORMST
GROUP
FORMST      0.01507
STUTTR      5.88035      5.30013

            FUNCTION
             NORMAL         FORMST         STUTTR
VARIABLE
  4         0.05821        0.05903        0.07430

CONSTANT
          -13.92988      -14.29138      -22.00229

              NUMBER OF CASES CLASSIFIED INTO GROUP -
            NORMAL FORMST STUTTR
GROUP
 NORMAL       4      2      0
 FORMST       3      1      2
 STUTTR       1      2      3

STEP NUMBER          2
VARIABLE ENTERED     5

VARIABLES INCLUDED AND F TO REMOVE - DEGREES OF FREEDOM    2   14

  4    2.8579         5    0.9871

VARIABLES NOT INCLUDED AND F TO ENTER - DEGREES OF FREEDOM    2   13

  1   0.4734        2   1.5286        3   0.4632        6   0.8730        7   0.8730

U-STATISTIC            0.58522     DEGREES OF FREEDOM    2    2   15
APPROXIMATE F          2.15037     DEGREES OF FREEDOM    4   28.00

F MATRIX - DEGREES OF FREEDOM    2   14

              GROUP
            NORMAL       FORMST
GROUP
FORMST      0.99075
STUTTR      3.08653      2.63880

            FUNCTION
             NORMAL         FORMST         STUTTR
VARIABLE
  4         0.09095        0.08809        0.10487
  5         0.04328        0.03842        0.04041

CONSTANT
          -41.82567      -36.27734      -46.32660

              NUMBER OF CASES CLASSIFIED INTO GROUP -
            NORMAL FORMST STUTTR
GROUP
 NORMAL       4      2      0
 FORMST       1      4      1
 STUTTR       1      2      3
```

Condition 2

STEP NUMBER 3
VARIABLE ENTERED 2

VARIABLES INCLUDED AND F TO REMOVE - DEGREES OF FREEDOM 2 13

2 1.5286 4 3.6219 5 2.4462

VARIABLES NOT INCLUDED AND F TO ENTER - DEGREES OF FREEDOM 2 12

1 0.2118 3 0.0985 6 0.3719 7 0.3719

U-STATISTIC 0.47380 DEGREES OF FREEDOM 3 2 15
APPROXIMATE F 1.96210 DEGREES OF FREEDOM 6 26.00

F MATRIX - DEGREES OF FREEDOM 3 13

GROUP	NORMAL	FORMST
FORMST	1.56492	
STUTTR	1.91417	2.47387

VARIABLE	FUNCTION NORMAL	FORMST	STUTTR
2	-0.09128	-0.04435	-0.08845
4	0.11330	0.09895	0.12652
5	0.05677	0.04498	0.05349
CONSTANT	-43.90253	-36.76756	-48.27669

NUMBER OF CASES CLASSIFIED INTO GROUP -

GROUP	NORMAL	FORMST	STUTTR
NORMAL	4	2	0
FORMST	1	4	1
STUTTR	0	2	4

STEP NUMBER 4
VARIABLE ENTERED 6

VARIABLES INCLUDED AND F TO REMOVE - DEGREES OF FREEDOM 2 12

2 0.9385 4 3.9144 5 2.1100 6 0.3719

VARIABLES NOT INCLUDED AND F TO ENTER - DEGREES OF FREEDOM 2 11

1 0.1722 3 0.1113

THE FOLLOWING VARIABLES DID NOT PASS THE TOLERANCE TEST 7
THEY WILL NO LONGER BE PRINTED

U-STATISTIC 0.44614 DEGREES OF FREEDOM 4 2 15
APPROXIMATE F 1.49144 DEGREES OF FREEDOM 8 24.00

F MATRIX - DEGREES OF FREEDOM 4 12

GROUP	NORMAL	FORMST
FORMST	1.13795	
STUTTR	1.41896	2.00402

VARIABLE	FUNCTION NORMAL	FORMST	STUTTR
2	-0.08498	-0.04170	-0.07735
4	0.11701	0.10051	0.13307
5	0.05657	0.04489	0.05315
6	-0.00392	-0.00160	-0.00672
CONSTANT	-44.03754	-36.70135	-48.69527

NUMBER OF CASES CLASSIFIED INTO GROUP -

GROUP	NORMAL	FORMST	STUTTR
NORMAL	5	1	0
FORMST	1	4	1
STUTTR	0	2	4

Condition 2

STEP NUMBER 5
VARIABLE ENTERED 1

VARIABLES INCLUDED AND F TO REMOVE - DEGREES OF FREEDOM 2 11

1	0.1731	2	0.8216	4	2.1003	5	2.1379	6	0.31

VARIABLES NOT INCLUDED AND F TO ENTER - DEGREES OF FREEDOM 2 10

3	0.1569

THE FOLLOWING VARIABLES DID NOT PASS THE TOLERANCE TEST 7
THEY WILL NO LONGER BE PRINTED

U-STATISTIC	0.43252	DEGREES OF FREEDOM	5	2	15
APPROXIMATE F	1.14516	DEGREES OF FREEDOM	10	22.00	

F-MATRIX - DEGREES OF FREEDOM 5 11

GROUP	NORMAL	FORMST
FORMST	0.92770	
STUTTR	1.04799	1.51766

FUNCTION VARIABLE	NORMAL	FORMST	STUTTR
1	1.05880	1.07563	1.06354
2	-0.09786	-0.05479	-0.09029
4	0.34694	0.32409	0.36403
5	-0.06192	-0.07548	-0.06589
6	0.44694	0.45632	0.44606
CONSTANT	-463.11694	-469.30127	-471.54150

NUMBER OF CASES CLASSIFIED INTO GROUP -

GROUP	NORMAL	FORMST	STUTTR
NORMAL	4	1	1
FORMST	1	4	1
STUTTR	0	2	4

Condition 2

STEP NUMBER 6
VARIABLE ENTERED 3

VARIABLES INCLUDED AND F TO REMOVE - DEGREES OF FREEDOM 2 10

1	0.2137	2	0.8080	3	0.1569	4	0.5206	5	1.4032

THE FOLLOWING VARIABLES DID NOT PASS THE TOLERANCE TEST 7
THEY WILL NO LONGER BE PRINTED

U-STATISTIC 0.41937 DEGREES OF FREEDOM 6 2 15
APPROXIMATE F 0.90699 DEGREES OF FREEDOM 12 20.00

F MATRIX - DEGREES OF FREEDOM 6 10

GROUP	NORMAL	FORMST
FORMST	0.77640	
STUTTR	0.80198	1.18273

F LEVEL INSUFFICIENT FOR FURTHER COMPUTATION

FUNCTION

VARIABLE	NORMAL	FORMST	STUTTR
1	1.12492	1.14514	1.13079
2	0.32998	0.39498	0.34480
3	0.53797	0.56554	0.54708
4	-0.12718	-0.16433	-0.11813
5	-0.04127	-0.05377	-0.04489
6	0.48341	0.49466	0.48315
CONSTANT	-505.14673	-515.74976	-515.00781

GROUP WITH LARGEST PROB. / SQUARE OF DISTANCE FROM AND POSTERIOR PROBABILITY FOR GROUP -

GROUP NORMAL CASE		NORMAL	FORMST	STUTTR
1	FORMST	6.209 0.303,	4.904 0.582,	8.146 0.115,
2	NORMAL	4.029 0.650,	9.517 0.042,	5.519 0.308,
3	NORMAL	4.309 0.415,	5.777 0.199,	4.448 0.387,
4	NORMAL	0.852 0.758,	4.738 0.109,	4.326 0.133,
5	NORMAL	4.460 0.725,	6.968 0.207,	9.171 0.069,
6	NORMAL	0.279 0.609,	2.205 0.232,	2.964 0.159,

GROUP FORMST CASE		NORMAL	FORMST	STUTTR
1	FORMST	5.326 0.125,	1.734 0.751,	5.332 0.124,
2	FORMST	7.585 0.100,	3.233 0.883,	11.189 0.017,
3	NORMAL	2.977 0.794,	6.570 0.132,	7.720 0.074,
4	FORMST	5.110 0.232,	3.727 0.463,	4.563 0.305,
5	FORMST	19.863 0.024,	12.496 0.963,	21.123 0.013,
6	STUTTR	4.920 0.202,	4.041 0.314,	5.171 0.484,

GROUP STUTTR CASE		NORMAL	FORMST	STUTTR
1	FORMST	5.711 0.315,	5.047 0.439,	6.206 0.246,
2	STUTTR	6.030 0.121,	9.540 0.022,	2.183 0.857,
3	STUTTR	7.103 0.354,	9.743 0.095,	6.214 0.552,
4	FORMST	6.352 0.318,	5.317 0.534,	7.877 0.148,
5	STUTTR	5.279 0.376,	10.283 0.031,	4.364 0.594,
6	STUTTR	21.945 0.005,	19.403 0.016,	11.204 0.979,

NUMBER OF CASES CLASSIFIED INTO GROUP -

GROUP	NORMAL	FORMST	STUTTR
NORMAL	5	1	0
FORMST	1	4	1
STUTTR	0	2	4

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BIBLIOGRAPHY

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