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**Viswanath, Nagalapura Shankariaha**

AN INVESTIGATION OF PRE- AND POST-CURSIVE EFFECTS OF A  
STUTTERING EVENT IN THE CONTEXT OF A PLANNING UNIT AND  
TEMPORAL REORGANIZATION OF ADAPTING UTTERANCES

*City University of New York*

PH.D. 1986

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NAGALAPURA S. VISWANATH

A dissertation submitted to the Graduate Faculty in  
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May 8, 1986  
Date

Katherine S. Harris  
Chair of Examining Committee

May 8, 1986  
Date

Irving Horbhey  
Executive Officer

Oliver Bloodstein, Ph.D.

Edward Conture, Ph.D.

Lawrence Raphael, Ph.D.

Supervisory Committee

The City University of New York

Abstract

AN INVESTIGATION OF PRE- AND POST-CURSIVE EFFECTS OF A  
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by

Nagalapura S. Viswanath

Adviser: Professor Katherine S. Harris

The two purposes of the study were (1) to explore the nature of durational changes preceding and following a "clear" instance of stuttering event in the context of speech planning unit, namely, a clause, and (2) to explore (a) the trend of speech rate variables--total articulation time and total pause time-- during the course of adaptation in stutterers and fluent speakers, and (b) elucidate the relation between the speech rate variables and fluency enhancement during adaptation. Four stutterers and their controls read a passage five times in succession. To explore the issues raised by the first purpose, five readings of each one of the eight candidate clauses with last word of the previous clause and first word of the succeeding clause were earmarked for spectrographic analysis. The first reading of each candidate clause contained a clearly identifiable stuttering event, with the

other four readings being fluent. Word locations X-2, X-1, X+1, X+2 within the candidate clauses, and Xp and Xf outside them were defined in relation to stuttered word location (X). Within and between group comparisons of duration of words in these locations were carried out by using ANOVA by repeated measures. Significant durational changes in words occupying locations X-1 and X in the immediate vicinity of stuttering events and Xp location (the last word of the previous clause) were noted. The result of this analysis has been discussed in the light of speech planning literature, hypotheses on moments of stuttering. To explore the issues raised by the second purpose, frequency counts of stuttering events in the five readings for the four stutterers were determined, speech rate variables, total articulation time and total pause time were defined and computed. Comparisons between stutterers and fluent speakers using ANOVA by repeated measures of speech rate variables for the five utterances of each one of the eight candidate clauses in the two groups of speakers were made. Similar comparisons were made on five totally fluent utterances of two candidate clauses by the eight speakers during the course of adaptation. The nature of relation between fluency enhancement during adaptation trials and rate variables such as total articulation time and total pause time is discussed.

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Dr. Helen Cairns undertook to parse the passages used in my study. Her course on Psychology of Speech enabled me to develop an appreciation of the cognitive viewpoint.

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## CHAPTER I

### INTRODUCTION

Four bases, can be recognized for the present study investigating pre- and post-cursive effects of a stuttering event and the differences and similarities between the stutterers and fluent speakers in temporal reorganization of adapting utterances. They are, (1) the extant literature on planning and production of speech which suggests that a speaker, generally, plans in chunk sized units of clausal length; (2) the theoretical accounts on moments of stuttering which generate certain expectations of changes preceding and following a stuttering event; (3) the current literature on fluent speech of stutterers which suggests that electromyographically, acoustically there may be differences between stutterers' fluent speech and nonstutterers' fluent speech; (4) the current literature on fluency evoking conditions in stutterers, which suggests a need for elucidation of speech related variables associated with improved fluency. In the present study, an adaptation paradigm was used. It provides an opportunity to explore the course of selected variables in relation to the known fact of reduction in the frequency of stuttering during the course of adaptation. These four bases will be elaborated on in some detail to generate the hypoth-

eses for the present study.

### I. Clause As a Unit of Planning

a) The notion of planning. The point of departure for present day accounts of speech planning and production (Fromkin 1973; Garret 1976; Mackay 1970), which posit the clause as a unit of planning, is provided by the seminal observations of Lashley (1951) on the problems of serial order in behavior. In this paper, Lashley critiques Watson's associative chain account (see Watson 1913) of the serial order in behavior, and presents an alternative account, where the notion of planning is advanced. Indeed, language with its recognizable units of production (sounds, words and sentences) and their sequential arrangement, provided the basis for much of his critique of the associative chain theory and the alternative account he advanced. The associative chain account posits that behavior which is ordered serially in time (language production is one of the examples) can be construed as a chain of responses. In the context of linguistic behavior, any linguistically specifiable unit such as word can be considered a response to the previous word and a stimulus for the succeeding word. The associative chain account thus implies that there is not a structure or internal organization to an utterance. Among the several objections to this account, the one which is most pertinent to the present paper is the phenomenon of slips of tongue. Lashley proposed that slips of tongue argue for the notion that planning is an integral part

of speech production processes and that the slips reflect that this planning and production has gone 'awry' temporarily. For example, consider slips of tongue (1) and (2):

(1) "You wasted a whole term" (intended utterance)--  
"You tasted a whole worm" (actual production).

(2) "Ike is indisposed with a stomach ache" (intended utterance)--  
"Ake is indisposed with a stomach ike" (actual production).

The underlined speech elements in (1) and (2) exchanged their locations during the course of serial ordering the elements. These examples argue for the position that the later occurring (exchanged) elements in (1) and (2) must have been available to the speaker in order for the errors noted above to occur. In Lashley's words, "...prior to the internal or overt enunciation of a sentence, an aggregate of word units is partially activated or readied." This observation relates to the notion of planning. Furthermore, he observed that the fact that errors such as these can occur at all, indicates that the partially activated words must be without total inherent constraint of their temporal ordering seen in error-free productions. These two observations anticipate the notion of response buffer or short term store (Fromkin 1973; Garret 1976; Mackay 1970; Shattuck-Hufnagel 1979) and the like, where phonological representations of the lexical items of an utterance are stored, before implementation based on "motor control algorithms which respond to segmental specifications and current linguistic and nonlinguistic constraints"

(McNeilage 1980).

Given that planning of an utterance is an integral part of speech production processes, the question can be raised as to the nature of the planning unit involved. More specifically, what is the evidence for the argument that clause is a unit of planning? An attempt will be made to adduce some of the evidence in the following paragraphs.

(b) Evidence for clause as a unit of planning.

1. Boomer and Laver (1968) found that sound exchange errors (e.g. guinea pig cage--guinea kig page) most often took place between elements of the same clause. Garret and Shattuck (1974) found that in a corpus of 172 consonant and vowel slips, only two errors involved exchanges across clause boundaries. Furthermore, they found that the probability of exchange errors decreases as the distance between the exchanged elements in the intended utterance increases. Nootboom and Cohen (1975) report similar findings for errors in German and Dutch. Thus, based on this data, one can argue that clause is generally a planning unit.

2. The pattern of change of the fundamental frequencies (fo) for utterances has been investigated by several authors in the recent past (Cohen, Collier and t'Hart 1982; Collier 1975; Pierrehumbert 1979; Sorensen and Cooper 1980; Cooper and Sorensen 1977, 1981). A general tendency for the fundamental frequency to decrease across a declarative statement is seen in the English language. This downward drift of

fo (called declination) can be derived by either joining maximas (peaks) of the extracted fo for an utterance--the so-called topline approach (Cooper and Sorensen 1981)--or by joining the minimas (valleys) of fo change for an utterance--the so-called baseline approach (Cohen, Collier and t'Hart 1982).

Cooper and Sorensen (1981) found an interesting relationship between the rate or slope of declination, utterance duration and the amount of declination. They measured peak fo on underlined words in pairs of utterances such as these:

(3a) The deer could be seen from the car.

(3b) The deer by the Canyon could be seen from the window of the car.

They found a nearly constant amount of declination (15-20 HZ) for both versions (3a) and (3b), slower rate of declination for the longer version of utterances than the shorter version of utterances, and higher (initial) fo values for the longer version of utterances than for the shorter version of utterances. Given the above results, Cooper and Sorensen suggest that a look-ahead mechanism takes account of the length of an utterance before computation of the initial fo and the rate of declination in order to keep the amount of declination nearly constant.

Since this result suggests that declination for an utterance is planned, the question can be raised as to the domain over which a speaker plans a declination. Cooper and Sorensen (1981) suggest that the clause is the domain over

which declination is computed. In support of this proposal, they found that there is fo resetting at the end of two conjoined main clauses, for example, the fo peak of the word following the first clause boundary was significantly higher than the fo peak prior to the boundary and was comparable to the fo peak at the beginning of the first main clause. Clause, thus, seems to be the minimal unit over which declination is planned.

3. Investigations in the area of pause patterning and speech timing afford some support to the notion of planning and clause as a unit of planning.

The study of pauses has a long history (e.g., Lounsbury 1954; Goldman-Eisler 1968; Grosjean et al 1979a, 1979b) in both spontaneous speech and reading. Generally, in pausology, three basic kinds of pauses are mentioned. They are, (1) hesitation pauses, (2) juncture or grammatical pauses, (3) pauses attributable to phonetic factors (such as stop closure). Grammatical pauses are syntactically conditioned and include pauses for effect, for example, pauses used as a rhetorical device. Earlier studies (Lounsbury 1954; Goldman-Eisler 1958) using a spontaneous speech database seem to suggest that hesitation pauses were associated with points of high lexical uncertainty or indecision. By using Shannon guessing-game techniques, Goldman-Eisler (1958) determined the predictability of each content word in twelve spontaneous spoken sentences, given the rest of the sentence as a context. On analyzing the twelve spontaneous spoken sentences, hesitation pauses (pauses

longer than 250 msec) were used more frequently before high-uncertainty lexical items than before low-uncertainty items. The result was interpreted as supporting the notion that words are primary planning units in the integration of sentences.

These earlier studies have been severely criticized (see Fodor, Bever and Garret 1974 for extended review of limitations of these and other studies) on grounds of sampling technique, confounding of hesitation pauses with other types of pauses, etc. Boomer (1965), starting with the 'null' assumption that pauses are equiprobable between any two words, showed that pauses are highly probable at the beginning of a clause, specifically, between the first and second word, and their occurrence is at a chance level thereafter. In this analysis, Boomer did not include pauses at the beginning of the clauses, since he considered them grammatical pauses. The data were reanalyzed by Fodor et al (1974) after the inclusion of these pauses. This reanalysis was based on the reasoning that some of the pause times at syntactic boundaries were due to hesitations. The reanalysis showed that pauses were highly likely to occur at the beginning of the clause, suggesting a clause, not a word, as a unit of planning.

The above brief discussion shows that these studies were plagued by the problem of identification (operationally) of the three types of pauses. More specifically, identification of phonetically conditioned pauses present the least problem, since they can be readily identified in speech recordings such as spectrograms. It is difficult to identify

hesitation pauses and juncture pauses consistently. For example, not only are we faced with the problem of confounding the grammatical pause with the hesitation pause at the beginning of an utterance (the basis of Fodor et al's reanalysis) but the same potential problem exists between any two minor constituents. Probably it is better to study pause distribution without reference to categories of pauses. The recent studies of pause distribution by Grosjean and coworkers (1979a; 1979b) can be viewed in this light. Grosjean et al have found that during oral reading (1) the rate of utterance conditions pause duration and frequency differentially depending upon the pause location. Specifically, pauses between minor constituents are shorter and the first to drop out when rate is increased, pauses at major syntactic boundaries (clauses and sentences) are longer and less likely to drop out when rate is increased. This suggests that these later pauses have some useful speaker and/or listener oriented function. Grosjean et al (1979) found that breathing is largely limited to the major constituent boundaries, such as a clause or sentence, and speakers rarely exploit pauses at other locations to replenish their lungs. This result confirms Henderson's (1965) findings. Garret and Haker (reported by Fodor et al 1974) showed that speakers did not breath at artificially induced pauses except when such pauses occur at major constituents such as a clause or a sentence. In the study the subjects were asked to read passages which were typed in groups of five words on file cards, regardless of punctuation.

The speakers "rarely breathed at a card boundary that was not also a major syntactic boundary and all breathing which was not at card boundaries was syntactically conditioned." (Fodor et al 1974) Thus, it appears breathing is preplanned to respect the integrity of syntactic units such as a clause or a sentence.

Earlier discussion of the domain of fo application indicated that speakers consider a very general feature of an utterance--its length--as they begin to speak. Speech planning appears to influence the timing of words. This can be illustrated with reference to the phenomenon of constituent-final lengthening. In English, the last syllable of the final word in a clause or a sentence is considerably longer (100 msec) than the same syllable within an utterance. This lengthening mainly implicates vowels and consonants following them which do not invoke total occlusion of the vocal tract. Paccia-Cooper and Cooper (1981) in an interesting series of experiments tested two alternative hypotheses accounting for the lengthening effect. The first hypothesis--execution based--would consider segmental lengthening as a relaxation response of speech processing machinery upon completion of a given planned unit. The second hypothesis posits that constituent final lengthening affords an extra fraction of time in which to plan material not yet spoken in an utterance. Using a method called one-sided variation, they tested these two alternative accounts. This method involves keeping the material on one side of a given boundary constant while sys-

tematically varying the material on the other side of the boundary. Consider 4, which illustrates this principle.

(4a) Tom and I will reprimand Sue and Clark and Jane will talk to Steven

(4b) Tom and I will reprimand Sue and Clark and Jane plans to talk to Steven's brother and send Jeffrey to the principal

The results with twenty speakers, showed that the duration of the clause final word 'Clark' was significantly longer in (4b) than (4a) and that there is no significant difference between pause duration after the word 'Clark' in the two versions. This result supports the notion that the constituent-final lengthening is influenced by the length of upcoming material--apparently supporting the planning based hypothesis of constituent-final lengthening noted earlier. An additional finding of particular interest is that a speaker considers the general length of the upcoming clause rather than the length of the phrase constituting it.

Paccia-Cooper and Cooper (1981) tested the execution based hypothesis by varying material before the key word, Jake, in the following example (5).

(5a) Bob went to visit Jake, while Mary went on a picnic.

(5b) Bob went to the hospital in Atlanta to visit Jake, Mary went on a picnic.

There was no significant difference between Jake on these two versions, thus apparently refuting the execution-

based account of constituent-final lengthening.

In this section various evidence for clause as a unit of planning was considered. Taken together, distribution of phonemic exchange error, nature and scope of fo declination, distribution of pauses--especially breath pauses, and anticipation of length of upcoming clause by the degree of segmental lengthening of the last word of the previous clause, all argue for the clause as a unit of planning.

Given the above, one may conclude that planning at the later stages of the speech process involves specification of segmental duration, intonation pattern, sentence stress, pause distribution, etc. At this point, it becomes imperative to ask the question "What are the consequences of an apparent timing disturbance, which a stuttering event admittedly is, on the timing of other elements of the planned chunk (clause) within which it occurs?" At a more molecular level, studies on the capabilities of the articulators to achieve normal (perceptually and acoustically) productions after having undergone anticipated and unanticipated physical perturbations (Folkins and Abbs 1975, 1976; Folkins and Zimmerman 1981; Gay et al 1981; Lindblom et al 1979; Kelso and Tuller 1982) is well documented. The analogy between the externally and experimentally applied perturbation and a stuttering event is not without justification. The theories of stuttering which posit factors such as conditioned negative emotion (Brutten and Shoemaker 1967), belief that speech processes are difficult (Bloodstein 1984), etc., are in effect stating that the basic

source of the problem lies outside the speech production system. The momentary disruptions these posited factors engender can be compared to the perturbances applied from outside to the ongoing planned speech activity. Will we see compensations for stuttering events as we see for the externally applied perturbances? How is compensation effected at the molar level of a planned unit? This calls for an investigation of fluent portions of speech preceding and following the stuttering event occurring within a planned unit.

## II. Theories on Moment of Stuttering

The field of stuttering provides varied and numerous theories trying to account for the basic nature of the problem. The bewildering number and variety of theories 'cry' for some sort of rational classification (Ainsworth 1957; Bloodstein 1981) based on broad similarities and differences among the various theories. The theories are not always strongly databound and many of them draw heavily on clinical insights and knowledge (Bloodstein 1984). These theories are being considered in this paper to see whether they provide a basis for the present investigation. Hence, attention will be largely directed towards hypotheses accounting for a moment of stuttering.

Concept of moment of stuttering. The concept of moment of stuttering has gained wide theoretical and therapeutic acceptance. The concept draws attention to the perceptual phenomenon--that a stutterer's speech is comprised of periods

of fluency and moments of dysfluency--some of which receive the label of stuttering.

Bloodstein (1981) classifies the hypotheses on moments of stuttering into three categories: (1) repressed-need hypotheses, (2) breakdown under stress hypotheses, and (3) anticipatory-struggle hypotheses. These categories of hypotheses can be identified with certain general propositions. These general propositions will be considered along with an example(s) in order to see whether (a) these accounts generate expectations of measurable changes preceding and following a stuttering event, and (b) whether they differ in terms of the expectations they generate.

1. Repressed need hypotheses. Most of the theories (Coriat 1943; Barbara 1954; Travis 1957) subsumed under this category consider stuttering as a symptom of neurosis, and are couched in a vocabulary, and inspired by, the psychoanalytic paradigm. Stuttering is viewed in these accounts as a form of behavior growing out of repressed basic drives and needs. Furthermore, in those accounts conflicts and anxiety are looked on as primary factors rather than something that arises from reactions to situations surrounding the speech. For example, anxiety may arise from the child's inability to express or gratify his libidinous urges and at the same time adapt to parental expectations or standards. Stuttering, thus symbolizes a compromise between seeking and inhibiting gratification.

The various theorists use this basic 'theme' described

above, focusing on factors they consider important. For example, Coriat (1943) stresses the fixation at (or regression to) an early stage of psychosexual development as a source of the stuttering symptom. Travis (1957) focuses more attention on the child's needing to suppress strong tendencies towards enjoying culturally unacceptable pleasures of sucking, evacuating and exploring, all of which are prohibited by society. These prohibited urges are repressed to emerge as stuttering. Barbara (1954) proposed that the stutterer makes unrealistic (neurotic) demands of others, particularly women, in order to build up his self esteem. There is excessive fear and concealed hostility towards others and himself with the resultant guilt feelings and stuttering.

The brief accounts of repressed need hypotheses imply that, though a stutterer comes to a clinic with a tangible problem, the chief concern of the therapist must be uncovering his intrapsychic conflicts. In classical psychoanalytic accounts, symptomatic treatment--or dealing with the presenting problem directly--is strongly discouraged because of the fear of symptom substitution. Thus, as symptom (stuttering) is of secondary concern to these accounts emphasizing deep psychotherapy, little attention is paid by these theorists to analyze the presenting problem, or developing accounts, however sketchy, which would relate stuttering to the speech process. Because of these limitations, these theories cannot be related meaningfully to the present study. Hence, this category of theories will receive no further consideration here.

2. Breakdown under stress theories. These theories posit interaction between two factors: (a) predisposing condition(s), and (b) currently operating stressor(s). These interactional models of a moment of stuttering posit that delicately coordinated speech behavior is prone to momentary breakdowns in stutterers under the influence of emotional or psychosocial stress. As an example of this category, consider the theory of cerebral dominance proposed by Orton and Travis (Travis 1931).

Theory of cerebral dominance. The basic propositions of the theory of cerebral dominance proposed by Orton and Travis in the early thirties were: (1) speech articulation involves organs such as lips, tongue, soft palate, vocal folds, whose innervation are from the two halves of the brain; (2) the innervations from either half of the brain must be coordinated for smooth speech articulation; (3) the coordination between the halves is achieved by the dominant (generally, left) hemisphere taking "motor lead control;" and (4) if for some reason a clear "motor lead control" is not established, the two hemispheres would tend to operate independently, action of the two halves of the midline speech organs would be poorly coordinated, and a predisposition for speech breakdowns would exist. Orton and Travis suggested that the margin of dominance of one hemisphere over the other is reduced in ambidextrous individuals, and in individuals who are innately lefthanded (presumably with right hemisphere

dominance), and who are forced to change their handedness because of the cultural pressure. The enforced change in handedness, according to Orton and Travis, results in reduced margin of dominance for the right hemisphere.

Given the reduced margin of dominance and emotional or psychosocial pressure, the delicately coordinated speech in stutterers is prone to breakdowns. The breakdowns appear as discrete events in an otherwise fluent speech. Stuttering events are indeed discrete perceptually. There is an indirect suggestion in this account that perceived stuttering represents an end point of a series of events. However, the account does not specifically posit a phase of "build up" of the perceptual stuttering event nor its "build down". The present investigation, therefore, can be construed as a test of hypotheses of discreteness at a different level, namely acoustic, of speech organization.

3. Anticipatory struggle theories. Anticipatory struggle hypotheses are "first and foremost a cognitive theory of stuttering" (Bloodstein 1984). The basic proposition is that an eccentric system of belief that speaking is difficult is the basic source of the problem. The eccentric system of belief stems from early childhood experiences of "overcorrection" of speech by significant others and chronic speech failures. Thus, according to Johnson's (1967) diagnosogenic theory, when a child is "diagnosed" by parents as being a stutterer, there is no difference between the child's fluency characteristics

and those of any other normal child. The diagnosis on the part of the parents, reflects their overperfectionistic attitude in general, and unrealistic standards of speech in particular. Frequent and repeated evaluations of similar nature by the parents, apparently sets in motion a train of events leading to the child's belief that speech is difficult. In due course, the stutterer acquires the notion that specific elements of speech are difficult. Once a stutterer acquires the belief that certain elements of speech are difficult, he starts adopting attitudes and behaviors which he believes will enable him to avoid the difficulty (stuttering). However, these series of activities are inimical to fluent speech most of the time. To put it another way, stuttering is what a stutterer does--anticipation, apprehension, hypertonic reactions--to avoid it.

These basic statements have been modified by workers who followed Johnson's reasoning in several ways. Consider, for example, Bloodstein's (1984) modifications. They are:

1. The diagnosogenic aspect of Johnson's theory is considered too specific. A broader statement of how the belief system gets infected is adopted--that is, "any imaginable type of speech pressure or chronic speech failure in childhood..." is believed to lead to stuttering.

2. Bloodstein's (1984) theory of tension and fragmentation of cohesive speech units, differs from Johnson's position in another significant way. In Johnson's account, stuttering is what a stutterer does to avoid it, whereas in Blood-

stein's account, stuttering is what a stutterer does--fragmentation of speech units--because he lacks conviction that he can successfully produce the speech act.

In spite of these differences, both the accounts (and other accounts within this rubric) posit a series of cognitive events (anticipation, apprehension, and hypertonic reactions) leading to a stuttering event. Do these alleged antecedent chains of events affect the fluent portion of speech preceding a stuttering event within a clause? Do the effects of chains of events end with a stuttering event? These questions provide a basis for the present investigation of acoustic changes preceding and following a stuttering event within a clausal unit.

### III. Characteristics of the Fluent Speech of Stutterers

As we have seen, the concept of moment of stuttering has played a key role in the development of several theories in the area of stuttering. One should also take note of the fact that this concept has enjoyed a very critical status in appraisal, evaluation and measurement of therapy outcome of the problem. Of late, however, the extensive data (example, Hillman et al 1977; Adams and Hayden 1976; Zimmerman 1980; Shapiro 1980 and others) in the area of fluent speech of stutterers, suggest that the preoccupation with the concept of moment of stuttering may give a very narrow perspective on the nature of the stutterer's speech problem. Furthermore, the data also suggest a fresh perspective on the issue of therapy

goals, the problem of relapse, etc. (Adam and Runyan 1981; Bloodstein 1981). Before considering how these findings can be placed in the context of the present study, a few of these studies will be discussed in some detail.

There are a large group of studies (Adams and Hayden 1976; Starkweather et al 1976; Cross and Luper 1979; Watson and Alfonso 1983; Hillman et al 1977; Agnello 1975; Metz et al 1979; Zimmerman 1980; Shapiro 1980) which address the issue of temporal characteristics (timing and coordination of gestures and muscles) at a 'molecular' level of fluent speech production. There is another group of studies which have examined fluent speech of stutterers at a more 'molar' level, in the immediate vicinity of stuttering events (Knox 1975; Falk et al 1985) in the context of large chunks of utterances.

(a) Studies at "molecular" level of fluent speech production. Under this general rubric, the subset of studies dealing with VOT (Agnello and Wingate 1972; Hillman and Gilbert 1977; Metz et al 1979; Zimmerman 1980; Watson and Alfonso 1982) has provided a mixed picture in terms differences between 'fluent' VOT's of stutterers and fluent speakers.

VOT, or voice onset time, refers to a continuum of timing relation between the onsets of two gestures--the upper articulator release and the onset of phonation in the production of stops. A stop and its cognate (say /b/ and /p/) share a mutually exclusive contiguous range of VOT value on the VOT

continuum. In perceptual tests a sharp change in labeling function at VOT values between the boundary of the two ranges of values occurs. Hence, the VOT studies can be generally construed to raise the question, "Do stutterers employ 'atypical' VOT values, within the range of VOT values for a stop, when compared to fluent speakers?"

Agnello and Wingate (1972), using 12 adult stutterers and 12 normals, found significantly longer VOTs for stops. This result was confirmed spectrographically by Hillman and Gilbert (1977) when they analyzed CVs taken from oral readings in 10 adult stutterers and 10 normal speakers. Zimmerman (1980), in his movements patterning study using X-ray motion picture and CVC words further supported this finding with six adult stutterers and seven normal speakers. These encouraging results have to be tempered in the light of Metz et al (1979) and Watson and Alfonso (1982) studies. Metz et al (1979), in a spectrographic analysis of 18 different sound clusters in words, found that stutterers' VOTs were longer on only six of the 18 clusters. Watson and Alfonso (1982), however, found no significant difference between the stutterers and fluent speakers in speech samples involving three contiguous vowel+consonant+vowel+consonant sequences. The basis for the contradictory results need to be investigated. Can these contradictions be resolved if studies are designed taking into account the severity rating of the stutterers? Are the stutterers more likely to show an abnormal timing relationship between the two gestures implied by VOT in running speech

rather than isolated CVC combinations? Will there be a difference between stutterers who have a strong familial history of the problem as compared to those who do not? These general questions probably raise the issues which are also relevant to resolving contradictory findings in other areas of stuttering research. At present, therefore, the findings on VOT must be taken cautiously.

There is virtually a deluge of studies on the differences between stutterers' laryngeal reaction time (LRT) and speech initiation time (SIT). In the present paper, a few of these studies will be considered to highlight the general findings and the issues raised. These studies generally have used the reaction time paradigm, where subjects are required to phonate (usually a vowel), or initiate a speech task at the onset of a signal (visual or auditory).

Cross and Cook (1979), using eight adult stutterers and eight normal speakers, visual and auditory stimuli, found that stutterers were slower than the normals in initiating a phonation of the vowel /a/. Cross and Luper (1979), using 27 stutterers representing different age groups (five years, nine years, and adults) with matched normal speakers, found that stutterers were slower than fluent speakers in initiation of phonation of /n/ to a 1,000 HZ signal. Furthermore, the LRT in stutterers and fluent speakers shortened with age. Starkweather et al (1976) found that eleven stutterers were significantly slower than their matched controls in production of 26 syllables, and both groups showed a practice effect,

i.e., the LRT shortened from the beginning to the end of the experiment. Hayden et al (1982) tested LRT in the context of nine sentences beginning with vowels (e.g., "Almonds and nuts"), in all of which stutterers were slower than normals. In contrast to the positive findings of all these studies, Venkatagiri (1981), using 10 adult stutterers and 10 matched normals, and an auditory signal, found no difference between the groups. Watson and Alfonso's (1982) findings confirm Venkatagiri's conclusion. Watson and Alfonso (1983), in a carefully designed study, found an explanation for their earlier negative finding. Specifically, they found that the LRT is conditioned by the length of foreperiod (the duration between the warning signal and phonate signal) and the severity rating of the stutterers.

The above discussion leads one to conclude that slower laryngeal reaction is a general feature of the stutterer's fluent speech and its absence can be related to certain subject-related and experimental variables. This conclusion is in line with Cullinam and Springer's (1980) findings. Cullinam and Springer (1980) classified 20 child stutterers into two groups. The first group comprised of 11 stutterers with articulation and language problems, and the second, the remaining nine stutterers with no articulation and language problems. They were matched with 20 children on the basis of sex and age. The two groups of stutterers combined, had significantly slower LRTs than normals. However, this difference was a function of the extreme slowness of the stutterers with

articulation and language problems. In other words, "pure" stutterers (N=9) did not differ from normal speakers significantly on LRT.

Are the LRT effect and longer VOTs a function of an individual's history with the problem? To put it another way, after years of stuttering a stutterer might attempt speech or speech-like acts with caution and slowness. One way of testing this notion is to study VOTs and LRTs in very young stutterers, who probably have very little 'reactive' components to their problem. Wendell (1973) did find a significant VOT difference between 12 young stutterers and their fluent matches. Cross and Luper (1979) found the LRT effect in stutterers as young as five years of age. Thus, it seems likely that LRT effect is intrinsic to the problem and does not arise as a "reaction" to it.

Thus, these studies suggest that stutterers' speech exhibits atypical timing relation between laryngeal gesture and upper articulatory gesture and in timing of laryngeal vibratory activity in response to a stimulus. Though the basis for this difference is not firmly established, it probably is not due to stuttering.

There are various studies which have examined perceptually fluent utterances at other levels of the speech production processes. Thus, Zimmerman (1980) found significant temporal organizational differences in the movement pattern of fluent speech of stutterers and fluent speakers on such variables as transition time, movement onset and offset, duration

of the steady state portions. Shapiro (1980) discovered an inappropriately high degree of orbicularis oris, superior longitudinal and laryngeal abductor activity during a stutterer's fluent production.

The review of studies under the general rubric of 'molecular' level of speech production has revealed that there are subperceptually significant differences between the stutterers and fluent speakers at various levels of speech organization. These differences generally take on the character of a timing disturbance. What is the relationship between these subperceptual disturbances and perceptual stuttering? Does stuttering, as Zebrowski et al (1985) suggest, represent "a localized elaboration of pervasive, subtle disruptions which characterize the whole of their speech--both fluent and stuttered?" One may assume that these disruptions are most likely closer to, or in the immediate vicinity of, stutterings. The discussion on the studies of the characteristics of fluent speech at the "molar" level of production can be viewed in this light.

(b) Studies at 'molar' level of fluent speech production. The present investigator could find only two studies which objectively examined characteristics of fluent speech in the immediate vicinity of a stuttering event (Knox 1974; Falck 1985).

Knox (1974) examined several acoustic variables preceding a moment of stuttering. Using spectrographic technique,

he examined the frequency of the second vowel formant at pre-selected points, word duration, consonant-vowel and vowel-consonant transition slopes, fundamental frequency in at least three words, preceding a moment of stuttering. He compared these measures with the measures obtained on the same words when they were not followed by a moment of stuttering (i.e., in completely fluent utterances). To obtain the completely fluent match, he asked the stutterers to repeat the utterance containing stuttering until it was judged to be produced fluently both by the experimenter and the speaker. In addition, he obtained two repetitions of corresponding utterances from matched normal speakers. He found that stutterers changed significantly more on these measures from stuttered utterance to fluent utterance than normal speakers from their first repetition to the second. Stutterers were more likely to have statistically significant differences on these measures--i.e., when the prestuttered utterance was compared with its fluent counterpart from the same speaker--for the word immediately preceding an instance of stuttering.

Falck et al (1985) used similar strategy to study the course of fundamental frequency in a 1,024 msec speech sample before the onset of a stuttering event. They compared extracted, digitized fo pattern in a 1,024 msec sample of speech before the stuttering event (prestuttered) with a 1,024 msec speech samples (prefluent) from an identical utterance produced fluently by the same speaker. Since they used an adaptation paradigm, the identical fluent utterance could be from

any one of the five readings. For the purpose of analysis, they divided 1,024 msec into four quarters. They found that the mean (fo) was consistently lower during all the four quarters in prestuttered utterances compared with the prefluent one. Prestuttered utterances exhibited a greater variability around the mean fo than the prefluent utterance. Furthermore, they analyzed the feature of voicing and mean fo in three types of stuttering, namely, (1) inappropriate absence of phonation, (2) prolongations, and (3) repetitions. With those stuttering events identified as exhibiting inappropriate absence of phonation, laryngeal adjustment began at least 0.5 sec prior to the judged moment of stuttering. Moreover, the number of voicing data points was consistently smaller in the prestuttered than prefluent utterances across the four quarters. In prolongations, the mean fo was initially lower than the matched prefluent mean fo. However, the difference was reduced in the time period closest to the moment of stuttering. In repetitions, the mean fo was essentially the same for the prestuttered and prefluent utterances in all four quarters. It is not clear from the report how the determination of the beginning of the moment of stuttering labelled "inappropriate absence of phonation" was done. With regard to the two other types of stuttering events, namely repetition and prolongation of sounds and syllables, the beginning of a moment of stuttering was considered to be the point where the appropriate behavior necessary to proceed with smooth transition was missing. Thus, for repetitions, the beginning of the

moment of stuttering was the end of the first repetition of the sound or syllable, and for prolongation, the point at which voicing was judged to be of inappropriate phonatory quality.

These two studies taken together indicate that there are measurable changes in acoustic variables signalling the onset of a moment of stuttering. These studies did not consider a stuttering event in the larger perspective of an utterance chunk, like a clause. The paucity of data in this area demands further investigations along similar lines informed by extant literature in speech planning and production.

First purpose of the study. The three bases discussed above motivate the present study investigating durational changes preceding and following a stuttering event. Specifically, the study was designed to answer the following questions:

1. Are there pre- and post-cursive effects in terms of durational changes of words with reference to stuttering events?

2. What are the limits or boundaries of these effects in the context of a planned unit (clause)?

3. Do the durational changes preceding and following a stuttering event reflect an overall durational constraint on the planned utterance? This question presupposes that the planning process imposes a constraint on the duration of a planned utterance. If this assumption is true, an asymmetrical pre- and post-cursive effect--for example, signifi-

cantly longer duration of words in the pre-stuttering phase compensated by significantly shorter duration of words in the post-stuttering phase--can be expected. On the other hand, a symmetrical pre- and post-cursive effect would not support the notion of temporal constraint on overall utterance duration.

#### IV. Adaptation as a Fluency Evoking Condition

Adaptation as a fluency enhancing condition has received little attention in the recent past. This is probably because the other well-known fluency enhancing conditions such as shadowing (Cherry and Sayer 1956), metronome paced speech (Fransella and Beech 1965; Brady 1969 and others), delayed auditory feedback (Goldiamond 1965; Curlee and Perkins 1969; Martin and Haroldson 1979 and others), singing (Healy et al 1976; Colcord and Adams 1979), white noise masking (Maraist and Hutton 1957; Brayton and Conture 1978; Martin and Haroldson 1979 and others) produce immediate and dramatic enhancement of fluency. The second part of the present investigation on the temporal reorganization of adapting utterances was planned on the assumption that (1) all fluency enhancing conditions, whether gradual or sudden, must have a common basis; (2) a study of the course of certain selected global temporal variables during the course of adaptation may tell us the nature of fluency enhancement with general implications.

Basic facts about adaptation. Johnson and Knott (1937) published the first report on the adaptation phenomenon. In this report, they established a much replicated finding that

with successive reading of a passage, there is progressive reduction of stuttering. The significance of this initial report was reinforced by the claim (Wischner 1950) that adaptation is similar to extinction of a learned response established in learning laboratories. The parallelism between the laboratory extinction phenomenon and adaptation is striking. If adaptation is a reflection of extinction or unlearning process, the rate or degree of adaptation may be predictive of therapeutic outcome. Based on this reasoning, several attempts have been made to show that adaptation could be used as a "miniature model" of therapeutic improvement (Van Riper and Hull 1955; Johnson et al 1963; Prins 1968) without much success. In spite of these negative findings, Wischner's (1950) claim laid the foundation for more than three decades of research, from which certain general features of the adaptation process can be abstracted. Thus, adaptation is very marked during the first few readings and becomes progressively less so in the later readings. Most of the reduction that takes place will have occurred by the fifth reading. On an average, there is roughly 50 percent reduction in the frequency of stuttering when compared to the initial reading. The rate of adaptation decreases with the increase in the length of the period between successive readings. A sufficient period of rest after adaptation restores the frequency of stuttering to the original level.

Fluency enhancement and related variables. Given the

above general findings with adaptation, one might ask "how is the reduction in frequency of stuttering correlated with global variables like total articulation time and total pause time? For example, are the improvements in fluency correlated with a slower rate of speech output? Is slower rate of speech achieved by decreasing the total articulation time and/or total pause time? Most of the studies on temporal characteristics of speech under fluency enhancing conditions have been largely restricted to investigations of vowel and consonant durations. Increased duration of vowels has been noted under DAF (Wingate 1970). Brayton and Conture (1978) found lengthening of vowels and consonants during metronome pacing. Healy and Adams (1978) found increased duration of consonants and vowels during deliberately slow speech. Colcord and Adams (1977) reported increased vowel duration during singing. Martin and Haroldson (1979) reported lack of change in speech rate under four fluency enhancing conditions: response contingent stimulation, masking, DAF and rhythmic speech. The lack of change in speech rate may reflect the effect of two equal and opposing tendencies, namely, (1) increased speech rate due to reduction of number of stutterings (time consuming events), and (2) a decreased speech rate engendered by response contingent stimulation, masking, DAF and rhythmic speech.

Andrews et al (1982) investigated several measures in the context of spontaneously spoken speech in 15 fluency enhancing conditions in three subjects. The conditions ranged

from talking to animals, and arm swinging to DAF. The three subjects spoke on one to five topics selected at random from a very large pack of topic cards in 13 of the 15 fluency evoking conditions. In two conditions, shadowing and choral reading, the subjects followed or accompanied a speaker while he read. The measures investigated were: mean phonation time (the mean duration of fluent speech between pauses of 250 msec or more), pause proportion, articulation rate, mean sentence length and percentage of syllables stuttered. More than 90 percent of stuttering reduction occurred under DAF, singing, choral reading, shadowing, slowing, syllable timed speech and response contingent stimulation. Lengthened phonation duration occurred consistently under four conditions: choral reading, shadowing, singing and DAF. Slowed speech (lower articulation rate, increased pause proportion) occurred consistently in seven conditions: DAF, slowing, syllable-timed speech, singing, relaxed speech, speak and write, arm swing. Andrew et al (1982) conclude that stuttering is reduced by different strategies in different conditions. Lengthening phonation and slowing were the predominant strategies used.

There are several problems with Andrew et al's (1982) study. Multiplicity of conditions and several variables make this study confusing. Two problems will be pointed out. They are:

(a) Spontaneous speech using topic cards randomly selected in a small number of subjects for baseline and experimental condition is fraught with problems. Are the

conditions (control and experimental) matched except for the independent variable introduced?

(b) In conditions like choral reading and shadowing, where the subjects accompany or follow a model speaker, a baseline involving spontaneous speech is inappropriate.

This study, in spite of lack of tight control over the speech material, underscores the need for further investigations of global temporal variables likely to be associated with improved fluency.

Second purpose of the study. The second purpose of the present investigation is to track the course of two variables, total articulation time (TAT) and total pause time (TPT) in the chosen clauses during the course of an adaptation trial. Specifically, the answers to the following questions are being sought.

1. Are there differences in the course of global variables, total articulation time and total pause time between stutterers and fluent speakers, when all the readings in both groups are fluent?

2. Are there differences in the course of global variables, total articulation time and total pause time between stutterers and fluent speakers, when one of the stutterers' readings contains a stuttering event?

3. Are there differences in the course of global variables, total articulation time and total pause time, when stutterers stutter in one of the readings with other readings

being fluent as compared to when they are fluent in all five readings?

Thus, the course of molar variables TAT and TPT in SSS will be considered in the backdrop of their courses in Stutterers' Fluent Set and Fluent Speakers' Set I.

## CHAPTER II

### METHODOLOGY

Four male adult stutterers matched with four non-stutterers for age, sex, educational and/or occupational level constituted the eight subjects for the study. (See Appendix A for subjects' particulars.)

Each subject read two short stories (Appendix B), selected from a Thurber's Collection, five times in succession. The passages presented to the subjects were typed double-spaced without the parsing markers found in Appendix B. Between any two readings a short pause of two minutes was permitted. The subjects were instructed to read the passages aloud in their "normal" fashion, but without dropping words or word-endings, without substituting one word for another, without dropping or changing the phonetic elements as far as possible. The subjects were recorded in either a sound-treated room or a room with quiet ambiance, on a reel-to-reel tape recorder (Sony TC-270).

The recordings were analyzed in a systematic manner to obtain duration of words and pauses. Three chronological phases of analysis can be recognized depending upon the primary mode of analysis. The three phases were:

1. Perceptual phase of analysis

2. Instrumental phase of analysis

3. Segmentation and measurement phase of analysis

Before undertaking an elaboration of these phases, the definition of stuttering adopted for this study is in order. Stuttering was defined as repetition and/or prolongation of sounds and syllables (Wingate 1964, 1974; Young 1984). Focus on repetitions and prolongation of sounds and syllables was motivated by the findings that these types of dysfluencies are more frequently and consistently identified as instances of stuttering (Young 1984) by listeners than other types of dysfluencies. Furthermore, an effort was made to identify those instances of repetitions and prolongations of sounds and syllables which are most likely to elicit labelling of stuttering by listeners, namely, multiple repetitions and prolongations of significant durations. This decision to limit analysis to "clear cases" may be criticized on the grounds of representativeness. However, it was felt that understanding the phenomenon under investigation in relation to "clear cases" is the first necessary step to be taken before putting the hypotheses in the larger context of not so "clear cases."

Perceptual Phase of Analysis

In this phase of analysis the recordings were monitored to (a) isolate clauses for spectographic analysis, and (b) track frequency of stuttering events through the readings.

(a) A clause became a candidate for analysis if its five utterances met the following criteria: (1) a clear

instance of stuttering in the first reading of the clause, (2) no significant alterations in the phonetic and morphemic organization of the clause during five productions, (3) the last word of the previous clause and the first word of the succeeding clause must have been produced fluently and without distortion all five times, and (4) the matched fluent speaker must meet criteria (2) and (3). The recordings were further monitored to isolate clauses which were produced fluently by all eight speakers all five times. Also, the fluent utterances of these clauses must satisfy criterion (2).

Thus, at the end of the perceptual phase of analysis, the following four corpora were available for spectrographic analysis:

1. Stutterer's eight sets of utterances (five utterances in a set) of eight clauses with a clear instance of stuttering in the first reading of each clause. Two stutterers provided two clauses each, one provided three clauses and the one remaining stutterer provided the one remaining clause. This set is Stutterers' Stuttered Set (SSS).

2. Eight sets of utterances (five utterances per set) of the eight clauses from the matched fluent speakers. The set is Fluent Speakers' Set (FSSI).

3. Four sets of utterances (five utterances per set) of the two clauses produced fluently by the four stutterers. This set is Stutterers' Fluent Set (SFS).

4. Four sets of utterances (five utterances per set) of the same two clauses produced fluently by the stutterers'

fluent match. This set is Fluent Speakers' Set (FSSII).

The entire corpus, with types and location of stuttering, is represented in Appendix C.

(b) The stuttering events through the readings were categorized into (1) repetitions, that is, multiple repetitions of sounds and syllables; (2) prolongations of sounds and syllables; and (3) a combination of repetitions and prolongations. That is, each repeated element was prolonged. The frequency of each one of these categories of stuttering events for the five readings, the number of stuttering events collapsed across readings for the group and individual stutterers is represented in Appendix D.

#### Instrumental Phase of Analysis

During this phase of analysis, the selected utterances were analyzed spectrographically using a digital sonograph (Kay 7800). Generally, broadband spectrograms with settings at 300 HZ filter bandwidth and 0-8 KHZ range were made of the utterances. At this range one can input 2.56 sec of speech sample at a time in the digital sonograph.

There were certain precautions taken to ensure 'complete' acoustic representation of words at the beginning and end of the input sample and pauses at the end of input sample and longer than 2.56 sec. It is a well known finding that the perception of a word can be influenced by factors such as the knowledge of the input string (the so-called top-down effect) and also by the inherent redundancy of acoustic representation

of phonetic elements. The top-down effect is well documented in terms of phonemic restoration in selectively distorted speech (Warren 1970) and systematically altered speech (Marslen-Wilson and Welsh 1978). The inherent redundancy of acoustic representation can be illustrated with reference to fricatives such as /s/. It was frequently found during the course of this study that a fraction of the duration of /s/ in the initial and final positions was sufficient to generate the perception of the whole word in question. This could result in incorrect demarcation of word boundaries.

Pauses at the boundary of input signal and pauses longer than 2.56 sec also present problems in terms of representation and measurement. Thus, to overcome the problem of 'complete' acoustic representation of words and pauses, the following precautions were taken.

1. The last two words of the previous clause and the first two words (with reference to selected clauses) of the succeeding clause were input in order to ensure complete spectrographic representation of the last word of the previous and the first word of the succeeding clause.

2. Representation of pauses longer than 2.56 sec--usually in clause boundaries--was achieved by inputting speech signals in the 0-4 KHZ range (which allows a sample size of 5.12 sec).

3. In utterances longer than 2.56 sec, (a) if a 2.56 sec input sample ended in a pause, then the succeeding spectrogram was made in such a manner as to include the last word

(or portion of it) of the previous spectrogram. This ensured complete representation of the pause. (b) If a 2.56 sec input sample ended with a speech signal, then the succeeding spectrogram was made in such a manner as to include the last two words of the previous spectrogram. In such cases, segmentation and measurement of the last word on the previous spectrogram was always done on the succeeding spectrogram.

#### Segmentation and Measurement Phase of Analysis

The spectrograms of the utterances in the corpora were segmented into words and pauses. The demarcations of the word boundaries were essentially based on spectrographic details. (See Appendix E for a representative sample of demarcated spectrograms of an utterance.) Specification of the address location of the alleged boundaries of words and pauses in the memory of the sonograph was achieved by using overlay with address locations provided by Kay for the digital sonograph. These specifications in conjunction with the gating facility feature of the sonograph allowed "sounding out" of individual words, thus providing an auditory perceptual confirmation of word-boundaries based on spectrographic details. The first reading of a clause by each speaker was subjected to the segmentation process described above. The segmented first reading was used as a guide to segment the remaining utterances of the clause by the speaker.

In most cases, the word boundaries could be determined easily on the basis of spectrographic details. Details which

specially facilitated the process of segmentation were:

1. Words beginning and/or ending with fricatives and affricates

2. Words beginning and/or ending with plosives. When a word began with a plosive, the release of the Plosive was considered the beginning of the word. The difficulty of determining what fraction of the pause preceding the word contributed to the "silent" phase of the plosive articulation, motivated the decision to consider the release of the plosive as the beginning of the word. If a subject showed inconsistency in terms of releasing a stop at the final position of a word during the course of five readings, the release (in those instances in which it occurred) was not included in the measurement. In all such cases, the utterances from the match were treated in the same manner.

3. Words preceded and followed by pauses.

Words ending with a vowel, immediately followed (that is, without a pause) by another word beginning with a liquid or a vowel (e.g., "you will," "who lay," "on a") were least suitable in terms of segmentation. The continuous motion of the articulators, resulting in extensive coarticulation, precluded the determination of the word boundary. Such closely associated words were considered a single word for the purpose of this study.

Generally, all "gaps" or no energy zones in a spectrographic representation, including gaps filled with noise (breath or otherwise), were considered pauses. The only

exception to this general rule were gaps attributable to plosive closure in an intervocalic context of a word.

The following method was used to derive the duration of words and pauses. The overlay provided by Kay with the address locations was placed on spectrograms so that '0' address location coincided with the initial boundary marker of the word (or pause). The address location corresponding to the final boundary marker of the word (or pause) multiplied by 10 (for recordings in the 0-8 KHZ range) and by 20 (for recordings in the 0-4 KHZ range) gave the duration of the word (or pause).

The durations of a word in the five readings were examined to see if any one of the measurements was significantly different from others. The difference might be valid, or invalid, due to segmentation and measurement errors. Therefore, an attempt was made to rule out the contribution of two obvious sources of variance. They were:

1. Inconsistent application of segmentation criteria established on the first reading to the other readings
2. Wrong read out from the overlay. If the contribution of the above sources were ruled out, the observed difference was considered valid. This type of check was carried out for all the words and pauses in an utterance.

#### Methods of Data Treatment

The measured duration of words and pauses in SSS, FSSI, SFS and FSSII were examined in two ways to answer the ques-

tions raised in the Introduction, namely:

1. Are there pre-and post-cursive effects in terms of durational change with reference to stuttering events?
2. What are the limits or boundaries of these effects in the context of a planned unit (clause)?
3. Do the durational changes preceding and following a stuttering event reflect on the overall durational constraint of the planned utterance?
4. Are there differences in the course of global variables, total articulation time and total pause time between stutterers and fluent speakers, when one of the stutterers' readings contains a stuttering event?
5. Are there differences in the course of global variables, total articulation time and total pause time between stutterers and fluent speakers, when all the readings in both groups are fluent?
6. Are there differences in the course of global variables, total articulation time and total pause time, when stutterers stutter in one of the readings--other readings being fluent--as compared to when they are fluent in all five readings.

In order to answer questions (1) to (3), the stuttered word location was designated as 'X,' and other locations were identified in relation to the 'X' location. Thus, X-1 refers to one location before the stuttered word within the clause, X+1 refers to one location after the stuttered word location within the clause, X-2 refers to two locations before the

stuttered word within a clause and X+2 refers to two locations after the stuttered word within a clause. Xp refers to the last word of the previous clause. Xf refers to the first word of the succeeding clause.

The eight clauses in SSS (and FSSI) provided eight words for X location. Since these eight words were repeated five times by both the groups, ANOVA by repeated measures was used to examine the trends of duration within and between groups in X location. Four other locations within the candidate clauses (X-2, X-1, X, X+1, X+2) and two locations outside the clauses (Xp, Xf) were similarly examined. Limiting the analysis to five locations within the clauses can be justified on the grounds that there were very few candidate clauses with locations beyond X-2 and X+2. More specifically, there were four candidate clauses with the locations X-3 and X+3 (see Appendix F). Moreover, X-3 location was represented by only two subjects. Coincidentally, the data, as we will see later, showed that the pre- and post-cursive effects were bounded within the locations X-2 and X+2.

In order to answer questions (4) to (6), the composite variable total duration of an utterance was analyzed into its component variables, namely, total articulation time (TAT) and total pause time (TPT).

Total articulation time (TAT) was defined as the sum of duration of words composing the clause in question. TAT for stuttered utterances were calculated after excluding the duration of the stuttering event or block. Total pause time (TPT)

was defined as the sum of the duration of pauses within the uttered clause and the syntactic pauses at its boundaries. The course of TPT and TAT in SSS, FSSI, SFS, FSSII were examined statistically using ANOVA by repeated measures.

## CHAPTER III

### RESULTS

Results of the present study will be reported in two sections. The first section will deal with the changes in the duration of words occupying different locations (Xp, X-2, X-1, X, X+1, X+2, Xf) with reference to the stuttering events of the utterance sets SSS and FSSI. The second section will describe the results obtained with global variables such as Total Articulation Time (TAT) and Total Pause Time (TPT), reflecting on the differences and similarities in the overall temporal organization of the utterances between the stutterers and the fluent speakers during the course of adaptation. Results of the measurements of words and pauses for the five utterances of each candidate clause has been represented in Appendix G.

#### Locational Analysis of the Durational Changes

##### I. Locations Within the Candidate Clauses

X-Location. X-location was occupied by words which were produced successfully after having been stuttered. Table 1 gives the results of the ANOVA for the repeated productions of the eight words in this location (see Appendix F). Table 2 gives the means and standard deviations of the words for the five readings by groups. Figure 1 and Figure 2 are plots

TABLE 1

## ANOVA FOR REPEATED PRODUCTION OF WORDS IN X-LOCATION

| Source       | SS         | DF | MS        | F    | P      |
|--------------|------------|----|-----------|------|--------|
| Group        | 28,880.0   | 1  | 28,880.0  | 0.19 | 0.6687 |
| Reading      | 112,307.50 | 4  | 28,076.87 | 6.52 | 0.0002 |
| Gr X Reading | 49,382.50  | 4  | 12,345.63 | 2.87 | 0.0313 |

TABLE 2

MEANS AND STANDARD DEVIATIONS FOR THE DURATION OF WORDS  
IN X-LOCATION FOR READINGS BY GROUPS

| Groups                  | R1     | R2     | R3     | R4     | R5     |
|-------------------------|--------|--------|--------|--------|--------|
| <b>Fluent Speakers:</b> |        |        |        |        |        |
| $\bar{X}$               | 388.75 | 337.50 | 352.50 | 351.25 | 348.75 |
| SD                      | 200.31 | 187.82 | 181.00 | 192.46 | 183.18 |
| <b>Stutterers:</b>      |        |        |        |        |        |
| $\bar{X}$               | 505.00 | 415.00 | 346.25 | 353.75 | 348.75 |
| SD                      | 177.52 | 186.24 | 176.95 | 171.35 | 176.25 |

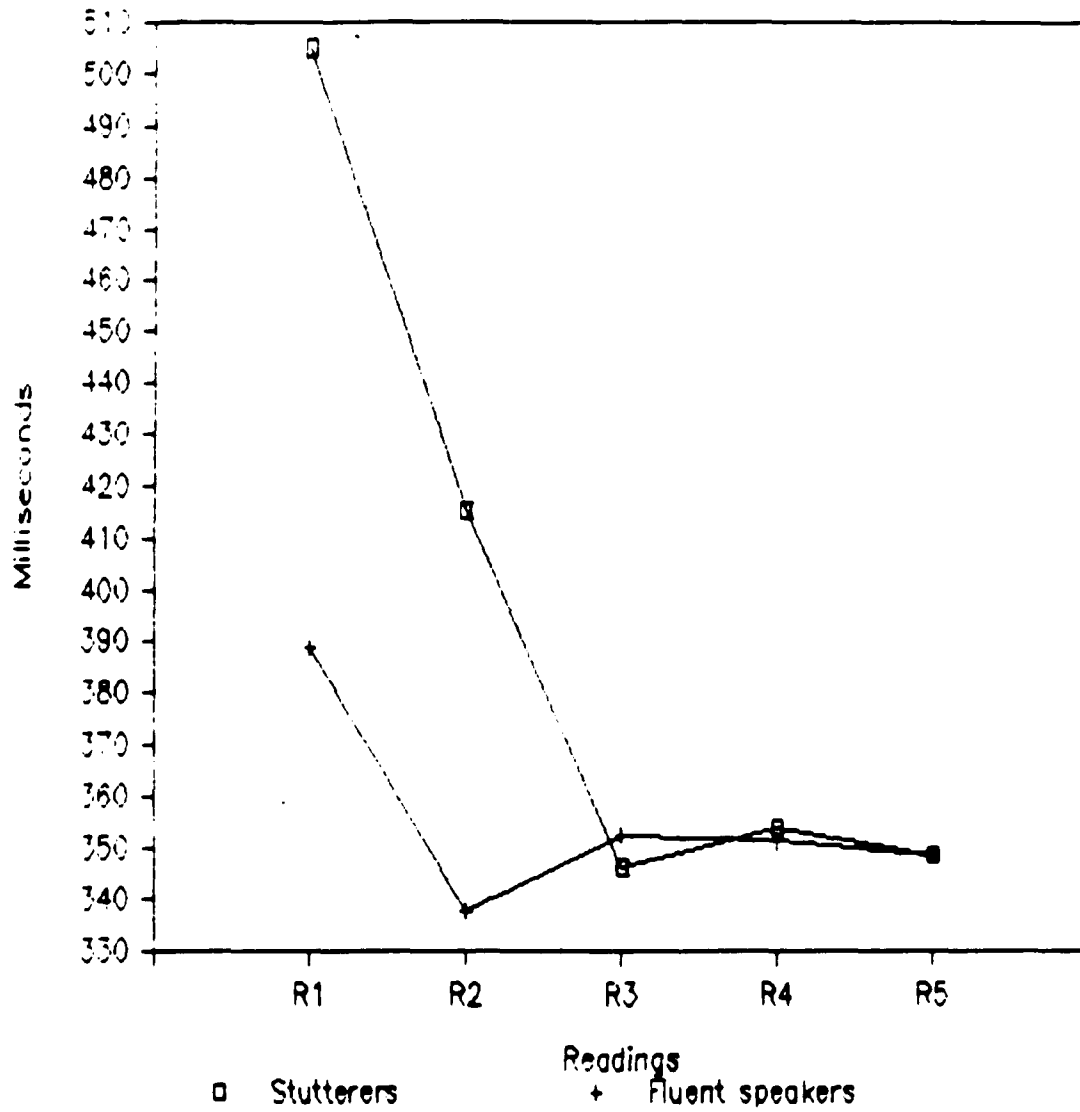


Fig. 1. Plot of means of the duration of words in X location for readings by groups.

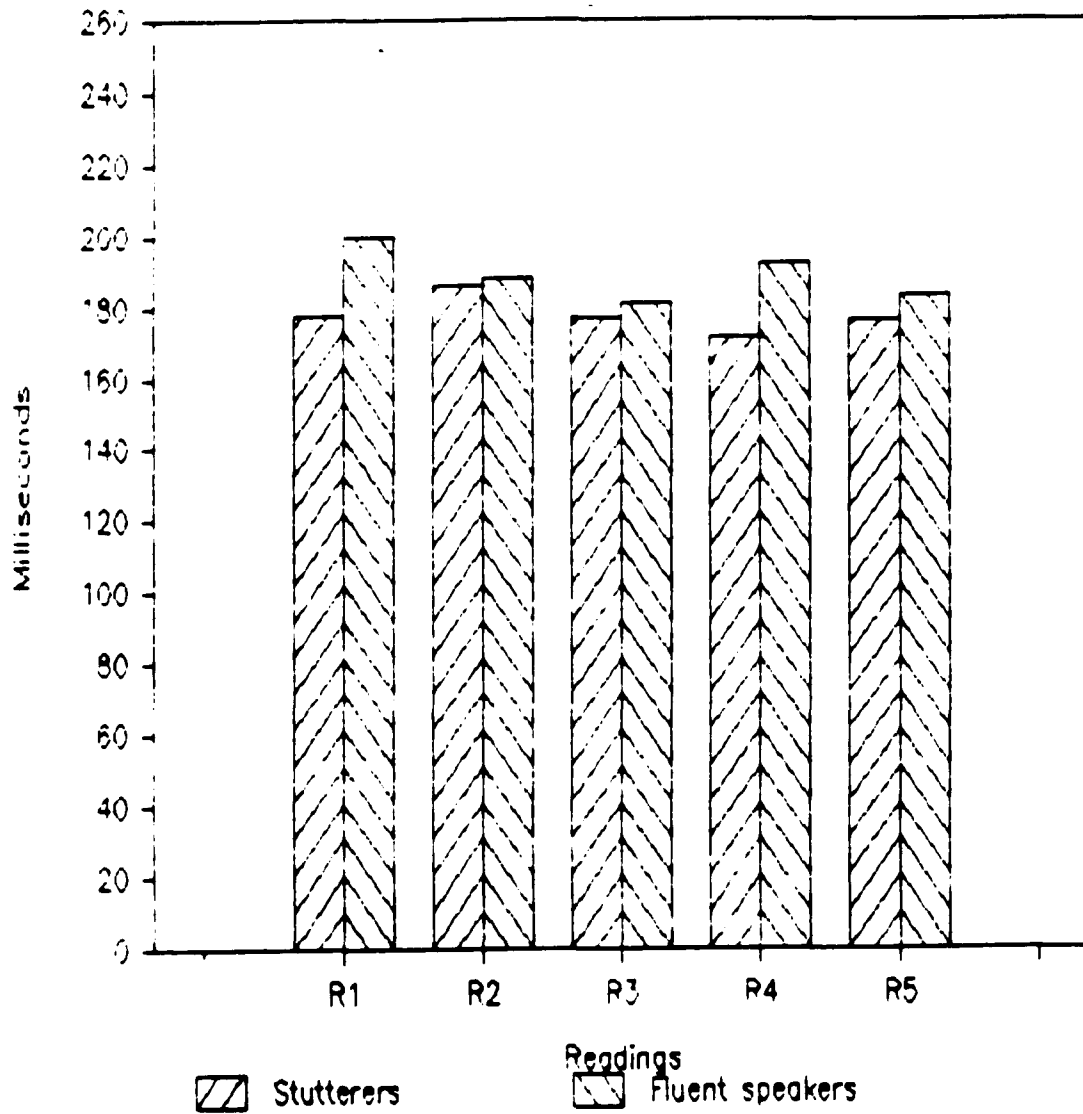


Fig. 2. Plot of standard deviations of duration of words in X location for readings by groups.

of mean and standard deviations, respectively, in the five readings for the two groups of speakers.

Table 1 reveals the following trends in the results. There is no significant difference in the duration of words between the stutterers and the nonstutterers in this location. There is a very significant difference ( $P < 0.001$ ) among the five readings. Furthermore, significant group and reading interaction predicates a differing course of word duration adaptation through the course of the five readings for the stutterers and the fluent speakers.

Figure 1 shows that a clear separation emerges between the stutterers and the fluent speakers in the initial phase of adaptation--a difference of 120 msec and 80 msec between them in R1 and R2 respectively--accounting for the significant interaction noted earlier. In the later phase of the adaptation, that is, in R3, R4, R5, the performances of the two groups is indistinguishable, stutterers effectively "closing the gap" to catch up with the fluent speakers.

Table 2 and the accompanying Figure 2 reveal the following trends: (1) the stutterers and the fluent speakers are comparable in the durational variability across the five readings, (2) the fluent speakers exceed the stutterers' variability by a very small margin across the five readings.

X-1 Location. X-1 location was occupied by words which immediately preceded the stuttering events. Table 3 gives the results of the ANOVA for the repeated productions of the

TABLE 3

ANOVA FOR REPEATED PRODUCTION OF WORDS IN X-1 LOCATION

| Source       | SS        | DF | MS        | F     | P      |
|--------------|-----------|----|-----------|-------|--------|
| Group        | 3,511.25  | 1  | 3,511.25  | 0.02  | 0.8928 |
| Reading      | 103,942.5 | 4  | 25,985.63 | 13.62 | 0.0000 |
| Gr X Reading | 17,132.5  | 4  | 4,283.125 | 2.25  | 0.0756 |

TABLE 4

MEAN AND STANDARD DEVIATIONS FOR THE DURATION OF WORDS  
IN X-1 LOCATION FOR READINGS BY GROUPS

| Groups                  | R1     | R2     | R3     | R4     | R5     |
|-------------------------|--------|--------|--------|--------|--------|
| <b>Fluent Speakers:</b> |        |        |        |        |        |
| $\bar{X}$               | 406.25 | 375.00 | 345.00 | 347.50 | 355.00 |
| SD                      | 218.10 | 206.32 | 217.97 | 205.13 | 226.58 |
| <b>Stutterers:</b>      |        |        |        |        |        |
| $\bar{X}$               | 477.50 | 371.25 | 351.25 | 345.00 | 350.00 |
| SD                      | 196.37 | 177.79 | 183.02 | 181.50 | 143.02 |

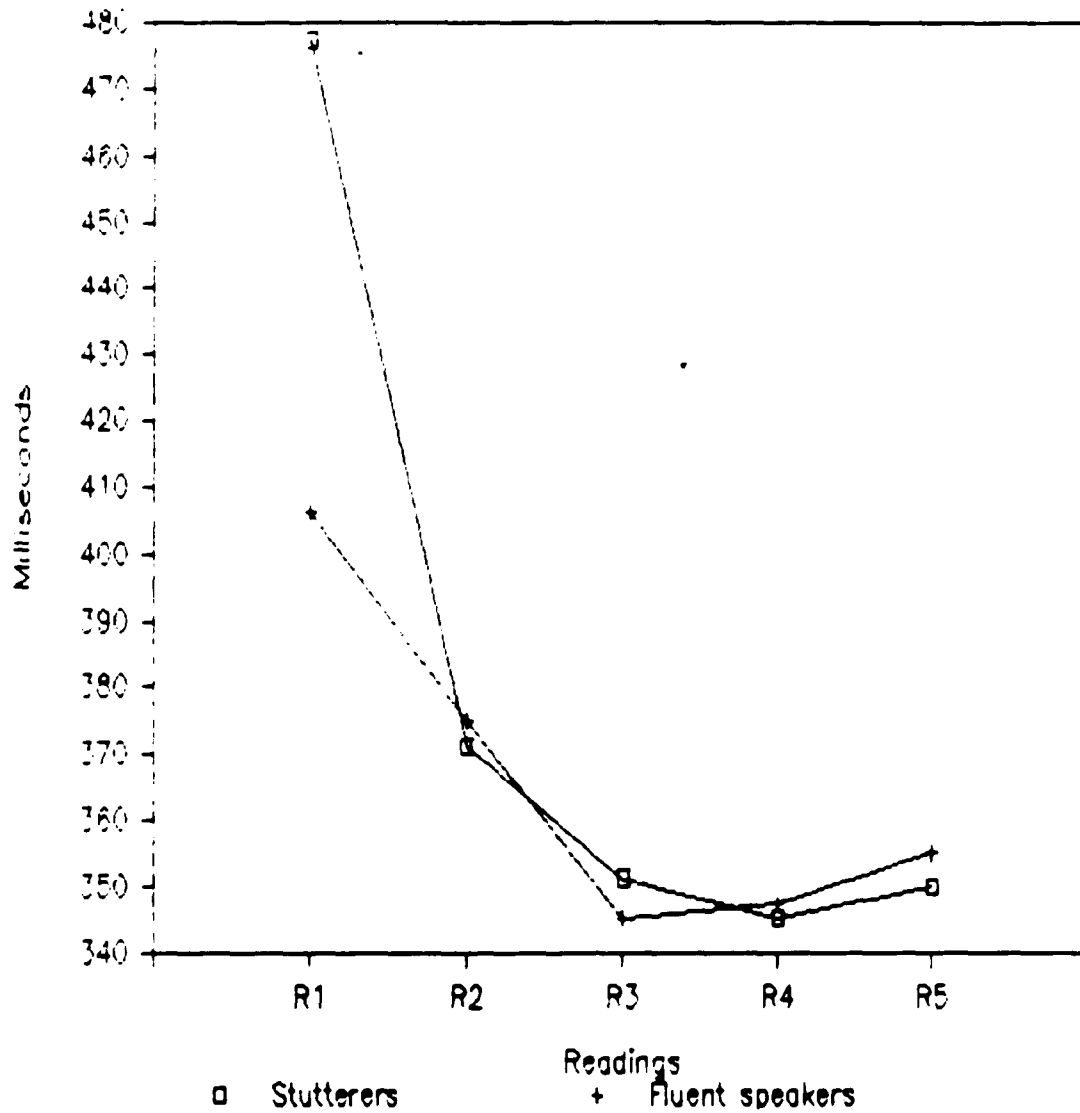
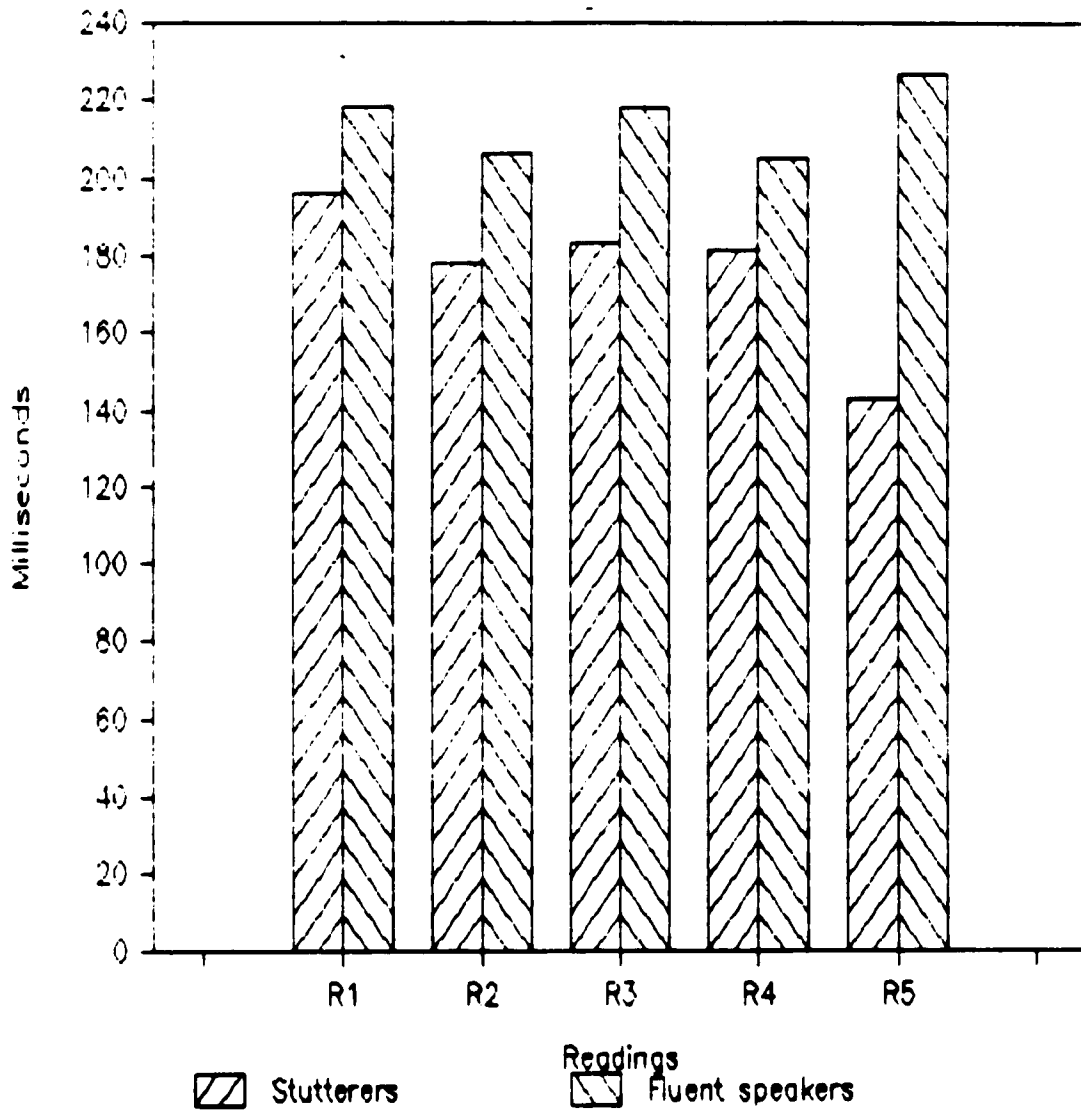


Fig. 3. Plot of means of duration of the words in X-1 location for readings by groups.



**Fig. 4.** Plot of standard deviations of duration of words in X-1 location for readings by groups.

eight words occupying this location (see Appendix F). Table 4 gives the mean and standard deviations of duration of words for the five readings by groups. Figure 3 is a plot of the means for the five readings for the two groups. Figure 4 depicts standard deviations for the five readings for the two groups.

Table 3 reveals a lack of significant difference ( $P>.05$ ) between the stutterers and the fluent speakers in the mean duration of the words in X-1 location. There is a significant difference ( $P<0.001$ ) among the readings. Group and reading interaction falls short of significance by a very small margin ( $P=0.07$ ).

Figure 3 reveals the differences and the similarities between the groups in the course of durational adaptation in X-1 location. A wide difference between the groups in reading one (a difference of approximately 70 msec) is found. From reading two, the stutterers attain durations which are not significantly different from that of the normal speakers.

Figure 4 reveals that the fluent speakers are durationally more variable than the stutterers in all five readings. Furthermore, the level of variability for the five readings is nearly the same for the fluent speakers. A similar tendency is seen in the stutterers in the first four readings.

X-2 Location. The X-2 location preceded and was one word removed from the stuttering events. Table 5 gives the

TABLE 5

ANOVA FOR REPEATED PRODUCTIONS OF WORDS IN X-2 LOCATION

| Source       | SS       | DF | MS       | F    | P      |
|--------------|----------|----|----------|------|--------|
| Group        | 2,160.00 | 1  | 2,160.00 | 0.01 | 0.9083 |
| Reading      | 4,940.00 | 4  | 1,235.00 | 0.68 | 0.6070 |
| Gr X Reading | 7,106.66 | 4  | 1,776.66 | 0.98 | 0.427  |

TABLE 6

MEANS AND STANDARD DEVIATIONS FOR THE DURATION OF WORDS  
IN X-2 LOCATION FOR READINGS BY GROUPS

| Group                   |           | R1     | R2     | R3     | R4     | R5     |
|-------------------------|-----------|--------|--------|--------|--------|--------|
| <b>Fluent Speakers:</b> |           |        |        |        |        |        |
|                         | $\bar{X}$ | 271.66 | 270.00 | 238.33 | 258.33 | 276.66 |
|                         | SD        | 207.21 | 195.44 | 152.10 | 216.18 | 211.53 |
| <b>Stutterers:</b>      |           |        |        |        |        |        |
|                         | $\bar{X}$ | 296.66 | 260.00 | 286.66 | 260.00 | 271.66 |
|                         | SD        | 140.94 | 140.14 | 177.72 | 169.94 | 168.45 |

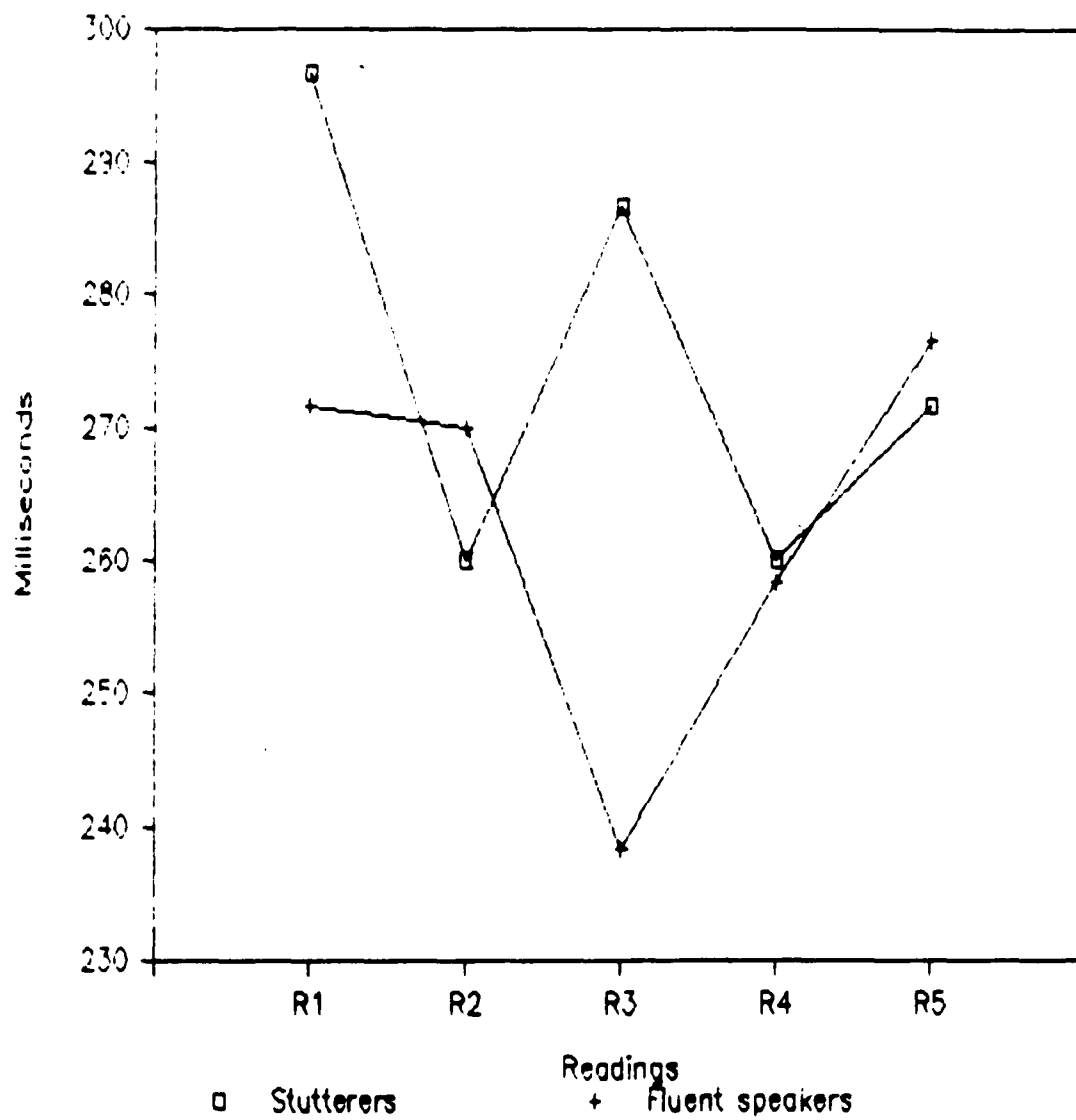


Fig. 5. Plot of means of duration of the words in X-2 location for readings by groups.

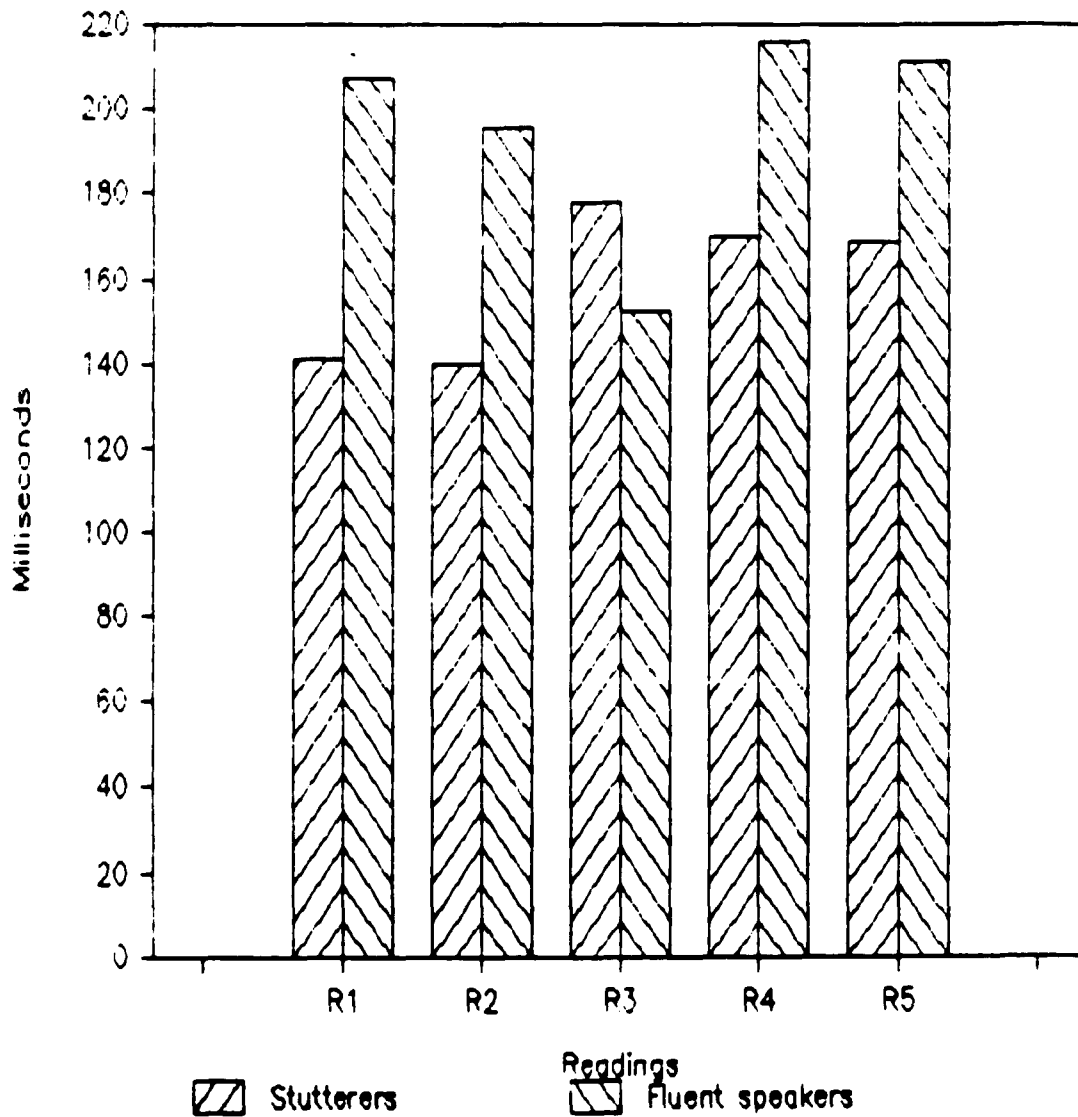


Fig. 6. Plot of standard deviations of words in X-2 location for readings by groups.

results of the ANOVA for the repeated productions of the six words (see Appendix F) in this location. Table 6 gives the means and the standard deviations of the deviations of words for the five readings in the two groups. Figure 5 is a plot of the means of duration of words for the five readings in the two groups. Figure 6 displays standard deviations for the five readings in the two groups.

The following statements can be made on the basis of the ANOVA results in Table 5. The fluent speakers and the stutterers do not differ significantly in the mean duration of words in this location ( $P > 0.05$ ). The main effect for reading is not significant ( $P > 0.05$ ) and the stutterers and fluent speakers apparently have a similar course of word adaptation for the five readings (group X reading,  $P > 0.05$ ).

Figure 5 reveals a very small difference in the mean duration between the groups in R1 and R3. The word duration adaptation function in this location, in view of insignificant main and interaction effects, can be described as having a similar trend in the stutterers and the fluent speakers.

Figure 6 reveals considerably greater variability of word duration in the fluent speakers in readings one, two, four, and five. This trend is apparently reversed in reading three.

X+1 Location. The X+1 location immediately followed the stuttered words and was thus one word removed from the stuttering events. This location was represented by seven

TABLE 7

ANOVA FOR REPEATED PRODUCTION OF WORDS IN X+1 LOCATION

| Source       | SS        | DF | MS        | F    | P      |
|--------------|-----------|----|-----------|------|--------|
| Group        | 45,772.85 | 1  | 45,772.85 | 0.35 | 0.5637 |
| Reading      | 18,905.71 | 4  | 4,726.42  | 2.62 | 0.0464 |
| Gr X Reading | 10,934.28 | 4  | 2,733.57  | 1.51 | 0.2129 |

TABLE 8

MEANS AND STANDARD DEVIATIONS FOR THE DURATION OF WORDS  
IN X+1 LOCATION FOR READINGS BY GROUPS

| Groups                  | R1     | R2     | R3     | R4     | R5     |
|-------------------------|--------|--------|--------|--------|--------|
| <b>Fluent Speakers:</b> |        |        |        |        |        |
| $\bar{X}$               | 232.85 | 217.14 | 225.71 | 210.00 | 221.42 |
| SD                      | 159.97 | 172.11 | 146.15 | 182.39 | 158.15 |
| <b>Stutterers:</b>      |        |        |        |        |        |
| $\bar{X}$               | 314.28 | 287.14 | 237.14 | 245.71 | 278.57 |
| SD                      | 175.86 | 175.09 | 146.36 | 160.19 | 174.87 |

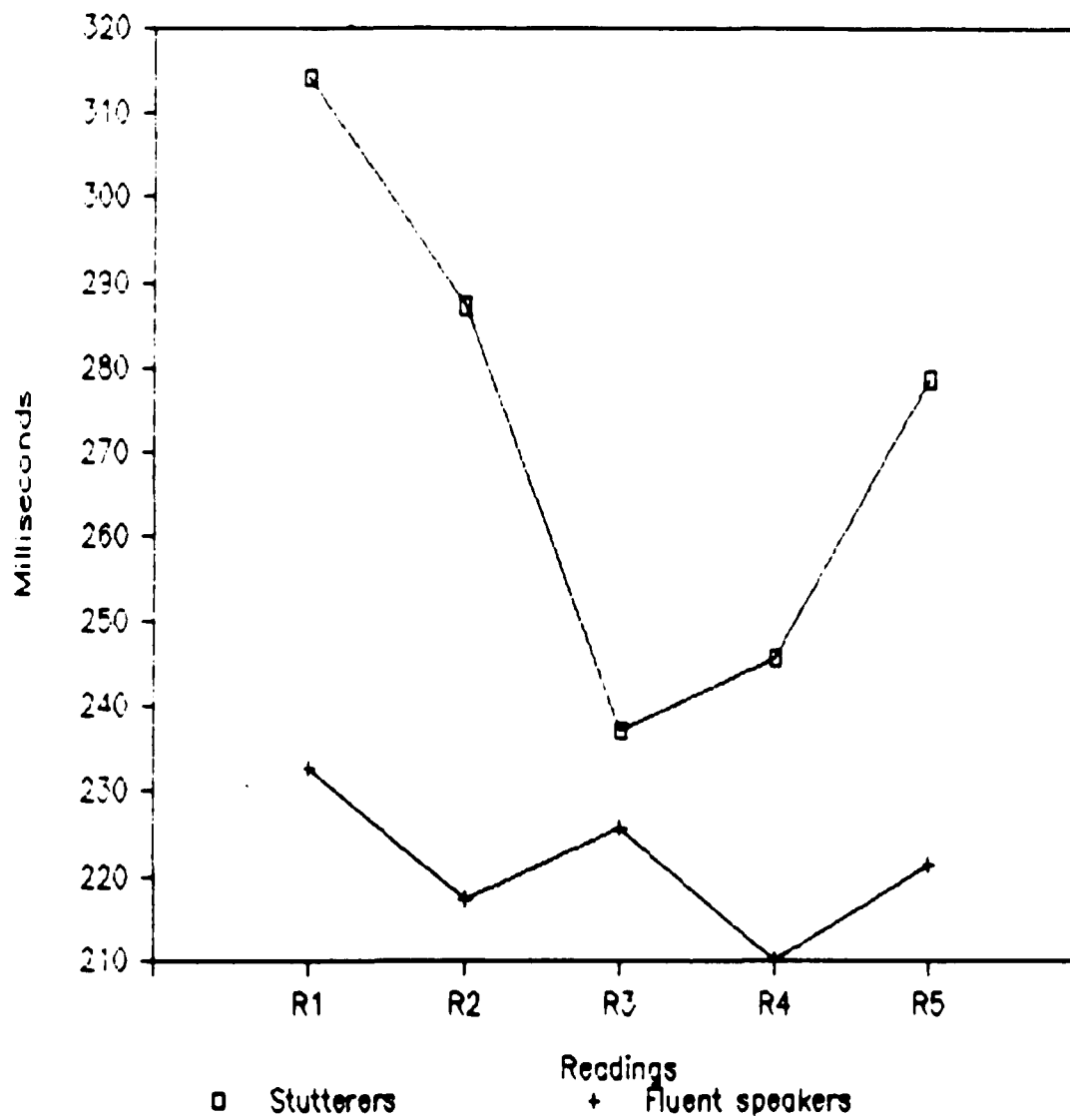


Fig. 7. Plot of means of duration words in X+1 location by readings and groups.

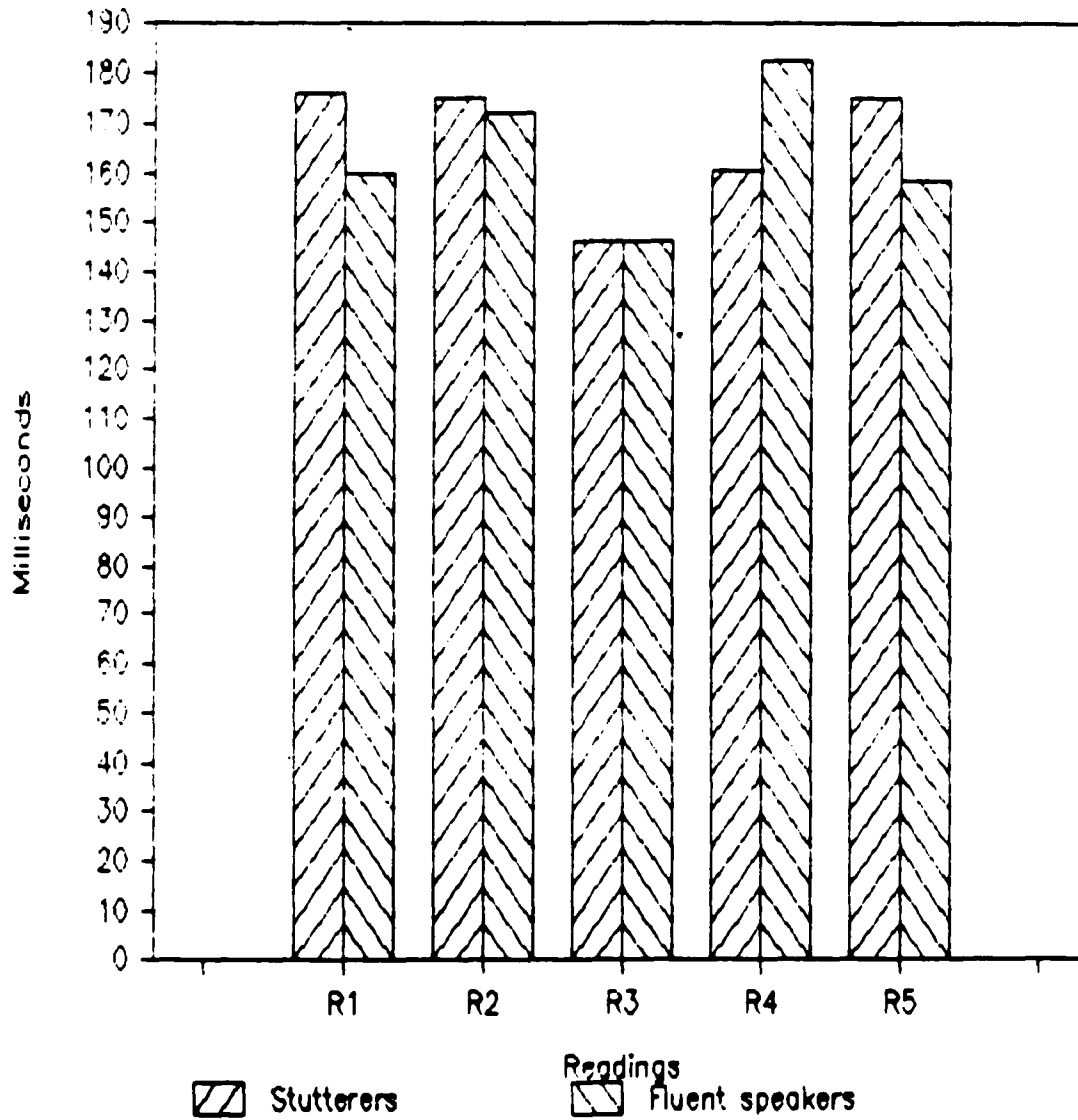


Fig. 8. Plot of standard deviations of duration words in X+1 location by readings and groups.

words (see Appendix F). Table 7 gives the results of the ANOVA for the repeated productions of these words for the two groups of speakers. Table 8 gives the means and standard deviations of words for the five readings for the two groups. Figure 7 is a plot of the means of the duration of the words for the five readings for the two groups. Figure 8 displays the standard deviations for the five readings for the two groups.

Table 7 reveals an insignificant difference in the duration of words ( $P > 0.05$ ) for the two groups in this location. Significant main effects for readings ( $P < 0.05$ ) and an insignificant interaction between the groups and the readings is present ( $P > 0.05$ ).

Figure 7 reveals the differences between the groups in the durational adaptation. The fluent speakers, in general terms, have zero slope function across the five readings. The stutterers, on the other hand, have an initial negative slope through R1, R2, R3, with a tendency towards positive slope from R3 to R5. The mean duration of the words is generally higher in the stutterers than in the fluent speakers in the five readings.

Figure 8 reveals that the stutterers are more variable than the fluent speakers in R1, the variabilities are comparable in R2 and R3, fluent speakers showing more variability than the stutterers in R4 and the stutterers showing more variability than the fluent speakers in R5.

X+2 Location. The X+2 location followed and was two words removed from the stuttering events. The results of the ANOVA for the repeated productions of the seven words (see Appendix F) is given in Table 9. Table 10 gives the means and standard deviations of the duration of the words for the five readings in the two groups. Figure 9 is a plot of the means for the five readings for the two groups. Figure 10 displays the standard deviations for the five readings for the two groups.

Table 9 reveals an insignificant difference in the duration of the words ( $P>0.05$ ) for the two groups. The main effect for the reading is insignificant ( $P>0.05$ ). Furthermore, there is no interaction between the groups and the readings ( $P>0.05$ ).

Figure 9 shows the parallel (non-interactional) tendencies of the word adaptation function in this location for the two groups. The stutterers, generally, have higher durations in all five readings than the fluent speakers.

Figure 10 reveals that the variability among the fluent speakers' productions is greater than that of the stutterers in all five readings.

## II. LOCATIONS OUTSIDE THE CANDIDATE CLAUSES

Xp. Xp refers to the last word of the clause preceding a candidate clause. The ANOVA for the repeated productions of the eight words occupying this location (see Appendix F) is represented in Table 11. Table 12 gives the means and stan-

TABLE 9

ANOVA FOR REPEATED PRODUCTION OF WORDS IN X+2 LOCATION

| Source       | SS         | DF | MS         | F    | P      |
|--------------|------------|----|------------|------|--------|
| Group        | 250,801.42 | 1  | 250,801.42 | 2.15 | 0.1685 |
| Reading      | 12,134.28  | 4  | 3,033.57   | 1.29 | 0.2864 |
| Gr X Reading | 2,848.57   | 4  | 712.14     | 0.30 | 0.8743 |

TABLE 10

MEANS AND STANDARD DEVIATIONS FOR THE DURATION OF WORDS  
IN X+2 LOCATION FOR READINGS BY GROUPS

| Groups                  | R1     | R2     | R3     | R4     | R5     |
|-------------------------|--------|--------|--------|--------|--------|
| <b>Fluent Speakers:</b> |        |        |        |        |        |
| $\bar{X}$               | 311.42 | 347.14 | 327.14 | 320.00 | 317.14 |
| SD                      | 166.57 | 148.17 | 174.23 | 182.75 | 169.97 |
| <b>Stutterers:</b>      |        |        |        |        |        |
| $\bar{X}$               | 450.00 | 467.14 | 445.71 | 442.85 | 415.71 |
| SD                      | 143.87 | 143.14 | 130.87 | 152.61 | 168.60 |

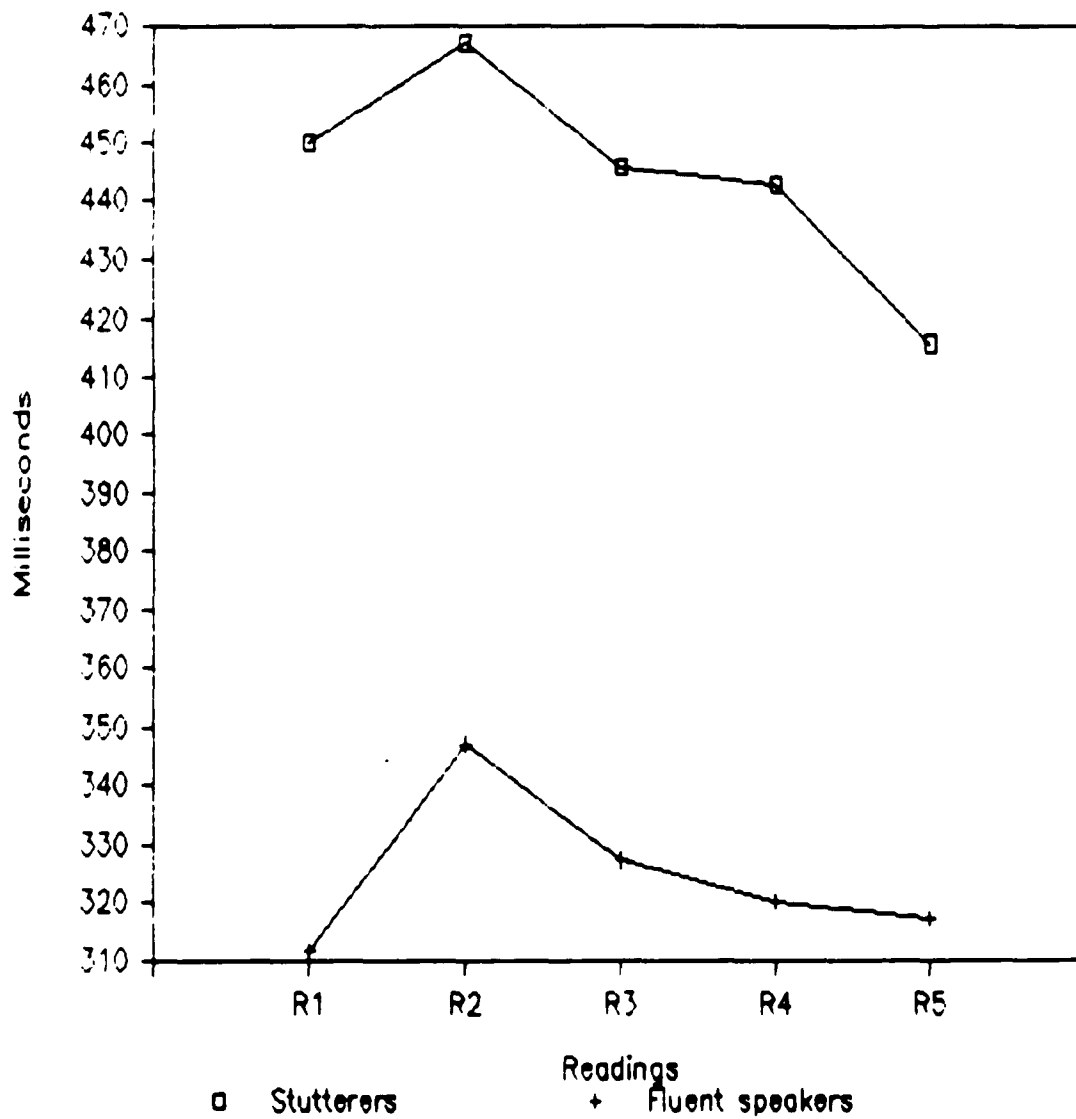


Fig. 9. Plot of means of duration of words in X+2 location by readings and groups.

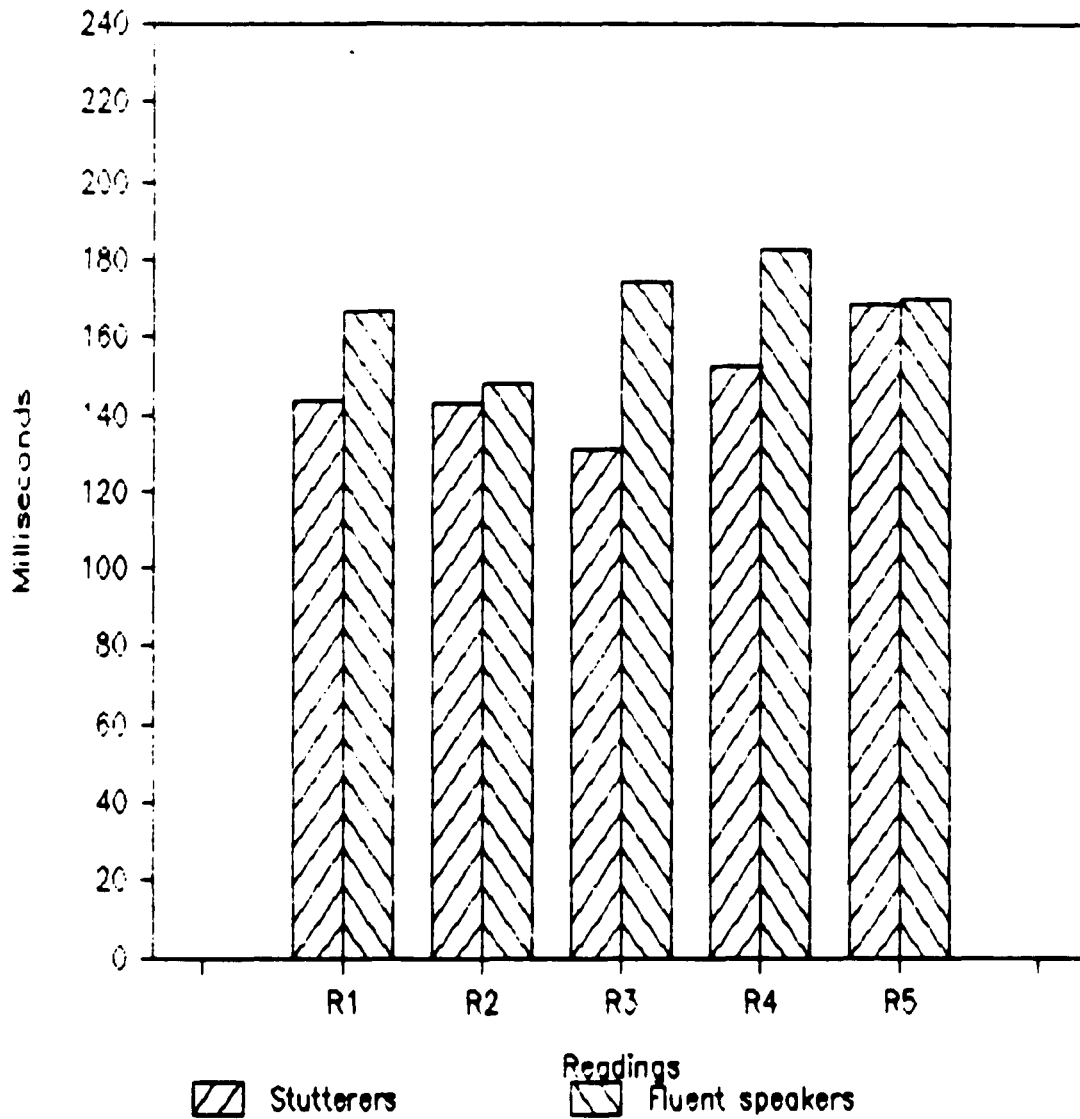


Fig. 10. Plot of standard deviations of duration of words in X+2 location by readings and groups.

TABLE 11

ANOVA FOR REPEATED PRODUCTION OF WORDS IN Xp LOCATION

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| Source       | SS         | DF | MS         | F    | P      |
|--------------|------------|----|------------|------|--------|
| Group        | 339,301.25 | 1  | 339,301.25 | 6.07 | 0.0273 |
| Reading      | 4,905.00   | 4  | 1,226.25   | 0.72 | 0.5829 |
| Gr X Reading | 7,880.00   | 4  | 1,970.00   | 1.15 | 0.3408 |

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TABLE 12

MEANS AND STANDARD DEVIATIONS FOR THE DURATION OF WORDS  
IN X<sub>p</sub> LOCATION FOR READINGS BY GROUPS

| Groups                  |           | R1     | R2     | R3     | R4     | R5     |
|-------------------------|-----------|--------|--------|--------|--------|--------|
| <b>Fluent Speakers:</b> |           |        |        |        |        |        |
|                         | $\bar{X}$ | 283.75 | 286.25 | 275.00 | 287.50 | 305.00 |
|                         | SD        | 89.27  | 83.99  | 75.59  | 79.23  | 69.28  |
| <b>Stutterers:</b>      |           |        |        |        |        |        |
|                         | $\bar{X}$ | 447.50 | 411.25 | 410.00 | 412.50 | 407.50 |
|                         | SD        | 162.19 | 130.86 | 109.80 | 135.51 | 140.68 |

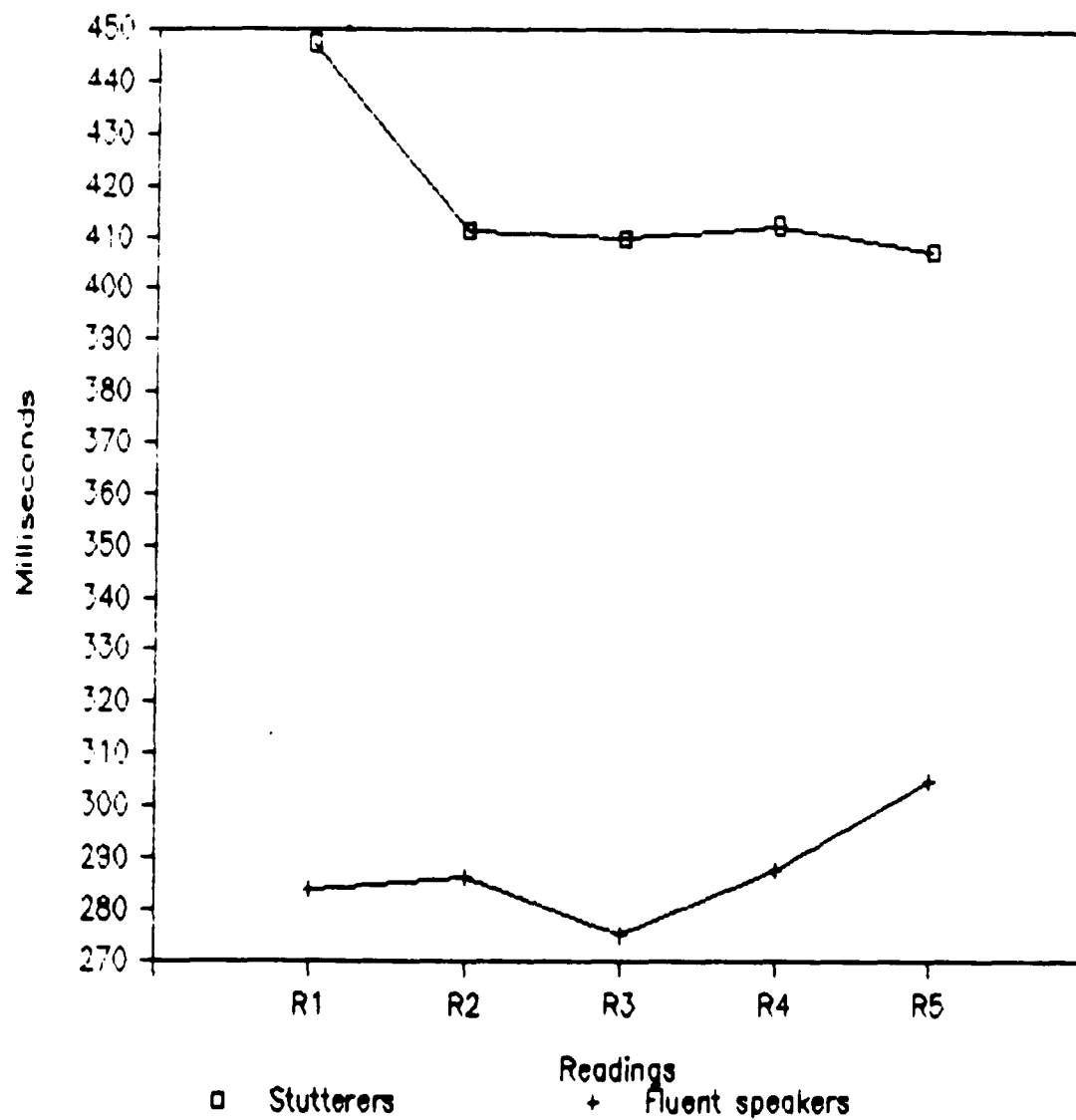
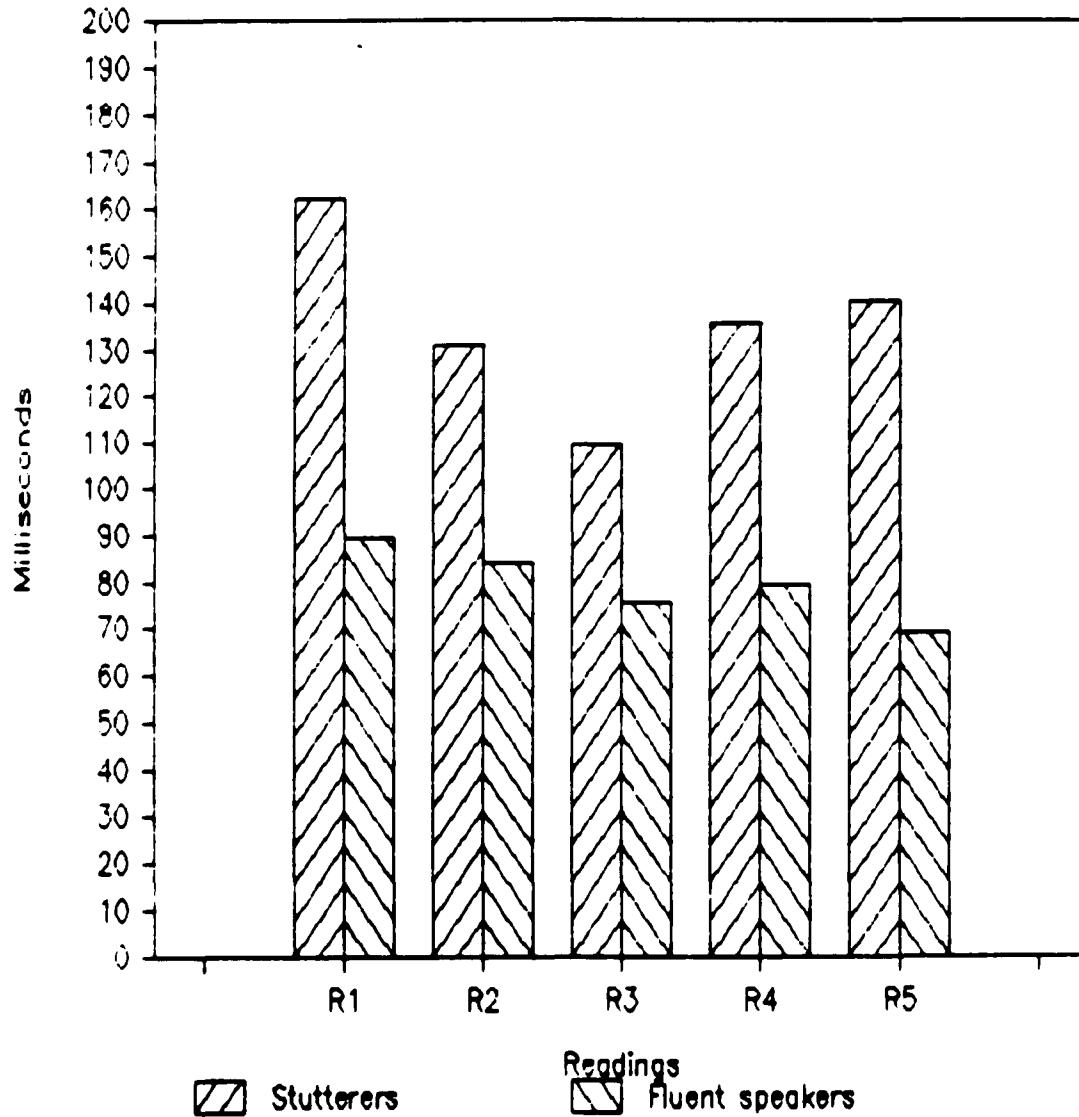


Fig. 11. Plot of means of duration of words in Xp location by readings and groups.



**Fig. 12.** Plot of standard deviations of duration of words in Xp location by readings and groups.

dard deviations of the duration of words for the five readings. Figure 11 is a plot of the means of the duration of the words for the five readings in the two groups. Figure 12 displays the standard deviations of the duration of words for the five readings in the two groups.

Table 11 shows a significant difference in the duration of the words between the two groups ( $P < 0.05$ ). The main effect for reading, and the group and reading interaction, are insignificant ( $P > 0.05$ ).

Figure 11 reveals the non-interactional tendencies for the groups across the five readings. The difference in duration between the groups in any one of the readings is significant as noted earlier.

Figure 12 reveals an interesting reversal of the variability tendencies noted in other locations. Stutterers, unlike their performance in other locations, exceed the fluent speakers in variability in all five readings.

Xf. Xf location was occupied by the first words of the clause following the candidate clauses. The results of the ANOVA for the repeated productions of the eight words (see Appendix F) in this location is presented in Table 13. Table 14 gives the means and standard deviations of word duration for the two groups of the five readings. Figure 13 is a plot of the means of the duration of the words for the five readings in the two groups. Figure 14 displays the standard deviations for the readings for the two groups.

TABLE 13

ANOVA FOR REPEATED PRODUCTION OF WORDS IN Xf LOCATION

| Source       | SS        | DF | MS        | F    | P      |
|--------------|-----------|----|-----------|------|--------|
| Group        | 32,572.85 | 1  | 32,572.85 | 2.5  | 0.1397 |
| Reading      | 3,851.42  | 4  | 962.857   | 1.92 | 0.1225 |
| Gr X Reading | 12,662.85 | 4  | 3,165.71  | 6.31 | 0.0004 |

TABLE 14

MEANS AND STANDARD DEVIATIONS FOR THE DURATION OF WORDS  
IN Xf LOCATION FOR READINGS BY GROUPS

| Groups                  | R1     | R2     | R3     | R4     | R5     |
|-------------------------|--------|--------|--------|--------|--------|
| <b>Fluent Speakers:</b> |        |        |        |        |        |
| $\bar{X}$               | 151.42 | 145.71 | 164.28 | 161.42 | 164.28 |
| SD                      | 46.70  | 35.98  | 40.35  | 30.78  | 33.09  |
| <b>Stutterers:</b>      |        |        |        |        |        |
| $\bar{X}$               | 201.42 | 235.71 | 202.85 | 188.57 | 174.28 |
| SD                      | 77.98  | 68.76  | 64.73  | 66.44  | 59.12  |

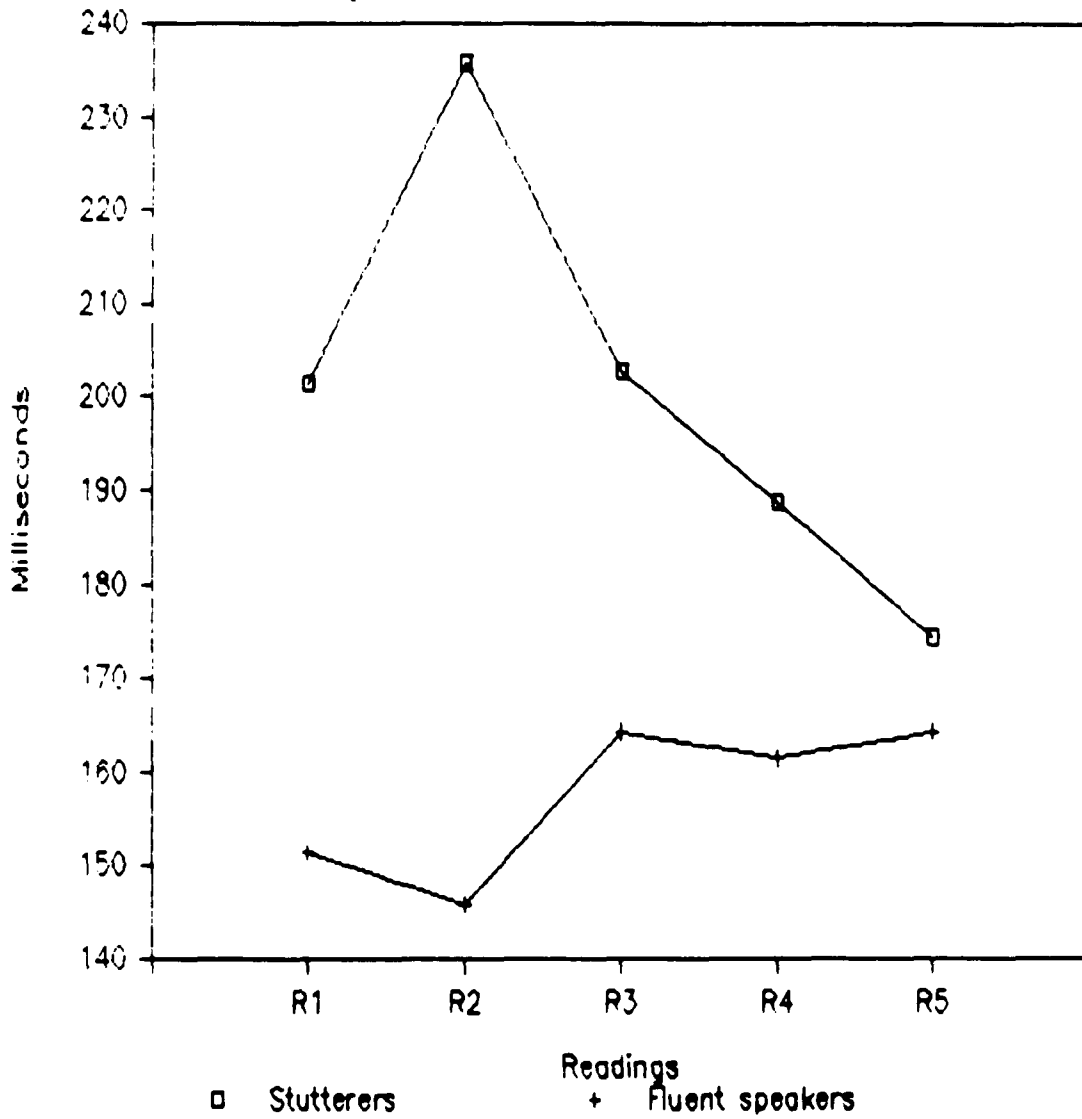


Fig. 13. Plot of mean of duration of words in Xf location by readings and groups.

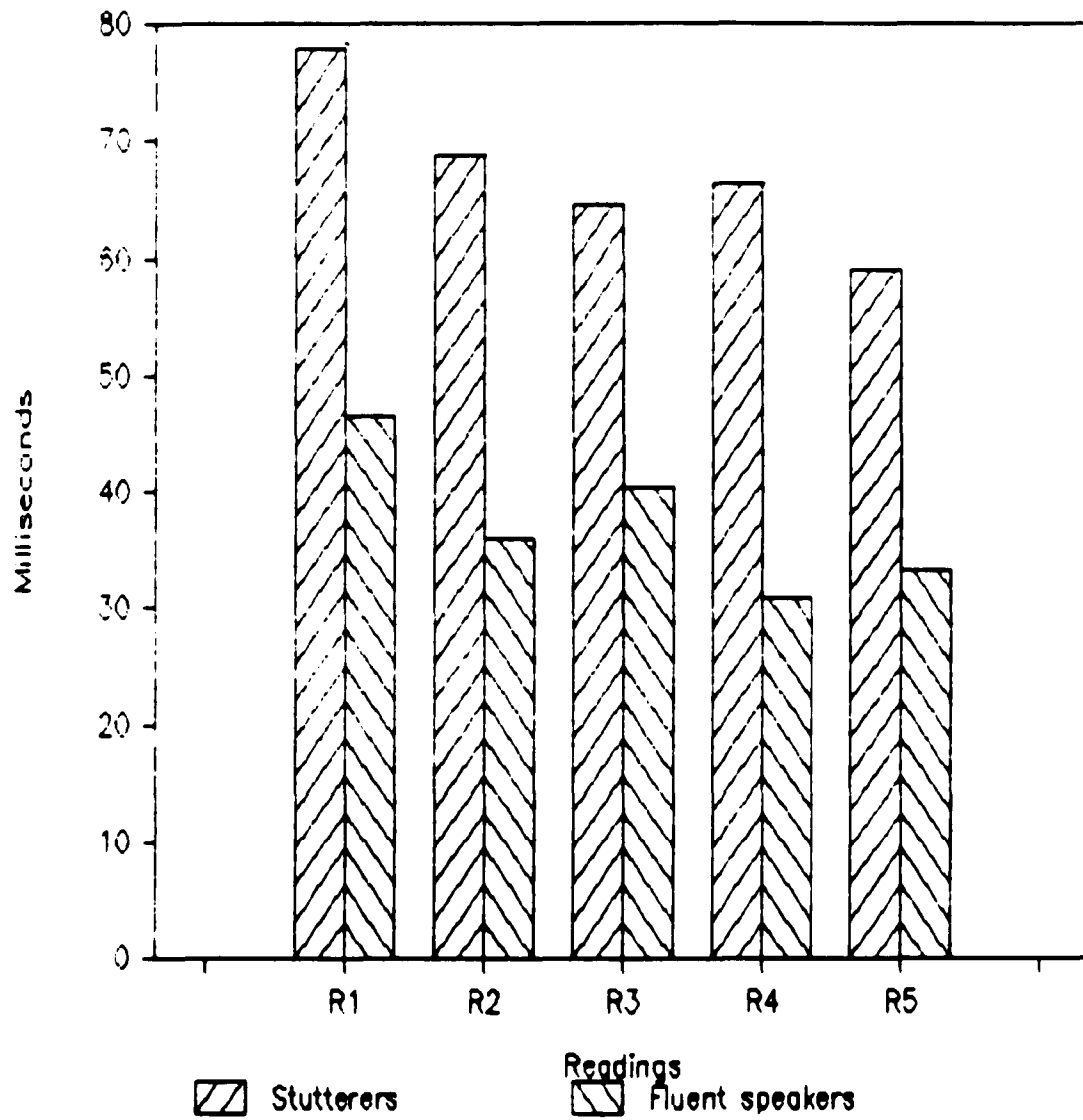


Fig. 14. Plot of standard deviations of duration of words in Xf location by readings and groups.

Table 13 permits the following statements. The stutterers and the fluent speakers do not differ significantly ( $P>0.05$ ) in the duration of the words in this location. The main effect for reading is insignificant ( $P>0.05$ ). A significant interaction between the readings and the groups ( $P<0.001$ ) predicate a differing course of word duration adaptation for the groups.

Figure 13 reveals the differences in the trend of word duration adaptation for the two groups. The stutterers increase the duration from R1 to R2, and then decrease it gradually through the remaining readings. On the other hand, the fluent speakers decrease the duration slightly from R1 to R2, increase it from R2 to R3, and then achieve "stable" durations through the remaining readings.

Figure 14 reveals that the fluent speakers are less variable than the stutterers in the five readings. Furthermore, the level of variability for the groups remains nearly the same across the five readings.

#### Summary Statements on Locational Analysis

1. There is no significant difference in the average duration of the words in locations X-2, X-1, X, X+1, X+2 and Xf between the stutterers and the fluent speakers. The stutterers differ significantly from the fluent speakers in the duration of the words in Xp location. Since the Xp location was always followed by a syntactic pause, one may conclude that the pre-pausal lengthening which is a feature of normal

speech, is significantly exaggerated in the stutterers.

2. Figures 15, 16, 17, 18, and 19 represent the difference in the mean duration of words between the stutterers and the fluent speakers (mean duration in the stutterers minus mean duration in the fluent speakers) for the various locations in R1, R2, R3, R4, and R5 respectively.

Figure 15 illustrates two noteworthy trends in R1, namely, (1) the stutterers exceed the fluent speakers in duration in all the seven locations. (2) Within the candidate clauses, the differential "builds up" gradually from X-2 to X location, and "builds down" in X+1 location. There is an unexpectedly large difference in X+2 location. In Xp and Xf locations outside the candidate clauses, stutterers exceed the duration of the fluent speakers, with a statistically significant difference existing in Xp location as noted earlier.

Figure 16 reveals that in R2, the difference between the groups, is nearly nonexistent in X-2 and X-1 locations. In locations X, X+1, X+2 within the candidate clauses, and Xp and Xf outside it, the stutterers exceed the fluent speakers in duration.

Figure 17 reveals that in R3, the fluent speakers exceed the stutterers' duration by a small margin in X location, but the stutterers exceed the fluent speakers by a small margin in X-1 and X+1 locations. There still exists a notable difference in X+2 location within the candidate clause. The difference in Xp location is significant and the difference in Xf location is present though reduced compared to Figure 16.

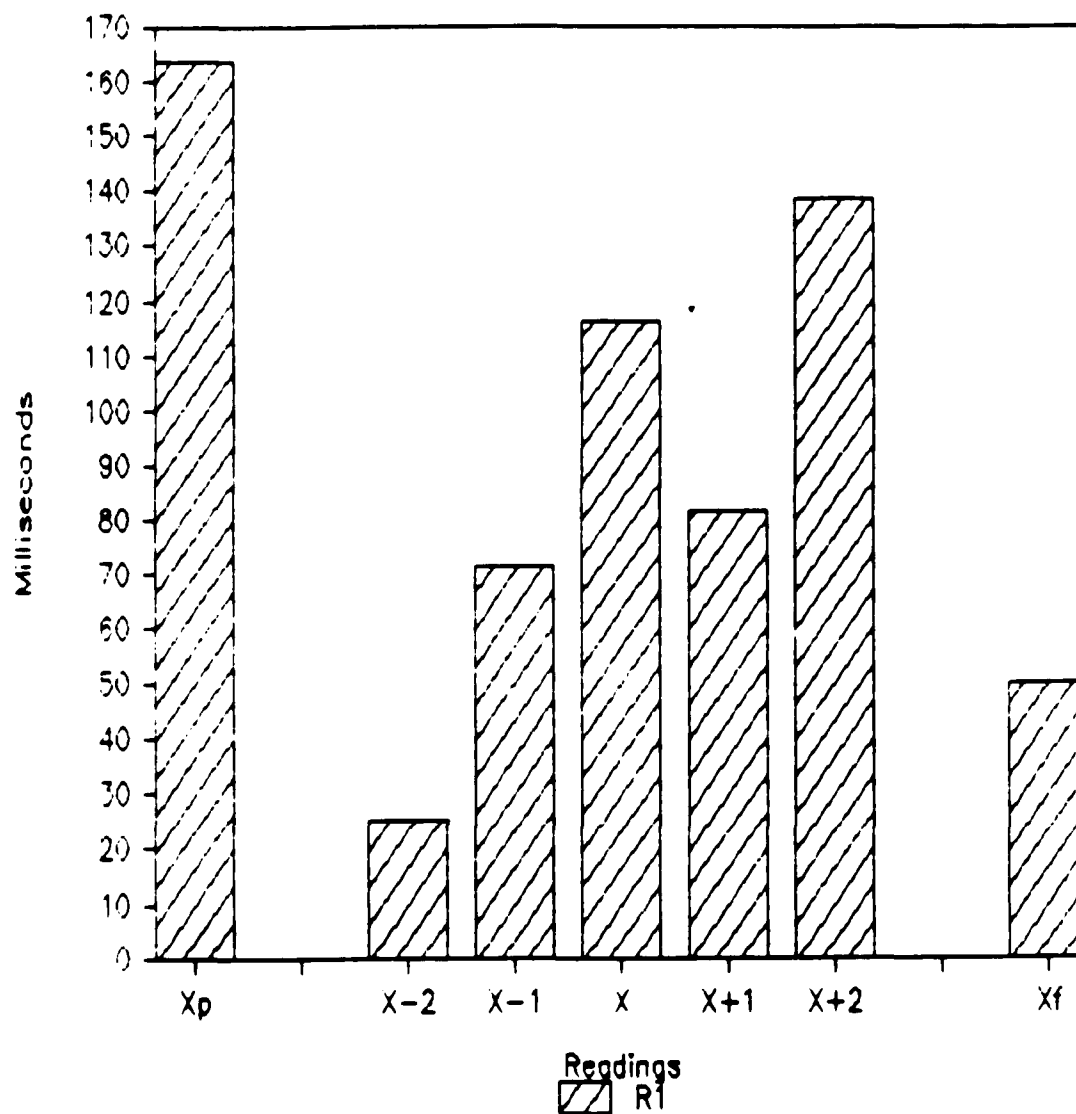


Fig. 15. Plot of differences of means (stutterers' mean minus fluent speakers' mean) for locations Xp, X-2, X-1, X, X+1, X+2, Xf, for R1.

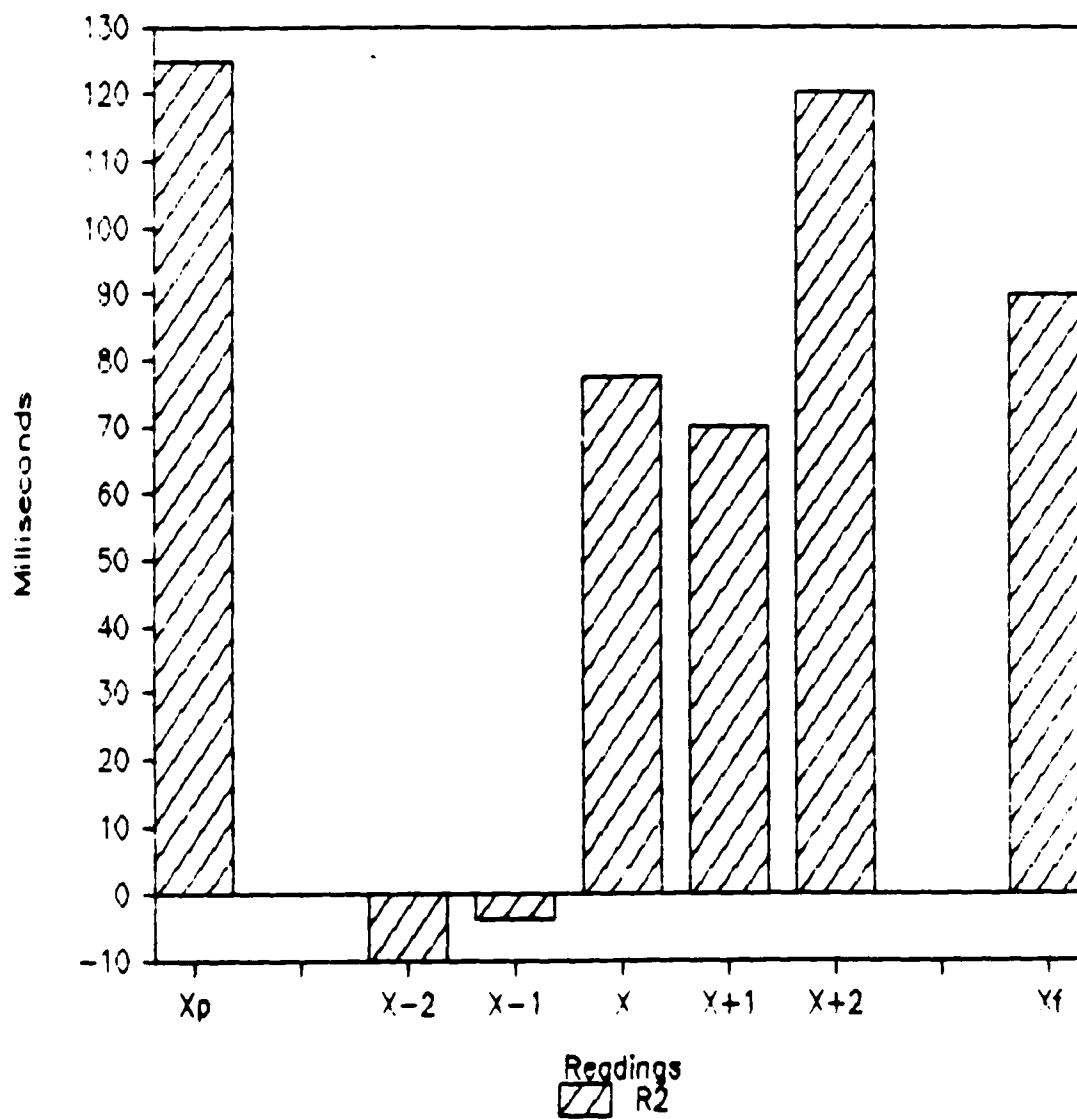


Fig. 16. Plot of difference of means (stutterers' mean minus fluent speakers' mean) for locations Xp, X-2, X-1, X, X+1, X+2, Xf, for R2.

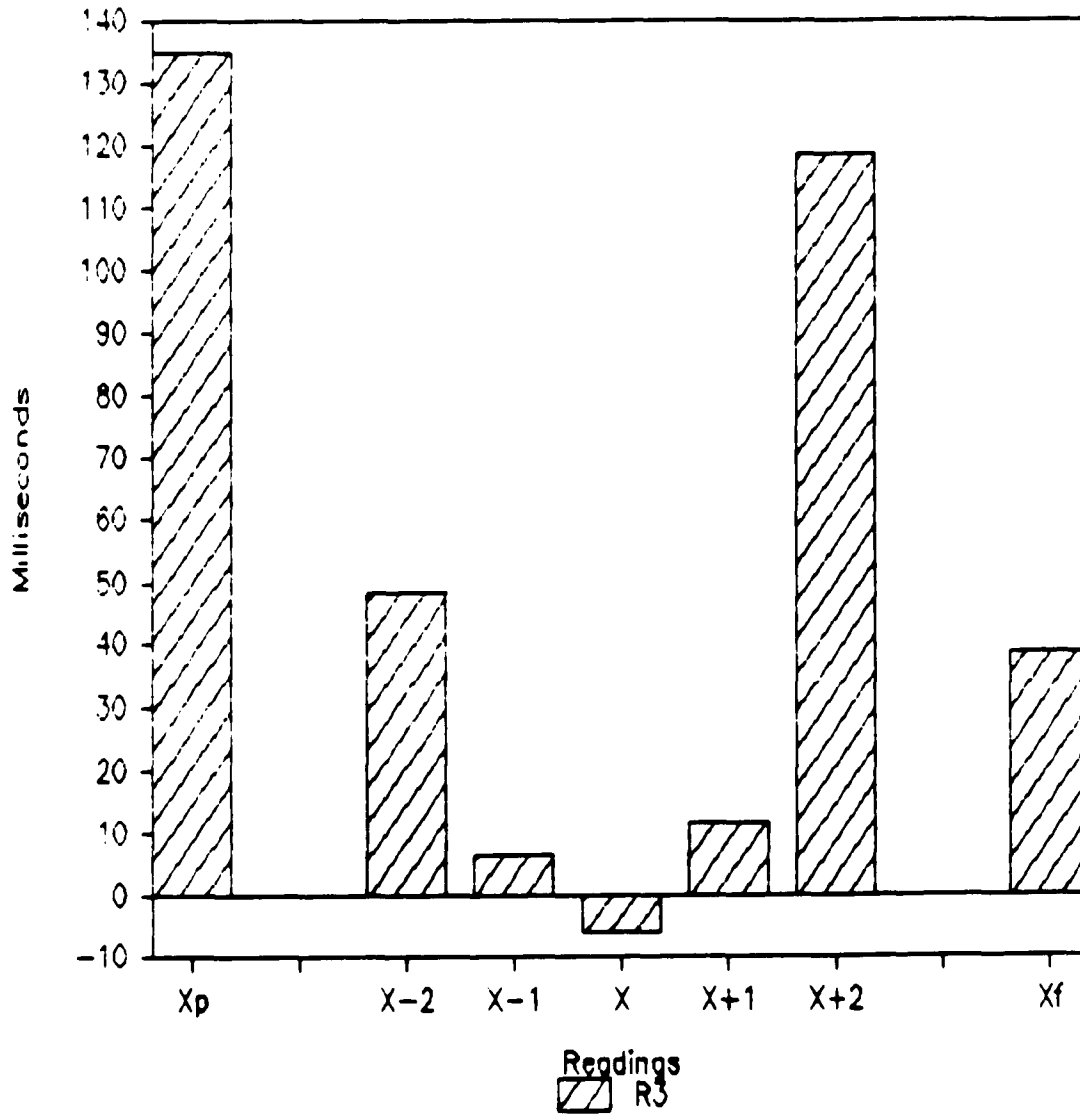
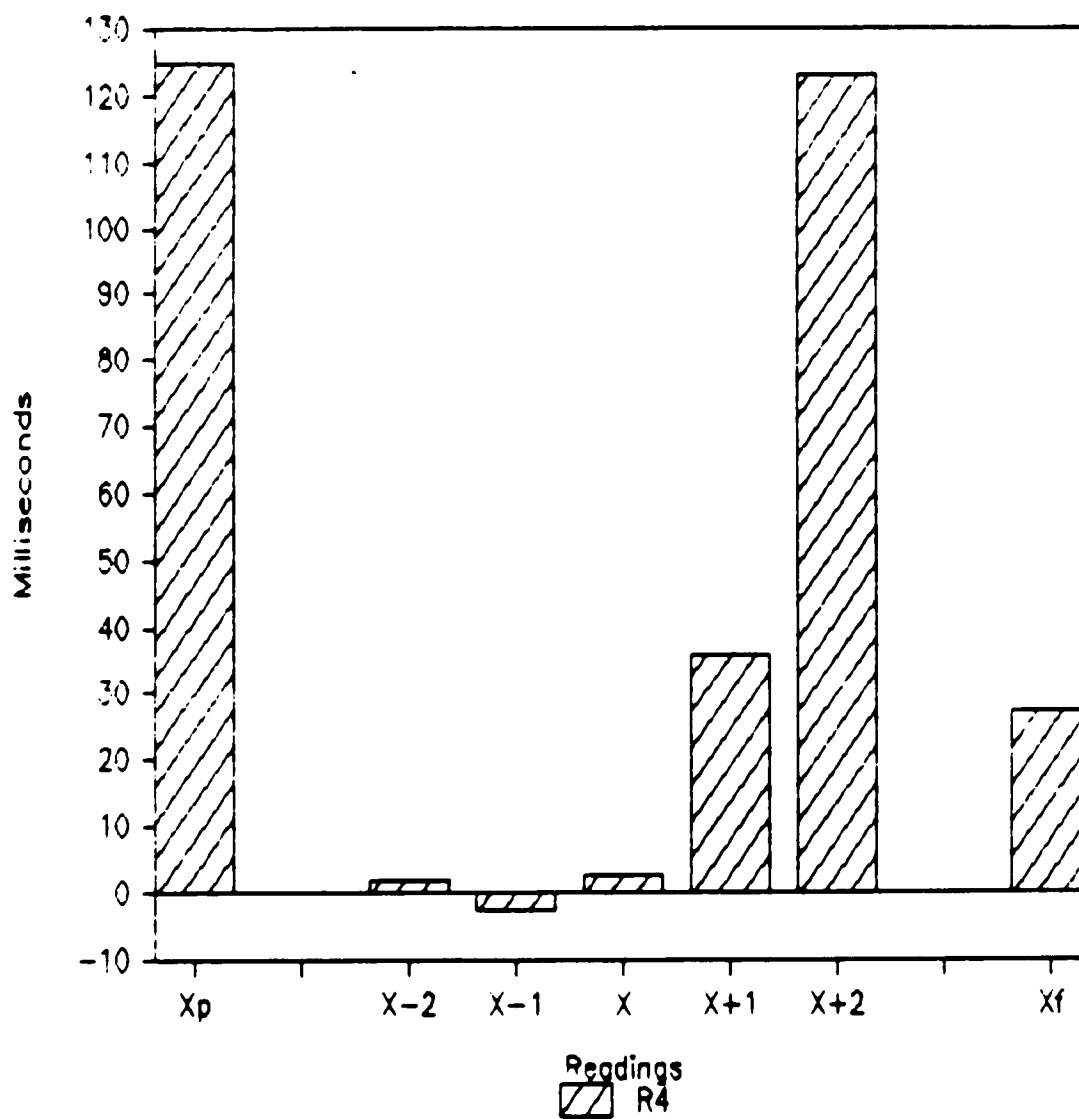


Fig. 17. Plot of difference of means (stutterers' mean minus fluent speakers' mean) for locations Xp, X-2, X-1, X, X+1, X+2, Xf, for R3.



**Fig. 18.** Plot of differences of means (stutterers' mean minus fluent speakers' mean) for locations Xp, X-2, X-1, X, X+1, X+2, Xf, for R4.

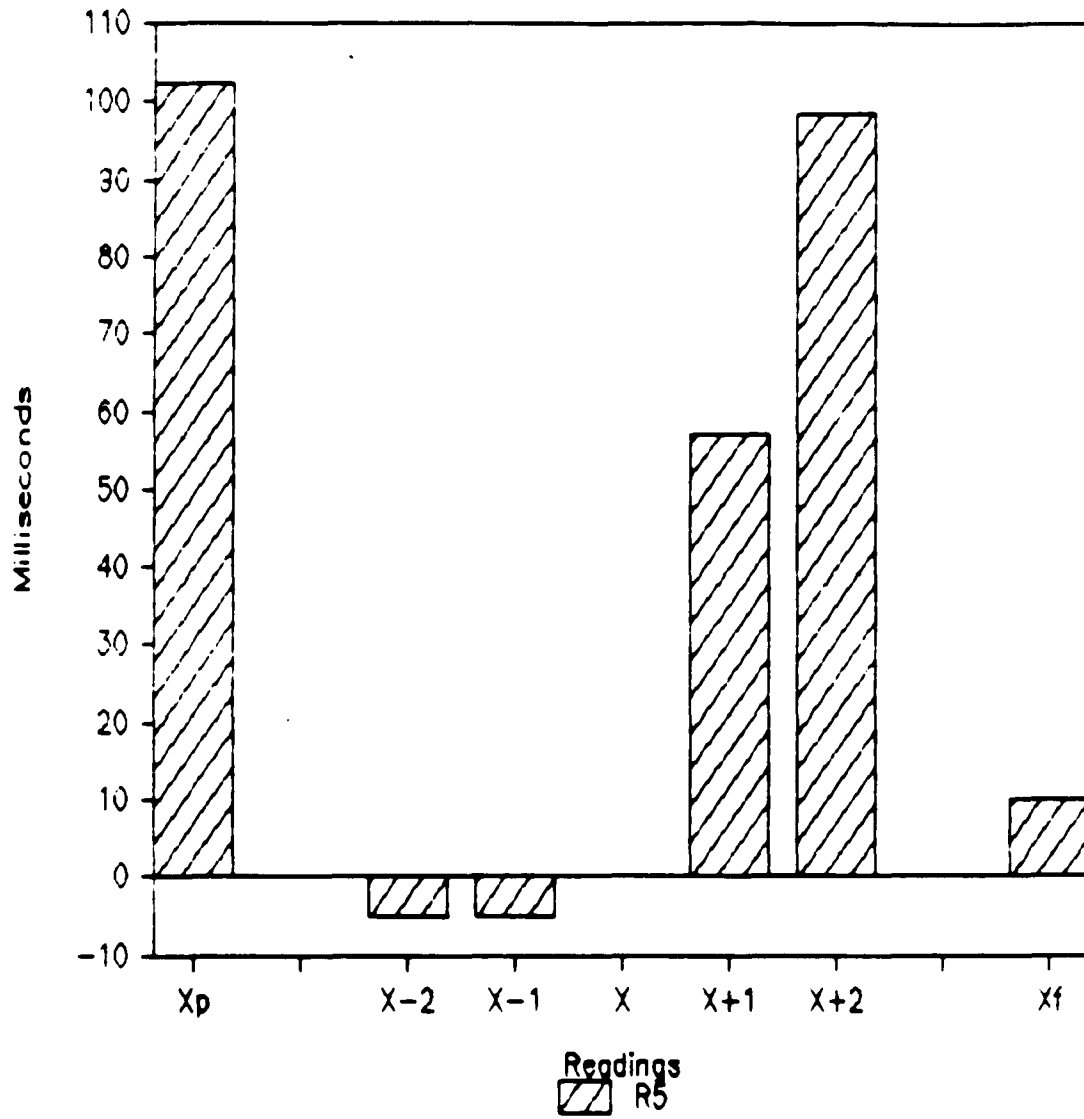


Fig. 19. Plot of differences of means (stutterers' mean minus fluent speakers' mean) for locations Xp, X-2, X-1, X, X+1, X+2, Xf, for R5.

Figure 18 reveals that in R4 there is no difference between the groups in locations X-2, X-1 and X. There is a small difference in location X+1 with a persistent large difference in the X+2 location within the candidate clauses. The differences in Xp and Xf locations continue to exist in R4.

Figure 19 reveals that in R5, the trends of the differentials in various locations are essentially similar to that in R4 (Figure 18). Thus, apparently, there is a "build up" of difference from X-2 to X location (Figure 15) and this build up gradually dissipates through R2 (Figure 16), R3 (Figure 17), R4 (Figure 18) and R5 (Figure 19) during the course of adaptation. Post-cursively, location X+1 exhibits a similar dissipation of the difference build up in R1, though a small persistent difference continues to exist. Location X+2 exhibits a persistent difference of duration through the fifth reading. One possible explanation for this persistent difference may lie in the fact that four out of seven words in this location were in clause final positions. The three words invariably were followed by a pause in all five readings (see Appendix E). As we noted earlier, in relation to the Xp location, the pre-pausal lengthening in stutterers is significantly exaggerated. Therefore, the persistent difference in X+2 location may reflect the contribution of these clause final words.

3. The fluent speakers are generally more variable than the stutterers. In four locations, namely, X, X-2, X-1, X+1, the fluent speakers are more variable than the stutter-

ers. In locations Xp and Xf, stutterers are more variable than the fluent speakers.

The next section will deal with differences and similarities in the temporal reorganization of utterances between the stutterers and the fluent speakers during the course of adaptation.

### Results of ANOVAS for Repeated Measures of TAT and TPT in SFS and FSSII

#### I. Results of ANOVA for TAT in SFS and FSSII

Table 15 gives the results of ANOVA for the variable TAT. Table 16 gives the means and standard deviations of TAT for the five readings for the two groups. Figure 20 depicts the means of TAT for the five readings for the two groups of speakers. Figure 21 is a plot of the standard deviations for the five readings.

Table 15 permits the following statements. The groups do not differ significantly in total articulation time ( $P > .05$ ). There is a significant difference ( $P < .001$ ) among repetitions (or readings) for total articulation time. The SFS and FSSII do not have different trends of TAT across the five readings (Group X Reading,  $P > .05$ ).

Figure 20 depicts the lack of interaction ( $P > .05$ ) between the groups and readings noted earlier. It is reflected in near parallel trends of simple main effects for the two groups. Figure 20 also reveals that the stutterers consistently have higher values of TAT than the normals for all

TABLE 15

## ANOVA FOR TAT IN SFS AND FSSII

| Source        | SS           | DF | MS         | F    | P      |
|---------------|--------------|----|------------|------|--------|
| Group         | 274,911.25   | 1  | 274,911.25 | 3.04 | 0.1032 |
| Readings      | 1,216,095.00 | 4  | 304,023.75 | 9.63 | 0.0000 |
| Gr X Readings | 213,070.00   | 4  | 53,267.50  | 1.69 | 0.1658 |

TABLE 16

MEANS AND STANDARD DEVIATIONS OF TAT FOR  
READINGS BY GROUPS IN SETS SFS AND FSSII

| Groups           | R1       | R2       | R3       | R4       | R5       |
|------------------|----------|----------|----------|----------|----------|
| Fluent Speakers: |          |          |          |          |          |
| $\bar{X}$        | 2,362.50 | 2,178.75 | 2,137.50 | 2,168.75 | 2,171.25 |
| SD               | 456.59   | 418.14   | 429.70   | 467.47   | 470.42   |
| Stutterers:      |          |          |          |          |          |
| $\bar{X}$        | 2,888.75 | 2,606.25 | 2,517.50 | 2,403.75 | 2,456.25 |
| SD               | 481.83   | 406.83   | 430.44   | 476.02   | 494.19   |

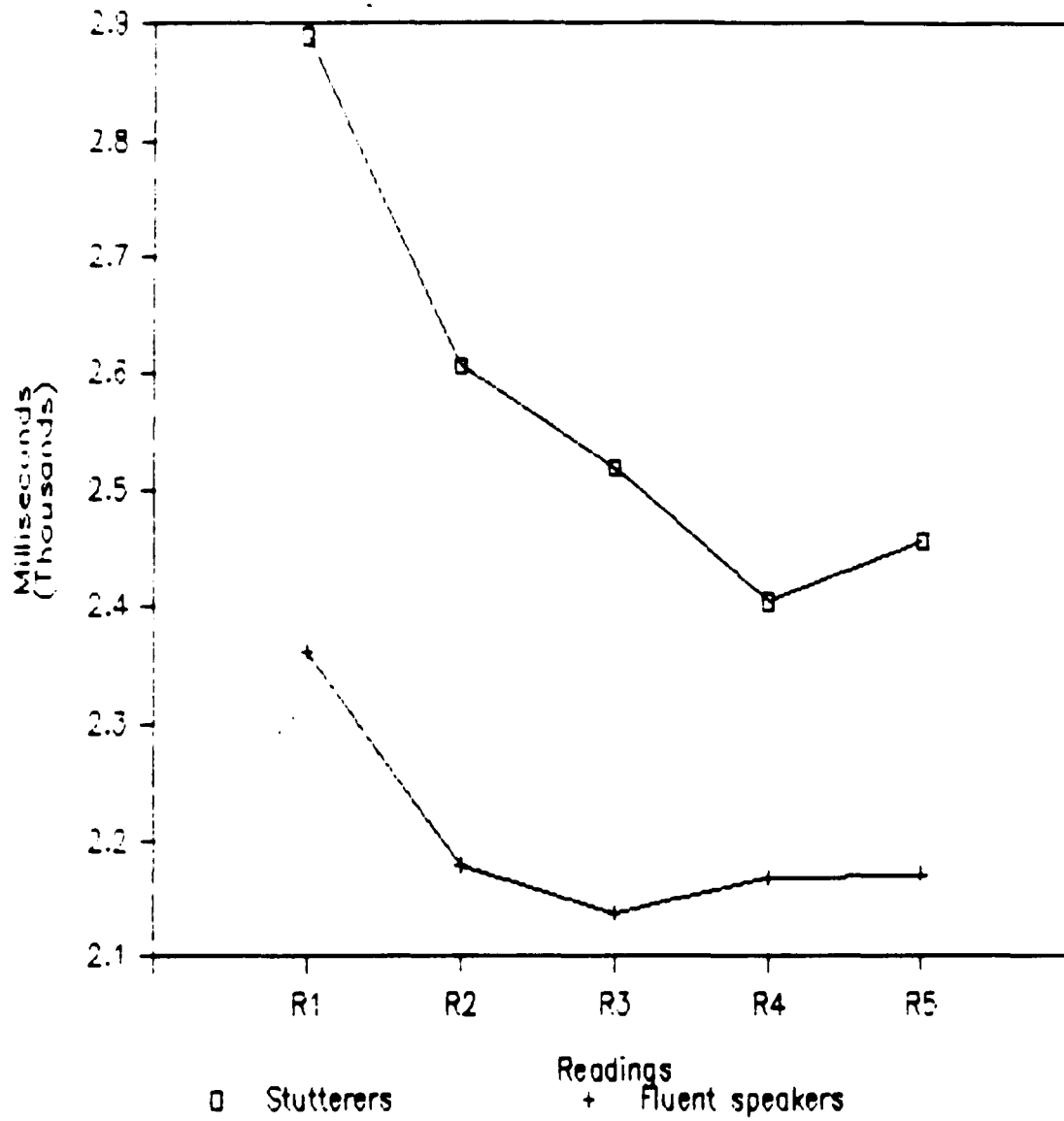


Fig. 20. Plot of means of TAT for SFS and FSSII for readings by groups.

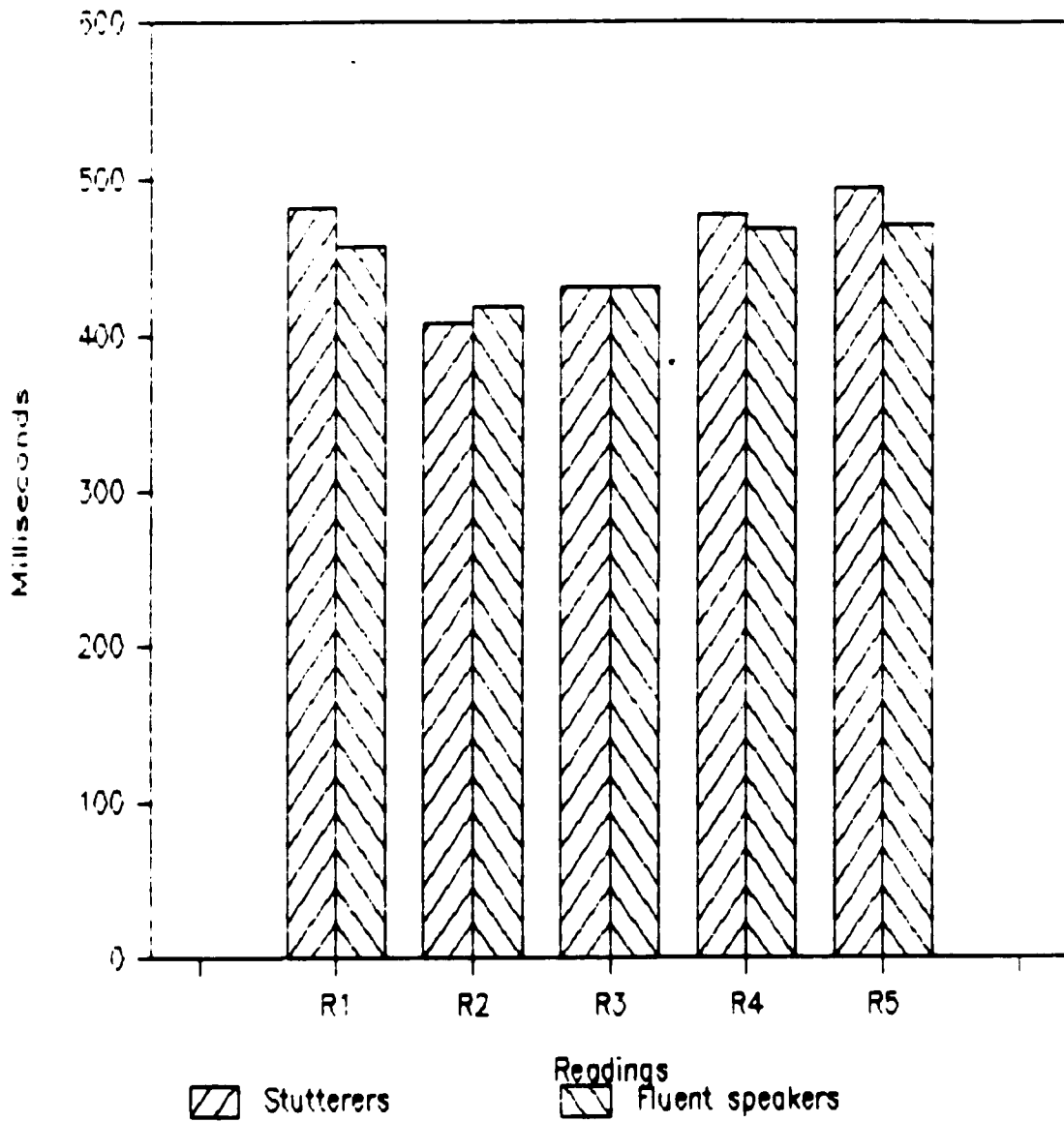


Fig. 21. Plot of standard deviations of TAT for SFS and FSSII for readings by groups.

five readings.

Figure 21 reveals the following two trends. Firstly, the fluent speakers are less variable than the stutterers in four out of five readings. Secondly, both the groups exhibit greater variability in readings one, four and five, as compared to two and three.

## II. Results of ANOVA for TPT in SFS and FSSII

Table 17 gives the results of ANOVA for TPT. Table 18 gives the means and standard deviations of TPT for the two groups across the five readings. Figure 22 is a plot of the means of TPT for the five readings. Figure 23 depicts the standard deviations of TPT for the five readings in the two groups.

Table 17 reveals the following similarities and differences between the two sets in the total pause time. The two sets (or groups of speakers) do not differ significantly in total pause time during the course production of utterances fluently ( $P > .05$ ). There is a significant difference ( $P < .05$ ) among repetitions or readings for TPT. The two groups of speakers apparently also share a similar trend across the five readings (Group X Reading,  $P > .05$ ).

Figure 22 reveals the differences between the stutterers and the fluent speakers. A steep drop in the TPT, from R1 to R2, R2 to R3, an increase from R3 to R4 and a slight decrease from R4 to R5, is seen in the stutterers. On the other hand, fluent speakers show a gradual decrease of TPT from R1

TABLE 17

## ANOVA FOR TPT IN SFS AND FSSII

| Source        | SS          | DF | MS         | F    | P      |
|---------------|-------------|----|------------|------|--------|
| Group         | 42,781.25   | 1  | 42,781.25  | 0.01 | 0.9301 |
| Readings      | 3,770,545.0 | 4  | 942,636.25 | 3.99 | 0.0064 |
| Gr X Readings | 1,577,175.0 | 4  | 394,293.75 | 1.67 | 0.1697 |

TABLE 18

MEANS AND STANDARD DEVIATIONS OF TPT FOR  
READINGS BY GROUPS FOR SFS, AND FSSII

| Groups                  | R1       | R2       | R3       | R4       | R5       |
|-------------------------|----------|----------|----------|----------|----------|
| <b>Fluent Speakers:</b> |          |          |          |          |          |
| $\bar{X}$               | 2,032.5  | 1,875.00 | 1,832.50 | 1,810.00 | 1,845.00 |
| SD                      | 1,409.18 | 1,072.34 | 1,183.07 | 1,310.08 | 1,277.25 |
| <b>Stutterers:</b>      |          |          |          |          |          |
| $\bar{X}$               | 2,625.00 | 1,845.00 | 1,633.75 | 1,792.50 | 1,730.00 |
| SD                      | 1,368.17 | 831.68   | 777.23   | 801.12   | 964.04   |

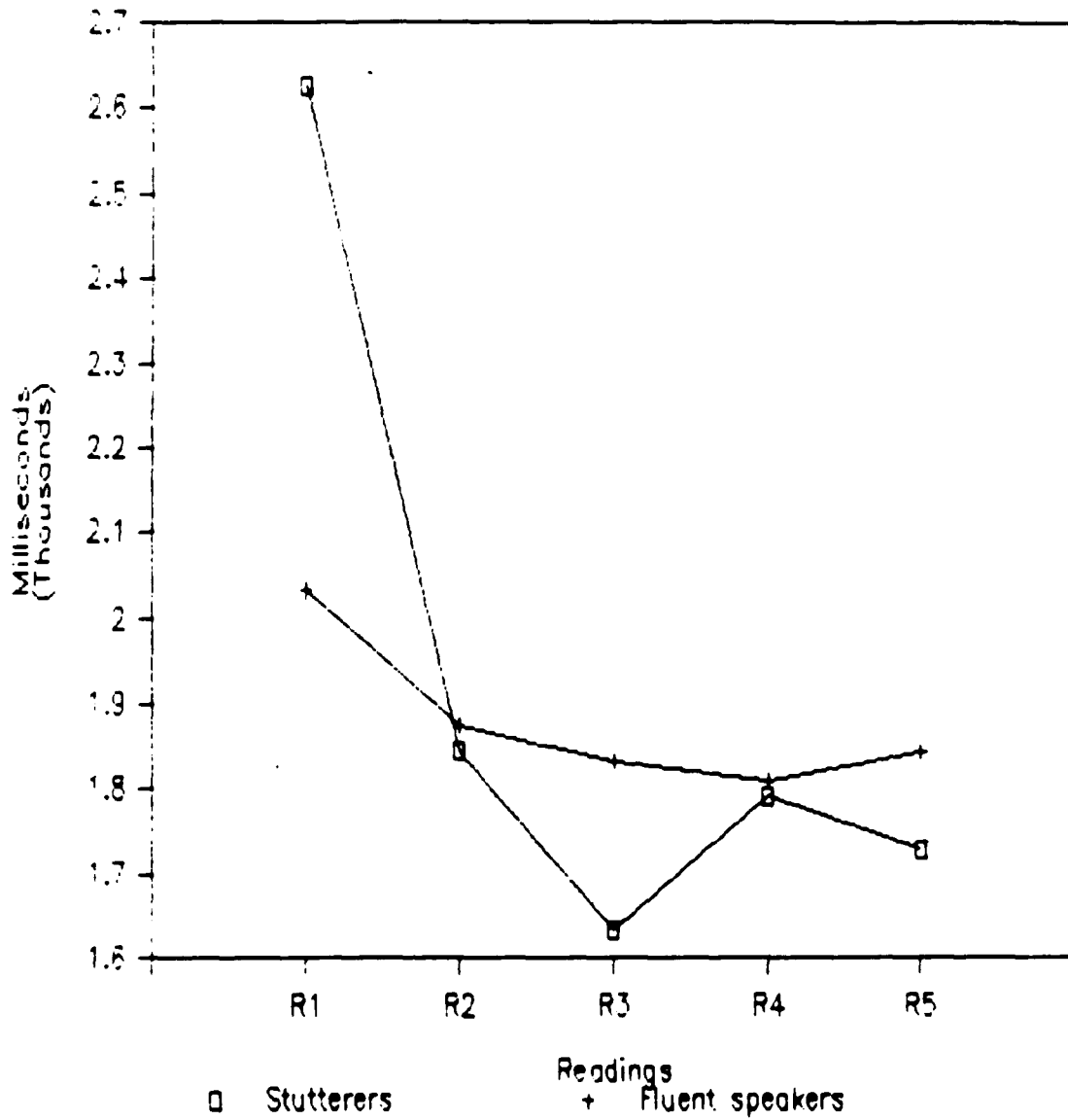


Fig. 22. Plot of means of TPT for SFS and FSSII for readings by groups.

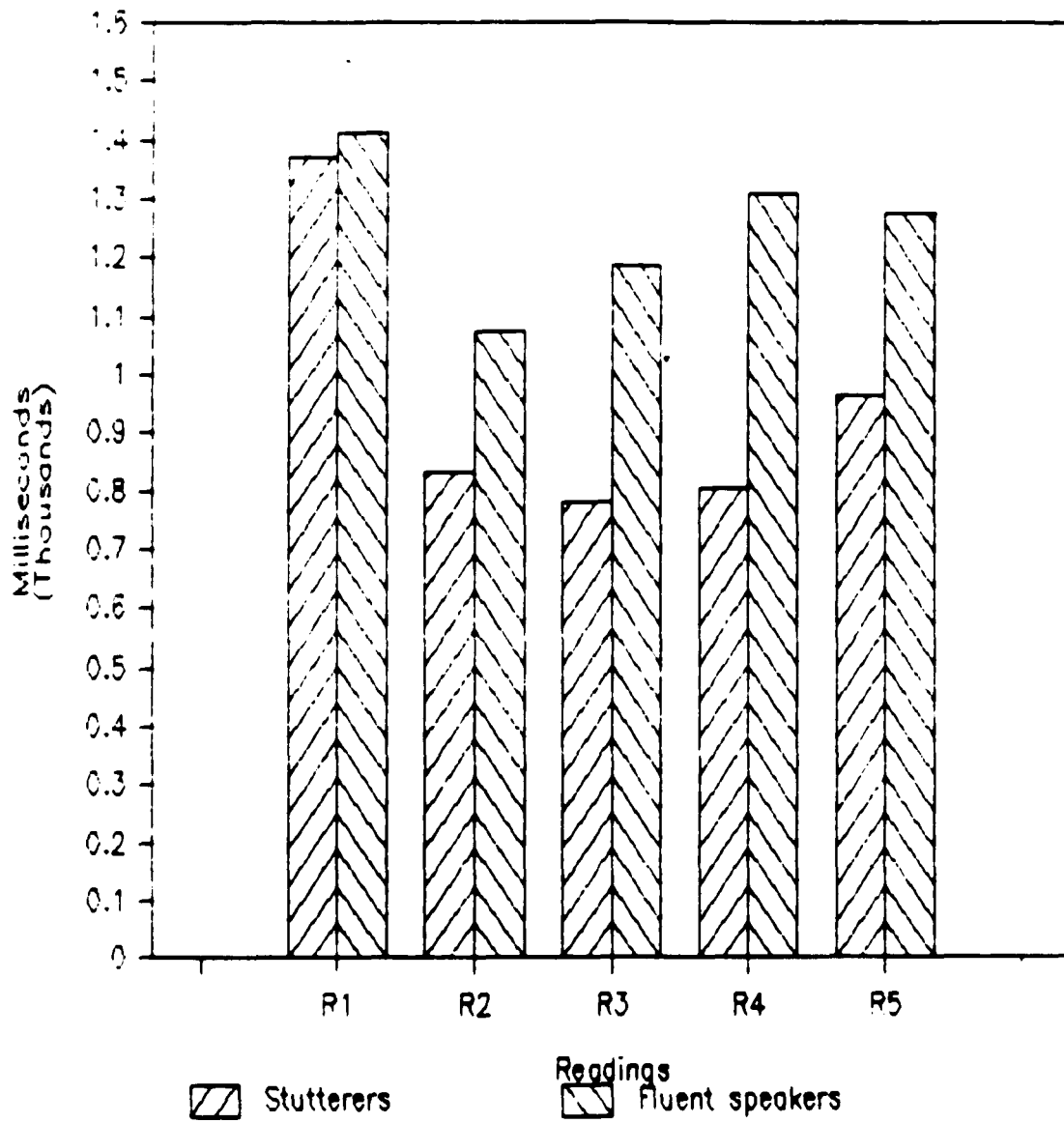


Fig. 23. Plot of standard deviations of TPT for SFS and FSSII for readings by groups.

to R2, R2 to R3, R3 to R4, and a slight increase from R4 to R5.

Figure 23 reveals that, generally, the total pause time in the fluent speakers exhibits a greater variability than in the stutterers. The groups are most variable in R1 and the variabilities in this reading for the groups is comparable. The greatest difference in variability between the groups occurs in reading four.

### III. Results of ANOVA for TAT in SSS and FSSI

Table 19 gives the results of the ANOVA for total articulation time (TAT). Table 20 gives the means and standard deviations of TAT for the two groups in the five readings. Figure 24 is a plot of the means of TAT in the five readings for the two groups. Figure 25 is a plot of standard deviations for the two groups.

Table 19 permits the following statements. There is a significant difference in the average total articulation time between the stutterers and fluent speakers ( $P > .001$ ). There is a significant difference between readings ( $P > .001$ ) and a significant group and reading interaction ( $P > .001$ ).

Figure 24 displays a steep fall in total articulation time from R1 to R2, R2 to R3, and gradual flattening out in stutterers. On the other hand, fluent speakers show a very gradual decrease in TAT from R1 to R2, R2 to R3, R3 to R4, with a slight increase in TAT from R4 to R5. TAT in the stutterers is consistently higher than that of the fluent

TABLE 19

ANOVA FOR TAT IN SSS AND FSSI

| Source        | SS           | DF | MS           | F     | P      |
|---------------|--------------|----|--------------|-------|--------|
| Group         | 4,255,031.25 | 1  | 4,255,031.25 | 0.47  | 0.5048 |
| Readings      | 1,440,305.0  | 4  | 360,076.25   | 10.43 | 0.0000 |
| Gr X Readings | 681,400.0    | 4  | 170,350.00   | 4.94  | 0.0018 |

TABLE 20

MEANS AND STANDARD DEVIATIONS OF TAT FOR  
 READINGS BY GROUPS FOR SETS SSS AND FSSI

| Groups                  | R1       | R2       | R3       | R4       | R5       |
|-------------------------|----------|----------|----------|----------|----------|
| <b>Fluent Speakers:</b> |          |          |          |          |          |
| $\bar{X}$               | 2,787.50 | 2,687.50 | 2,646.25 | 2,615.00 | 2,748.75 |
| SD                      | 1,344.26 | 1,315.62 | 1,230.03 | 1,221.48 | 1,475.88 |
| <b>Stutterers:</b>      |          |          |          |          |          |
| $\bar{X}$               | 3,570.0  | 3,210.0  | 3,030.00 | 2,997.50 | 2,983.75 |
| SD                      | 1,476.62 | 1,421.44 | 1,423.77 | 1,460.78 | 1,164.03 |

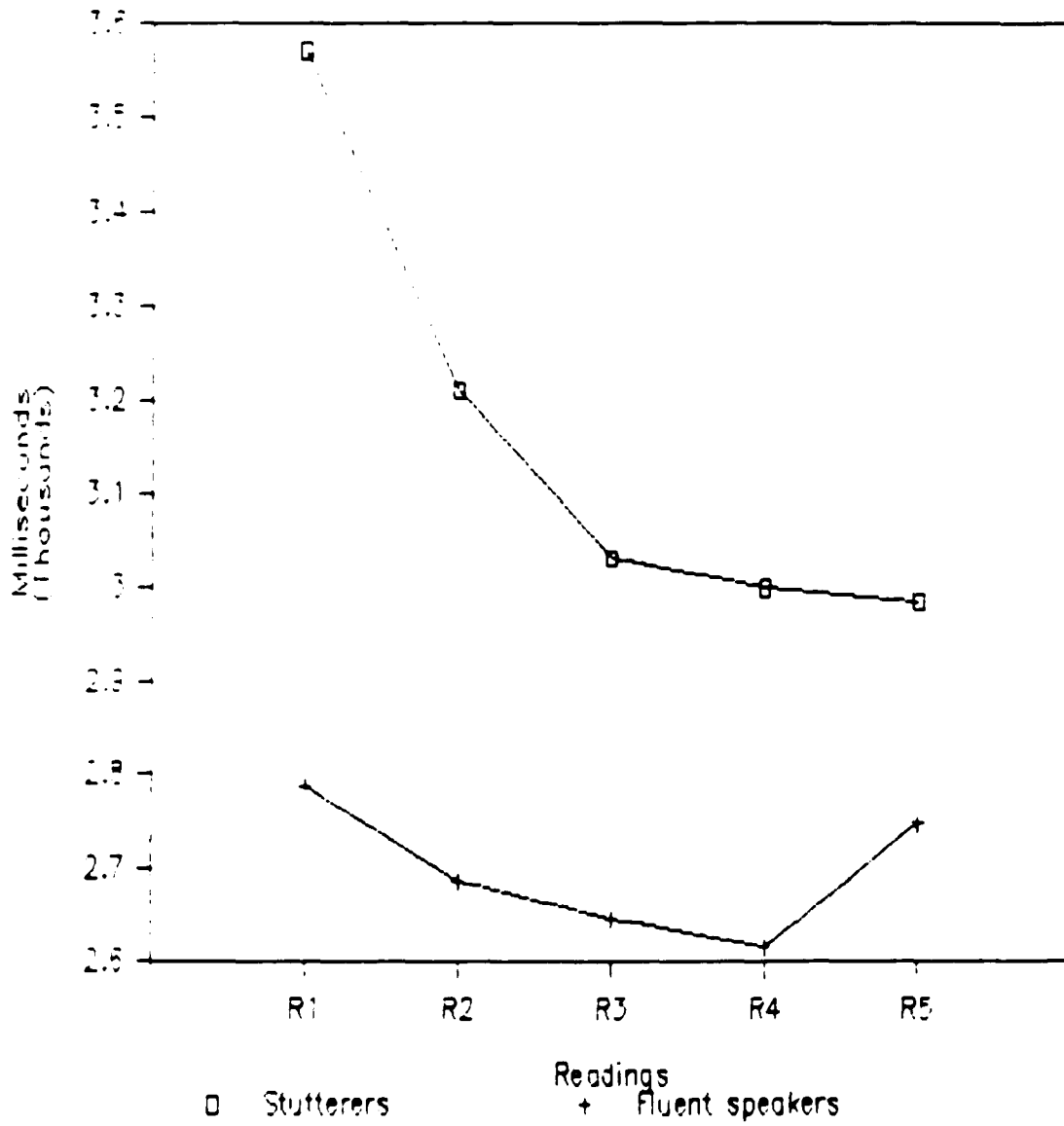


Fig. 24. Plot of means of TAT for SSS and FSSI for readings by groups.

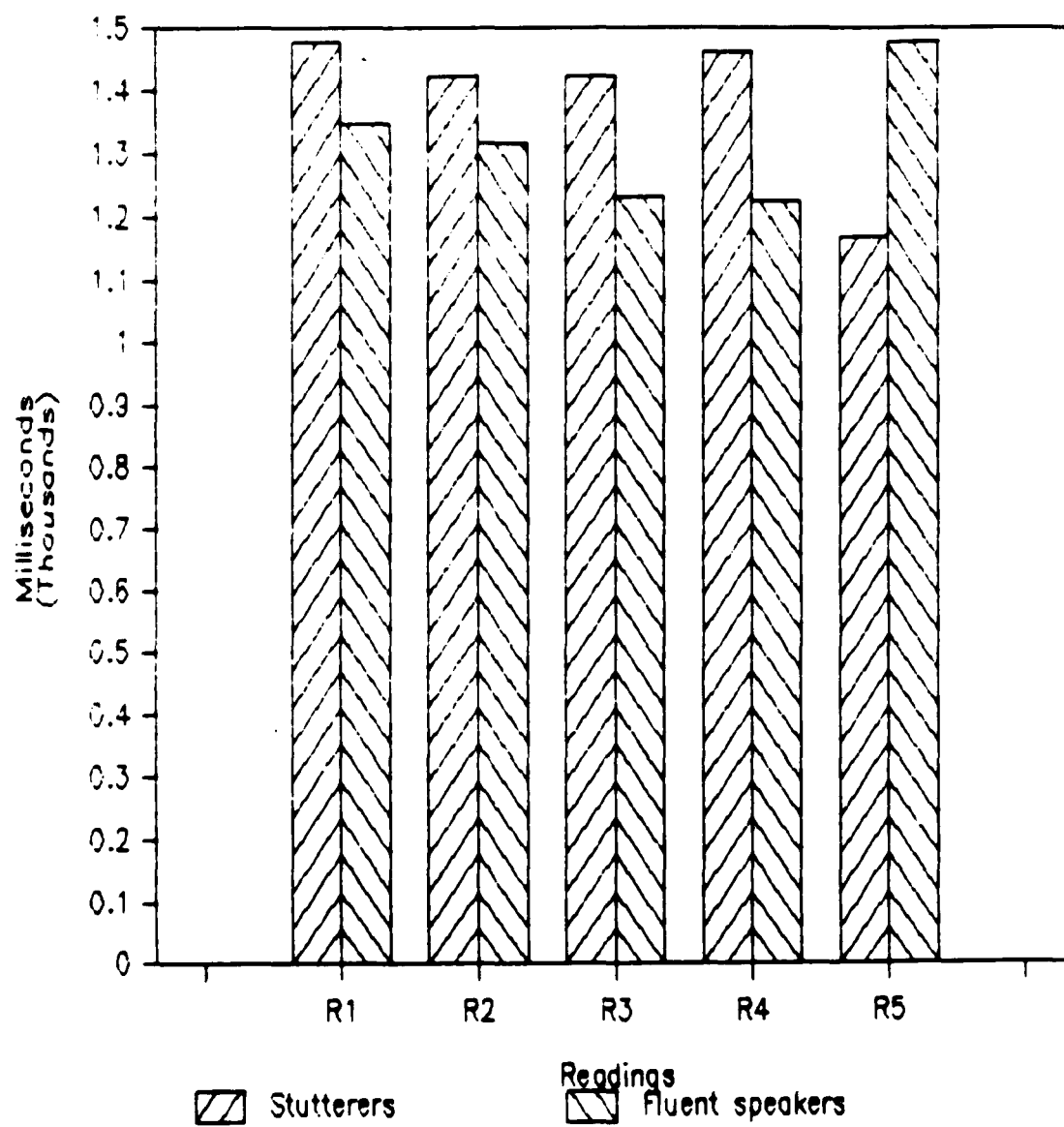


Fig. 25. Plot of standard deviations of TAT for SSS and FSSI for readings by groups.

speakers. The greatest difference in total articulation time between the stutterers and the fluent speakers exists in reading one and largely accounts for the significant interaction reported earlier.

Figure 25 reveals the following interesting trends: (a) the fluent speakers generally are less variable on TAT than stutterers in four out of five readings, (b) stutterers' variabilities across readings one, two, three and four, are comparable and fall in the range of 1,375-1,475 msec. However, this range of variability is precipitously reduced in the fifth reading. (c) Fluent speakers' TAT variability decreases progressively from reading one to four with a sudden jump in variability in reading five. Thus a "perturbation" in trend is seen in reading five in both groups of speakers, but in opposite directions.

#### IV. Results of ANOVA for TPT in SSS and FSSI

Table 21 gives the results of the ANOVA for TPT. Table 22 gives the means and standard deviations of TPT for the two groups in the five readings. Figure 26 is a plot of the means of TPT across the five readings for the two groups. Figure 27 displays standard deviations of TPT for the two groups in the five readings.

Table 21 reveals the following trends. Stutterers and fluent speakers do not differ significantly from each other on TPT ( $P > .05$ ). There is no significant difference among the readings for TPT. However, a significantly different trend in

TABLE 21  
ANOVA FOR TPT IN SSS AND FSSI

| Source        | SS           | DF | MS           | F    | P      |
|---------------|--------------|----|--------------|------|--------|
| Group         | 1,202,951.25 | 1  | 1,202,951.25 | 0.11 | 0.7437 |
| Readings      | 2,181,017.50 | 4  | 545,254.37   | 0.95 | 0.4397 |
| Gr X Readings | 7,219,767.5  | 4  | 1,804,941.87 | 3.16 | 0.0206 |

TABLE 22

MEANS AND STANDARD DEVIATIONS OF TPT FOR  
 READINGS BY GROUPS FOR SETS SSS AND FSSI

| Groups                  | R1       | R2       | R3       | R4       | R5       |
|-------------------------|----------|----------|----------|----------|----------|
| <b>Fluent Speakers:</b> |          |          |          |          |          |
| $\bar{X}$               | 1,491.25 | 1,943.75 | 1,610.00 | 1,960.00 | 1,788.75 |
| SD                      | 1,698.56 | 1,830.74 | 1,479.89 | 2,052.89 | 2,187.38 |
| <b>Stutterers:</b>      |          |          |          |          |          |
| $\bar{X}$               | 2,397.50 | 1,381.25 | 1,366.25 | 1,176.25 | 1,246.25 |
| SD                      | 2,358.42 | 984.77   | 843.43   | 915.99   | 832.46   |

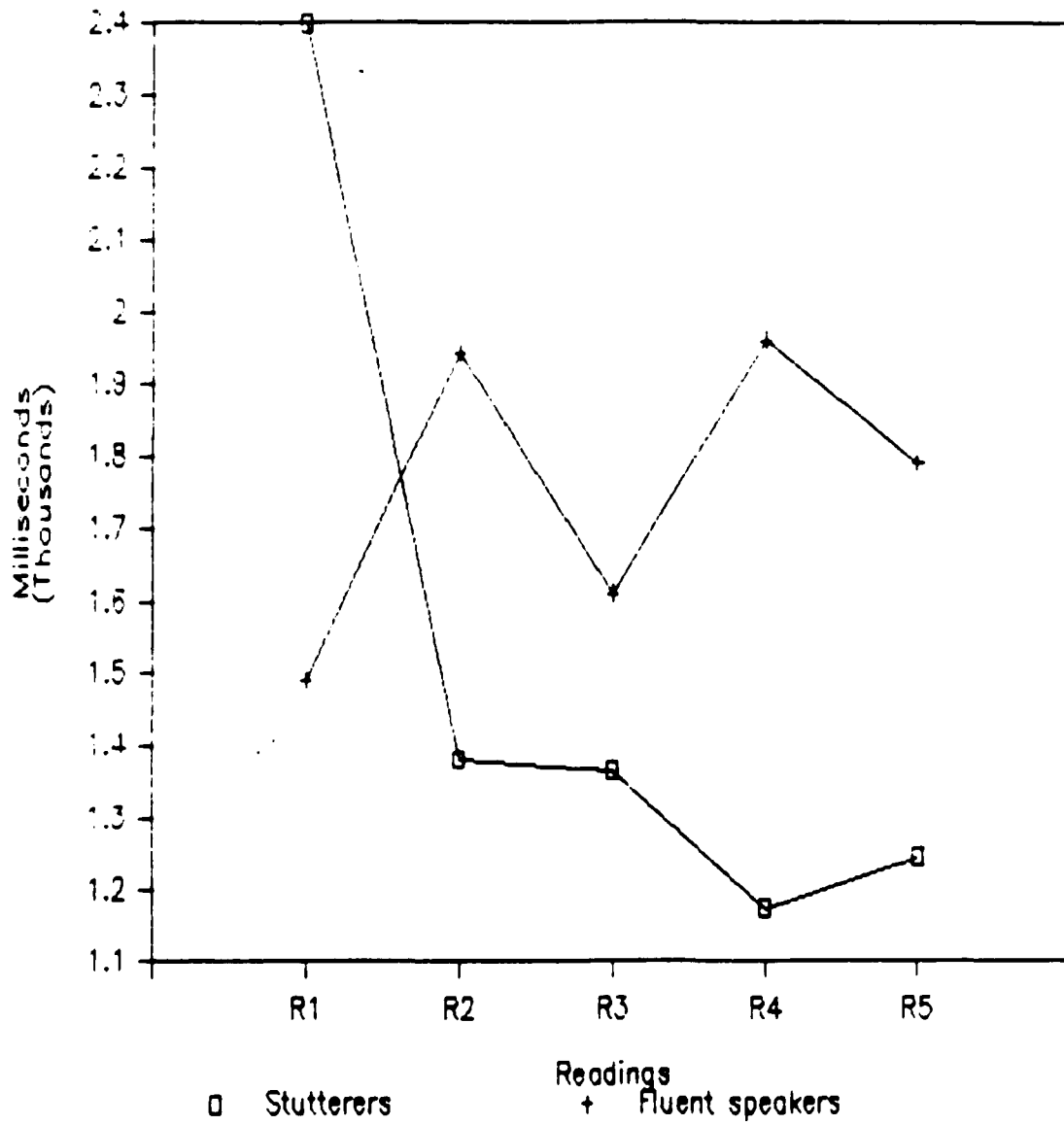


Fig. 26. Plot of means of TPT for SSS and FSSI for readings by groups.

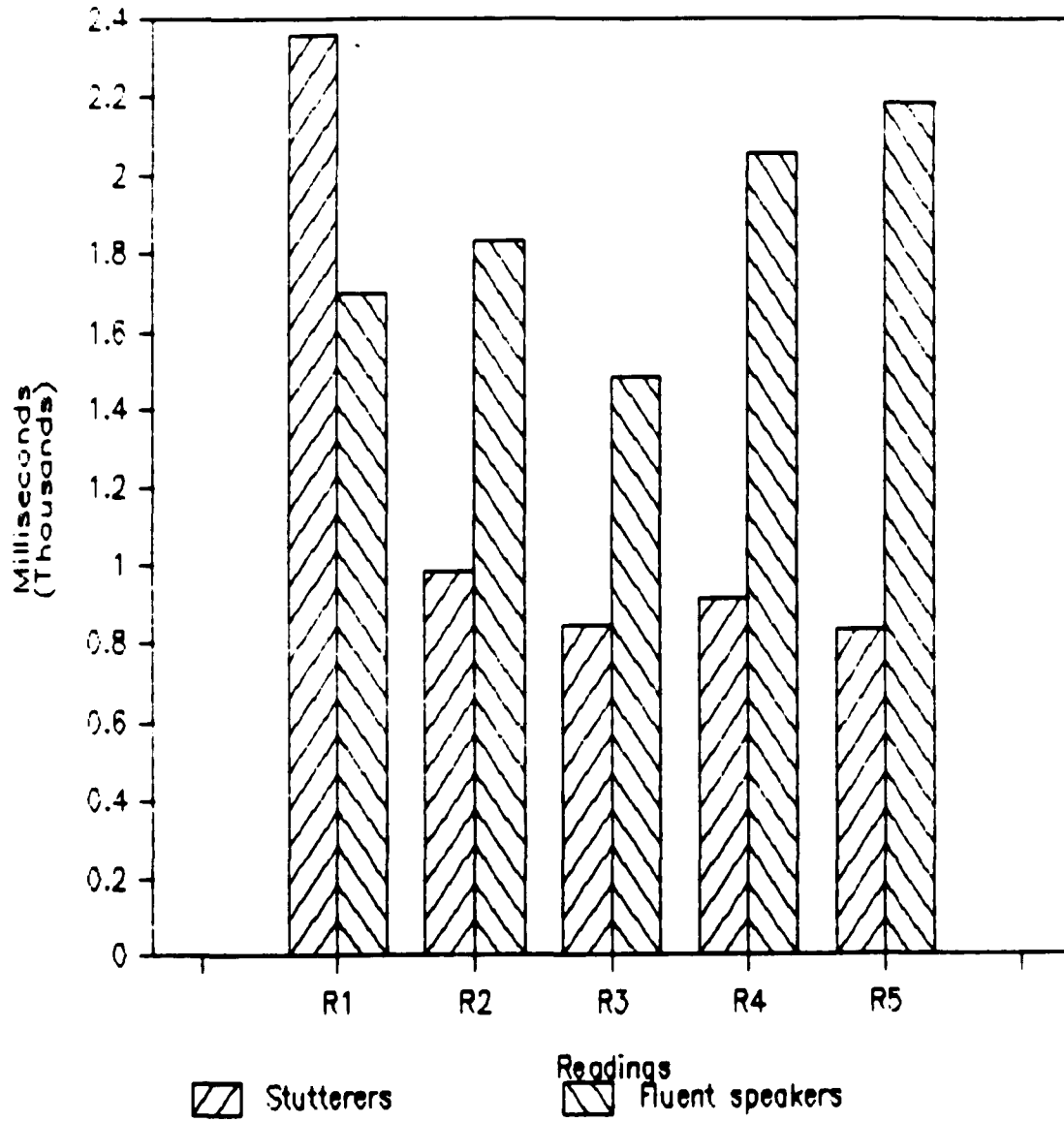


Fig. 27. Plot of standard deviations of TPT for SSS and FSSI for readings by groups.

the course of the five readings for the two groups of speakers is present (Group X Reading,  $P < .05$ ).

Figure 26 shows the trend of TPT across the five readings for stutterers and fluent speakers. The observed significant interaction between the group and readings can be accounted for by differing tendencies of TPT in the stutterers and the fluent speakers. Stutterers exhibit a significant drop in TPT from R1 to R2 and then gradually decrease from R2 to R3 and R3 to R4, with a slight increase from R4 to R5. On the other hand, fluent speakers exhibit a complex trend--an increase from R1 to R2, a decrease from R2 to R3, an increase from R3 to R4, and a small drop from R4 to R5.

Figure 27 permits one generalization and a significant exception to it, namely, that the fluent speakers are more variable in TPT than the stutterers, but this general trend is significantly reversed in reading one.

#### Summary of Results on Global Variables TAT and TPT

There are several interesting differences and similarities, in the course of adaptation of TPT and TAT, between the stutterers and fluent speakers on the one hand, and between the two stutterers' sets on the other. The following general statements can be made based on the results described above.

1. The fluent speakers and the stutterers decrease their TAT from reading one to five.
2. The fluent speakers consistently have lower total articulation time across the five readings than the stutter-

ers.

3. The course of total articulation time for the stutterers and fluent speakers is essentially parallel or non-interactive when both groups produce the chosen clauses fluently all five times.

4. The course of total articulation time for stutterers is influenced by the presence of stuttering events in the first reading. This is reflected as significant group and reading interaction for the stutterers' stuttered set and fluent speakers' set (II).

5. The sets FSSI and II do not differ in terms of the amount of change across the five readings. The difference between the lowest TAT and the highest TAT is 200 msec for FSSI and II. For SSS it is 600 msec, and for SFS it is 480 msec. Thus, there is a difference of 120 msec between SSS and SFS. The steeper slope (from R1 to R2) in SSS accounts for nearly 80 msec of the difference.

6. The stutterers generally exhibit a greater variability in total articulation time than the fluent speakers. On the other hand, fluent speakers exhibit a greater variability in total pause time than the stutterers.

7. The prototypical TPT function for stutterers can be described as a steep negative slope from R1 to R2 with considerably reduced rate of change thereafter. The sets SSS and SFS differ in the direction of change from R3 to R4, and R4 to R5. In SFS, TPT increases from R3 to R4, and decreases from R4 to R5. The exactly opposite trend is seen in the set SSS

(compare Figures 22 and 26).

8. The fluent speakers' TPT function, in contrast, is highly variable (see Figures 22 and 26).

In the next chapter, an attempt will be made to relate the results of locational analysis and global variables analysis to the issues and hypotheses raised in the Introduction.

## CHAPTER IV

### DISCUSSION

The discussion of the results will roughly follow the organization of results in Chapter III. The discussion on the results of locational analysis will be followed by the discussion of results on the course of global variables, total articulation time and total pause time. This will be followed by a brief general discussion of the overall results.

#### A. Discussion of the Results on Locational Analysis

The ANOVAS for duration of words in various locations within the candidate clauses can be summarized thus: (1) in locations X and X-1 an insignificant main effect for group, a significant main effect for reading, and significant group and reading interaction was found. In X-1 location the interaction fell short of significance by a very small margin ( $P=.07$ ). (2) In locations X-2, X+2, the main effects for group and readings was insignificant as was group and reading interaction. (3) In X+1 location there was an insignificant main effect for group, insignificant group and reading interaction with significant effect for readings.

First, consider the significant interaction between the group and readings in X-location. An examination of figure 1

suggests that the basis for the significant interaction is the wide gap in the mean duration of words between the stutterers and fluent speakers in the first and second reading. The durational gap in the first reading indicates that a stutterer is slower than normal in producing a stuttered word fluently. The gap in the second reading suggests a "lingering effect" of a stuttering event on the duration of words in this location, even though the second utterance of the clause was judged to be totally fluent. Next, consider the basis for the significant interaction in X-1 location (Fig. 3). The interaction is due to the wide gap in the mean duration of words in the first reading, suggesting that stutterers have a tendency to prolong the duration of words preceding a stuttering event. In the remaining three locations, namely, X-2, X-1, X+2, statistically significant durational differences between the two groups do not exist. This conclusion is prompted by lack of significant main effect for group and group and readings interaction. Thus, statistically significant difference in duration is limited to one word before a stuttering event and one word after it. Furthermore, there seems to be a lingering effect of a stuttering event on the duration of words occupying X-location in the second reading, even though the utterances were judged to be totally fluent.

Though statistically significant changes in duration are limited to one word before and one word after a stuttering event, an examination of figures 15, 16, 17, 18, 19 shows that stutterers generally have a longer duration of words in all

locations in the first reading, with a progressive reduction of the number of locations exhibiting noticeable differences in the succeeding readings. This observation, taken with statistically significant changes in X-1 and X locations leads to the following conclusion: stutterers have longer duration of words than normal speakers in the various locations around a stuttering event, and this difference is accentuated in X-1 and X locations.

Is there an indication in the data for progressive 'increment' of durational changes and progressive 'decrement' of durational changes with reference to a stuttering event? Fig. 15 shows that the difference in duration between stutterers and fluent speakers gradually increases from location X-2 to X-1, X-1 to X and then decreases from X to X+1. The changes in these locations (X-2, X-1) confirm the notion of gradual build up to a stuttering event. The post-stuttering phase (X, X+1 and X+2) indicates that pre-stuttering phase build up continues in X location. The 'build down' starts and ends at X+1 location, because of an unexpectedly large difference in X+2 location. Furthermore, as it was indicated in Chapter III, the differences observed in locations X-2, X-1, X, X+1, dissipate through the course of adaptation. However, the difference in X+2 location persists through all five readings. This trend-breaking location within the candidate clause will be considered later in this chapter.

Thus, statistically significant pre-cursive and post-cursive effects in terms of durational changes are limited to

locations X-1 and X, and there is a stronger evidence for build up than build down of a stuttering event in the present data.

Is there any evidence for overall constraint on the duration of planned utterance? The answer to this question is in the negative, but with a significant reservation. It was suggested in the Introduction that an asymmetrical word durational change with reference to a stuttering event, would argue for an overall durational constraint on an utterance. Specifically, a strong support for overall durational constraint would involve a demonstration that significant durational increases preceding a stuttering event would be compensated for by significant durational decreases after it (or vice versa). The data do not seem to support this requirement. But what is the reservation against an unqualified negative answer? The reservation pertains to contribution of frequency and duration of pauses preceding and following a stuttering event in affecting the overall duration of an utterance. A specific pause distributional and durational analysis preceding and following a stuttering event was not undertaken in the present study. Hence, the reservation. Therefore, one can cautiously conclude that though the speech planning involves computation of fo contour over the clausal domain (Sorensen and Cooper 1980) by consideration of the general length of the upcoming clause (Paccia-Cooper and Cooper 1981), it does not involve a specification of the total duration of an utterance.

How do the present findings relate to other findings in the area of characteristics of fluent speech at the molar level of speech production? It is, in general, supportive of Knox's (1975) finding that words preceding a moment of stuttering are lengthened. Specific comparisons in terms of number of words affected by a stuttering event can not be made because Knox limited his analysis to the comparison between a stutterer and his control, without attempting to determine group trends. Falck et al's (1985) finding that mean fo was significantly lower in pre-stuttered utterances than their pre-fluent match, generally, accords with the present finding.

How do these findings relate to the anticipatory struggle hypothesis and breakdown under stress hypothesis? The evidence of 'build up' in X-2, X-1 locations preceding a stuttering event can be construed as supportive of the anticipatory struggle hypothesis. However, the data also suggest post-cursive changes in duration not predicted by the anticipatory struggle hypothesis. Those hypotheses--breakdown under stress--which suggest that a stuttering event is a perceptually discrete entity need to be broadened in the light of the present result. More specifically, these hypotheses must address the issue of lack of discreteness at the acoustic level of speech organization.

The results of ANOVA for locations Xp and Xf will be considered in some detail in the following paragraph. Xp location was characterized by a significant main effect for groups, insignificant main effect for readings, and insignifi-

cant group and reading interaction. On the other hand, Xf location was characterized by an insignificant main effect for group and readings and a significant group and reading interaction.

Among the seven locations sampled in the study, only Xp location exhibited significant main effect for group. It was suggested in Chapter III that stutterers may significantly exaggerate the clause final word lengthening--a normal feature of speech. This explanation was used to account for the persistent difference in duration between stutterers and fluent speakers in the X+2 location through the adaptation trends. Specifically, it was pointed out that four out of seven words in this location were in clause final positions, and were invariably followed by syntactic pauses. Therefore, following the explanation given for the durational difference in Xp location, it was suggested that the persistent difference in X+2 location could be attributed to the longer duration of these words.

The existing data provide an opportunity to test the hypothesis that clause final word lengthening is significantly exaggerated in stutterers. The clause final words in the stutterers' fluent set and fluent speakers' set (swim, circus, better, balanced) were examined using ANOVA by repeated measures. The average duration of words in these clause final locations was longer in stutterers than in non-stutterers ( $\bar{X}$  for stutterers, 488.50 msec;  $\bar{X}$  for fluent speakers, 431.12 msec) though they did not reach statistical significance (P

>.05). Thus, it seems that a significant durational difference in clause final position between stutterers and fluent speakers is limited to the stutterers' stuttered set and fluent speakers' set (I). What is the significance of this finding? A speculative answer to this question can be provided by the results of experiments conducted by Paccia-Cooper and Cooper (1981) on the influence of the general length of upcoming clause on the duration of the final word in the previous clause (see Introduction for an extended discussion of the experiment). Specifically, Paccia-Cooper and Cooper (1981) found that (1) clause final lengthening was affected by the length of the upcoming clause, (2) that there was a significant difference in clause final lengthening between long and short upcoming clauses, (3) the data seemed to support the hypothesis that greater clause final lengthening for long clauses afforded extra time for the speaker to plan long, as opposed to short, clauses. Based on this interpretation, one can argue that significantly longer duration of words in Xp location afforded extra time to plan an upcoming utterance which was longer than normal by virtue of it containing a stuttering event.

In other words, a stutterer 'factors in' the duration of a stuttering event while planning an utterance which is produced with a stuttering event. At this point, one must recall that a significant durational difference between the groups extends to other (R2 to R5) fluent readings. The result with this fluent subset (R2 to R5) contradicts the

results with completely fluent utterances discussed earlier, and seems to challenge the planning explanation given for utterances containing stuttering events. The explanation can be saved if one assumes that a stutterer while planning a (fluent) utterance (in readings 2 to 5) is influenced by the knowledge that he stuttered during the course of the earlier (first) reading and may stutter once again. In this connection, one must take note of the consistency effect (Johnson and Knott 1937; Neelley and Timmon 1967; Siedel et al 1973). It refers to a tendency on the part of stutterers to stutter on the same word in the course of repeated readings of a passage. According to Bloodstein (1981), on the whole, about 65 percent of a subject's stutterings in a given reading take place on words that were stuttered in the previous reading. Since the consistency effect is less than perfect, one may assume that a stutterer plans utterances (in readings 2 to 5) making an allowance for a stuttering event, which does not always materialize perceptually.

The significant interaction between group and readings in Xf location is due to the diverging trend of mean duration of words in stutterers and fluent speakers in R1, R2, R3 (Fig. 13). From R1 to R2, stutterers increase the mean duration of words whereas fluent speakers decrease it. From R2 to R3, stutterers decrease the mean duration of words whereas fluent speakers increase it. The reason for this significant interaction is not clear at the present time.

Discussion on locational analysis is not complete with-

out consideration of the variability of the duration of words in the sampled locations. Fluent speakers, generally, tended to be more variable in locations (X, X-1, X-2, X+2) within the candidate clauses than non-stutterers (see figures 2, 4, 6, 8, 10). On the other hand, stutterers were noticeably more variable than fluent speakers in locations (Xp, Xf) outside the candidate clause (see figures 12, 14). The difference in variability in each reading not only reflects the differences between the groups but also the differences in the inherent duration of the words in each location. An ANOVA, taking into account the duration of the word (short vs. long) may have further illuminated the results on variability noted earlier. Length of a word as a factor is suggested on an examination of Appendix F. The words in the locations Xp and Xf are considerably less variable in inherent duration than the words in X-2, X-1, X, X+1, X+2 locations. A three way analysis of variance (group X length X reading) implied by the discussion calls for more words in each location than is available in the present data.

#### B. Discussion of the Results on Total Articulation Time and Total Pause Time

The global variables total articulation time and total pause time decreased through the readings in stutterers' sets. This patently goes against the suggestion made in the Introduction that the fluency enhancement during adaptation is negatively correlated with the variables total articulation time and total pause time. To put it another way, instead of

an expected gradual increase in the duration of these variables, a decrease through the readings was found. At this point, consider some of the studies which have examined global variables in relation to fluency enhancement. Martin and Haroldson (1979) examined speech rate under four fluency enhancing conditions: response contingent stimulation, masking, DAF and rhythmic pacing. They did not find any significant change in speech rate with improved fluency in all these conditions. It has been suggested (Adams and Hutchinson 1974; Ingham and Packman 1979) that the unchanged speech rate may have been due to two opposing forces: (1) increased speech rate produced by a decrease in number of (time-consuming) stutterings, and (2) decreased speech rate engendered by these fluency enhancing conditions. To get a direct answer to this issue, measures of fluent speech, which excludes stuttering events, is most appropriate (Perkins et al 1979). In the present paper, stuttering events were deliberately excluded during calculation of total articulation and total pause time. This was the strategy followed by Andrews et al (1982) in their study of selected speech variables in relation to fluency enhancement. Andrews et al found that in those fluency enhancing conditions where greater than 90 percent of reduction in stuttering occurred (prolonged/DAF speech, singing, choral reading, shadowing, slowing, syllable-timed speech and response contingent stimulation) lengthened phonation time and slowing were predominant strategies. Phonation time, in their study, referred to the duration of speech bounded by

pauses of 250 msec or more. The result with phonation time suggests that frequency of pauses with duration greater than or equal to 250 msec decreased during the experimental segment of AB design. This also suggests that total pause time may have decreased, although they do not provide data on this variable. Slowed speech was achieved by lowering the articulation rate, increasing pause proportion (i.e. time spent in pauses, expressed as a proportion of total fluent speaking time).

Andrews et al's (1982) statement that lengthened phonation time and slowed speech are predominant strategies used in achieving fluency in these conditions represents an inferential leap. Their data, with some of the limitations noted (see Introduction) only suggest that reduced frequency of stuttering is correlated with the lengthened phonation time and slower speech rate. In the present study, the issue of whether the changes in selected variables are independent of the reduction in frequency of stuttering during adaptation, was tackled by tracking the course of these variables in totally fluent sets (stutterers' fluent set and fluent speakers' set II). As figures 20 and 24 make it abundantly clear, the course and extent of change in total articulation is remarkably similar in the two stutterers' sets. The same statement can be made with respect to total pause time, with some qualifications. The striking similarities in the course and extent of change in these variables becomes all the more important when one considers the fact that the two sets

involved a different set of clauses. Thus, it appears that fluency enhancement during adaptation is largely independent of changes in rate of speech, and suggests the possibility that both the changes in rate and frequency of stuttering are a function of a third (common) factor.

Consider the striking similarities in total articulation time function in stutterers' sets and the course of adaptation in these groups of stutterers (see Appendix D). Total articulation time exhibits significant reduction for R1 to R3, with a marked change from R1 to R2. This parallels the trend in Appendix D--a trend for frequency of stutterings to decrease markedly in the earlier readings of the adaptation trial. The tendency for frequency of stuttering to stabilize in the later readings is reflected in a reduced rate of change in the total articulation time through readings three, four and five. The extent of change (expressed in percent) from the first reading to the reading with the lowest total articulation time in the stutterers' two sets are remarkably similar. For stutterers' stuttered set (R1 minus R5) it is 16.42 percent, and for stutterers' fluent set (R1 minus R4) it is 16.78 percent.

How do stutterers compare with fluent speakers on total articulation time? Consider figures 20 and 24. Fluent speakers in both sets I and II reduce total articulation time gradually. In fluent speakers' set I the lowest total articulation time is attained in R4, whereas in fluent speakers' set II, the lowest total articulation time is attained in R3. The

extent of change (expressed in percent) from the first reading to the reading with lowest articulation score in fluent speaker sets I and II is 7.2 percent and 9.5 percent respectively. Thus, it is quite clear from the data that fluent speakers effect considerably less change in total articulation time than stutterers. Furthermore, stutterers tend to, but never equal the, total articulation time of the fluent speakers. What is the significance of this constraint? The constraint is intriguing when one considers the fact that it persists in spite of 'practice' or rehearsal the adaptation trials afford.

The parallel trend for the variable total articulation time established for the two groups in the totally fluent sets (SFS and FSSII) is 'disturbed' in the sets SSS and FSSI. An examination of figure 24 indicates the source of significant interaction between group and readings lies in the changes from R1 to R2, R2 to R3 and R4 to R5. The lack of parallelism between the two total articulation functions--an indication of interaction--is most prominent in changes from R1 to R2 and R4 to R5. The reason for lack of parallelism in the change from R4 to R5 seems to be the fact that the fluent speakers attain lowest total articulation time in reading four and then exhibit an upward trend. And the reason for lack of parallelism for the change from R1 to R2 seems to be the reduced rate of change from R1 to R2 in fluent speakers. More specifically, the percent of change from R1 to R2 is 9.8 percent and 8.80 percent for stutterers' stuttered set and stutterers' fluent

set II respectively. In contrast, the percentage change from R1 to R2 is 10.9 percent and 3.6 percent for fluent speakers' set II and fluent speakers' set I. Thus, it seems, the fluent speakers show more variability in the course of total articulation time than the stutterers in the two sets FSSI and II. This is even more evident when the groups are compared for total pause time. Figures 22 and 26 reveal that the course of total pause time in the fluent speakers through the readings is more variable than in the stutterers. What is the reason(s) for such a variable course of total pause time in fluent speakers? The answer relates to an unavoidable limitation of the present study. One fluent speaker (MX), who consistently used long pauses in major and minor constituent boundaries was overrepresented in FSSI, by virtue of his being a control match with a stutterer (CR). The subject (CR) provided a maximum number of stuttering events for the present study. The significant interaction for groups and readings for the variable total pause time in the stutterers' stuttered set and fluent speakers' set I, therefore, may not present a true picture. On the other hand, as all the fluent speakers were equally represented in the fluent speakers' set II, the course of variable total pause time in this set (Fig. 22) may be more representative of the normal trend. This would, then, lead to the conclusion that fluent speakers exhibit a gradual negative slope of total pause time through the readings.

The variability of total articulation time for stutterers and fluent speakers is generally comparable across the

readings (Figures 21 and 25). Fluent speakers are more variable than stutterers in total pause time, more so in stutterers' stuttered set vs. fluent speakers' set I comparisons (Fig. 27) than in stutterers' fluent set vs. fluent speakers' set II comparisons (Fig. 25). As pointed out earlier, this may be due to the subject MX's use of long pauses in various locations in the utterances through the readings.

General discussion. In the Introduction of this thesis four bases for the present study were recognized. They were (1) the extant literature in planning and production of speech, (2) literature on the characteristics of fluent speech of stutterers, (3) hypotheses on moments of stuttering, and (4) adaptation as a fluency enhancing condition. In the general discussion an attempt will be made to relate the results to these four bases.

The literature on planning and production of speech lends ample support to the notion of planning, that planning involves units of clausal length. That planning involves a consideration of the general length of an utterance in order to compute the fundamental frequency contour and other global features of an utterance, such as sentence stress, seems not only intuitively plausible but also has been experimentally supported (Paccia-Cooper and Cooper 1981; Sorensen and Cooper 1980). This observation prompted one of the hypotheses of the present study, namely, whether durational adjustments preceding and following a stuttering event would reflect on the

overall durational constraint on an utterance. Specifically, it was suggested that if planning involves specification of a duration of an utterance, then, a significant pre-cursive effect in terms of durational changes of a stuttering event must be compensated for by a significant post-cursive effect in terms of durational change. For example, significant increase in duration of a word preceding a stuttering event must be compensated for by a significant decrease after it. The data do not confirm the overall durational constraint hypothesis. In other words, though a speaker take into account the general length of an upcoming clause during the planning process, he does not specify the overall duration of an utterance. One can maintain that this is a partial disconfirmation of the hypothesis because this study did not involve comparisons of frequency and duration of pauses in the pre-stuttering phase with frequency and duration of pauses in the post-stuttering phase of an utterance. Pause, as we know, affects the overall duration of an utterance.

The significant clause-final word lengthening was limited to the stutterers' stuttered set. It was suggested that the extra time obtained by significant clause-final lengthening reflects the fact that the upcoming clause containing a stuttering event is longer than the normal. Stutterers, probably using a look-ahead mechanism (Henke 1966), may be aware of the impending problem during the production of the final word of the previous clause. This seems plausible because seven out of eight stuttering events in the sample

occurred in the very beginning of a clause--that is well within the scope of a look-ahead mechanism. The fact that stutterers' fluent productions (from readings two to five) were also accompanied by significant clause-final word lengthening can be accounted for by suggesting that a stutterer, having stuttered once, plans the succeeding fluent utterances with the knowledge and expectation that he may stutter once again. The lingering effect of a stuttering event on the duration of words in X-location in the second reading is an indication of such a planning activity.

The data show that a stuttering event affects fluent portions of speech preceding and following a stuttering event. The significant increase in the duration of words occupying the location immediately preceding a stuttering event, and progressive increase in the duration of words in the pre-stuttering phase supports the anticipatory-struggle hypotheses (Bloodstein 1984). The increase in the duration of a word in the immediate post-stuttering phase is not predicted by these hypotheses. It is generally clear from the data that perceptual discreteness of a stuttering event does not extend to the acoustic level of speech organization.

The scope of significant pre- and post-cursive effects of durational changes was severely limited. It would be interesting to find whether the scope of these effects changes with the severity rating of each stuttering. The severity rating of stutterers is known to affect the LRT effect (Watson and Alfonso 1983) and there is some suggestion of influence of

severity rating on duration of words in Knox's (1975) data. However, it must be noted that the severity rating of individual stuttering events may or may not correlate with the severity rating of a stutterer.

Adaptation trials are generally known to decrease the frequency of stuttering events across the readings. Based on the existing literature on the course of selected global speech variables (Martin and Haroldson 1979; Andrews et al 1982) it was posited that fluency enhancement during the adaptation trial is a function of increases in total articulation time and/or total pause time. The course of these variables did not support this expectation. Furthermore, it was established that changes in these variables are independent of changes in the frequency of stuttering.

The general discussion will be completed by considering some of the hypotheses in the literature on the phenomenon of adaptation. Wischner (1950), for example, considered the reduction in the frequency of stutterings (and by implication, the improved fluency) during adaptation trials similar to the experimental extinction of learned anxiety motivated responses. Eisenson (1958), posited that the repeated readings of a passage resulted in decrease in 'propositional' value of the read material engendering "an articulatory and vocal set that approaches the automatic." Whatever may be the putative cause for the reduction in the frequency of stutterings (extinction of learned anxiety, decrease in the propositional value of the read material), adaptation trials, in a prosaic

sense, represent rehearsal of the read material. The present data on the course of total articulation time and total pause time can be viewed as an analysis of the nature of improvement during the rehearsal of the read material. Thus, the stutterers seem to become generally adept at making smooth and quick coarticulatory adjustments by increasing the rate of segmental output and by decreasing the frequency and/or duration of pauses through the trials. These changes in speech output are accompanied by (and independent of) decrease in frequency of stutterings. One can conclude by suggesting that these rehearsal based changes in rate of speech output and frequency of stutterings have a common (yet undetermined) basis.

## CHAPTER V

### SUMMARY AND CONCLUSIONS

Two broad areas of concern of the present investigation can be recognized. The first broad area of concern relates to testing whether the perceptual discreteness of a moment of stuttering extends to other levels of speech organization. In other words, are there pre- and post-cursive effects in terms of durational changes, reference: stuttering events? In the present study, the acoustic level of speech production process was chosen for investigation. Within the first broad area of concern, an attempt was made to relate the moment of stuttering to what is generally considered to be a planning unit, namely a clause. Since stuttering events are timing disturbances, it was suggested that the possible adjustments in durations preceding and following a stuttering event may reflect on the overall constraint of the duration of utterances. The second broad area of concern relates to fluency enhancement during adaptation trials, and the question whether fluency enhancement is accompanied by, and related to, changes in total articulation time and total pause time.

Four adult stutterers matched with four fluent speakers for age, sex and educational and/or occupational background formed the subject sample for the study. An adaptation

paradigm was used to elicit stuttering events in an otherwise fluent utterance. Four sets of utterances were isolated for spectrographic analysis. They were: (1) stutterers' stuttered set (SSS), which comprised five utterances of eight clauses, the last word of the previous clause and the first word of the succeeding clause. The first reading of each clause contained a stuttering event. (2) Fluent speakers' set I (FSSI), which comprised of five fluent utterances of eight clauses in the stutterers' stuttered set, last word of the previous clause, first word of the succeeding clause by the matched normal speakers. (3) Stutterers' fluent set (SFS) which comprised five fluent utterances of two clauses, the last word of the previous clause and the first word of the succeeding clause by the stutterers. (4) Fluent speakers' set II (FSSII), which comprised five fluent utterances of the two clauses in SFS, the last word of the previous clause and the first word of the succeeding clause by the matched fluent speakers. The corpus was analyzed using the digital sonograph (Kay 7800). The spectrograms of these sets of utterances were segmented into words and pauses, and the duration of each word and pause was determined. The duration of words in five locations within a candidate clause ( $X-2$ ,  $X-1$ ,  $X$ ,  $X+1$ ,  $X+2$ ) and two locations outside it ( $X_p$ ,  $X_f$ ) in the stutterers' stuttered set and fluent speakers' set I were subjected to ANOVA by repeated measure to address the issues raised in the first broad area of concern. ANOVA by repeated measure for global variables, total articulation time, and total pause time for

the four sets of utterances were done to address the issues raised in the second broad area of concern.

The main conclusions from the study were that:

(1) there are pre- and post-cursive effects in terms of durational change in utterances containing a stuttering event. Statistically significant changes in duration are limited to the X-1 location in the pre-stuttering phase and X location in the post-stuttering phase. However, beyond this, there seems to be some evidence for a gradual build up of durational changes to a stuttering event and a gradual build down of durational changes away from it. The evidence for build up is the stronger of the two.

(2) The data did not, within its limited scope, support the idea that durational changes would reflect an overall durational constraint of an utterance. Specifically, there was no evidence of compensatory relation between durational changes preceding a stuttering event and durational changes following it.

(3) Significant clause final word lengthening was limited to the stutterers' stuttered set. It was suggested following Paccia-Cooper and Cooper (1981) that it may reflect extra planning time needed to plan (the lengthier) clause containing a stuttering event. Furthermore, it was suggested that once a stutterer stutters in an utterance, the planning of repeated fluent production of the same clause will be affected by the knowledge (or memory) that he stuttered.

(4) Stutterers were more variable durationally in

locations  $X_p$  and  $X_f$ . In contrast, fluent speakers were generally more variable in location  $X-2$ ,  $X-1$ ,  $X$ ,  $X+1$ ,  $X+2$ . An examination of the words in these various locations revealed that locations  $X_p$  and  $X_f$  were occupied by the words which were more homogenous--in terms of inherent duration--than the words in  $X-2$ ,  $X-1$ ,  $X$ ,  $X+1$ ,  $X+2$  locations. Hence, it was suggested that an ANOVA with a third factor, lengthen the word, may explain the differing pattern variability in the locations.

(5) The expectation that the reduction in frequency of stuttering through the adaptation trials would be correlated with increases in total articulation time and/or total pause time was not borne out. Indeed, the exact opposite was the case, that is, a decrease in total articulation time and total pause time through the readings was seen.

(6) The total articulation time function for the stutterers' stuttered set and stutterers' fluent set were strikingly similar. The total pause time function for the two stutterers' sets were similar with some qualifications. This data was used to conclude that the reduction in frequency of stuttering during adaptation trials was independent of changes in speech rate related variables--total articulation time and total pause time. Furthermore, it was suggested that adaptation of stuttering events, total articulation time, and total pause time reflect the effect of rehearsal.

In conclusion, it can be said that there are precursive and post-cursive effects of stuttering events in terms of durational change, that the changes do not reflect an over-

all durational constraint of an utterance. In addition, one may conclude that fluency enhancement during adaptation is accompanied by (and independent of) a decrease in speech rate related variables--total articulation time and total pause time.

**APPENDICES**

APPENDIX A

SUBJECTS' PARTICULARS

| <u>Stutterers</u>   | <u>Their Match</u>  |
|---|---|
| 1. (CR), 43 year old black man<br>High School education<br>Electronic technician by<br>by vocational training<br>Age of onset: childhood<br>Familial history: strongly<br>positive<br>Severity of stuttering:<br>moderate to severe according<br>to source of referral<br>Therapy history: several<br>different types of therapies<br>with moderate success | (MX), 40 year old black man<br>High School education<br>Electronic technician<br>by vocational training |
| 2. (JB), 22 year old white man<br>In 3rd year of College<br>Age of onset: 5 years<br>Familial history: father<br>and grandfather (paternal)<br>were stutterers<br>Severity of stuttering:<br>moderate to severe according<br>to source of referral<br>Therapy history: school<br>speech therapy for 6 years.<br>Has enrolled in Fluency<br>Shaping Program  | (TA), 23 year old white man<br>In 3rd year of College   |

## Subjects' Particulars (Cont'd.)

| <u>Stutterers</u>  | <u>Their Match</u>  |
|--|---|
| <p>3. (GT), 16 year old white boy<br/>11th grade student<br/>Age of onset: 5 or 6 years<br/>Familial history: mother is a stutterer<br/>Severity of stuttering: mild to moderate according to source of referral<br/>Therapy history: school speech therapy for 3 years, private speech therapy. Has enrolled in Fluency Shaping Program</p> | <p>(JJ), 16 year old white boy<br/>11th grade student</p> |
| <p>4. (KG), 25 year old white man<br/>Graduate<br/>Age of onset: childhood<br/>Severity of stuttering: moderate to severe according to source of referral</p>  | <p>(JO), 25 year old white man<br/>Graduate</p>           |

## APPENDIX B

A seal/ who lay basking on a smooth rock/ said to himself,/ all I ever do is swim./ None of the other seals can swim any better/ than I can,/ he reflected,/ but, on the other hand,/ they can swim just as well./ The more he pondered the monotony and uniformity of his life,/ the more depressed he became./ That night he swam away and joined a circus./

Within two years the seal had become a great balancer./ He could balance lamps, dollar cigars and anything else you gave him./ When he read in a book a reference to the Great Seal of the United States,/ he thought it meant him./ In the winter of his third year as a performer he went back to the large, smooth rock/ to visit his friends and family./ He gave them the big town stuff right away: the latest slang, liquor in the golden flask, gardenia in his lapel./ He balanced for them everything there was on the rock to balance,/ which was not much./ When he ran through his repertory,/ he asked the other seals/ if they could do/ what he had done/ and they all said no./ "Let me see you do something/ I can not do" he said./ Since the only thing they could do was swim,/ they all plunged off the rock into the sea./ The circus seal plunged right after them,/ but he was so hampered by his smart city clothes,/ (including a pair of seventeen-dollar shoes),/ that

he began to founder at once./ Since he had not been in swimming for three years,/ he forgot what to do with his flippers and tail,/ and he went down for the third time,/ before the other seals could reach him./ They gave him a simple but a dignified funeral./

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Once upon a time a crow fell in love with a Baltimore oriole./ He had seen her flying past his nest every spring on her way north and every autumn on her way south,/ and he had decided/ that she was a tasty dish./ He had observed/ that she came north every year with a different gentleman,/ but he paid no attention to the fact/ that all the gentlemen were Baltimore orioles./ "Anybody can have that mouse"/ he said to himself./ So he went to his wife and told her/ that he was in love with a Baltimore oriole/ who was cute as a cuff link./ He said he wanted a divorce,/ so his wife gave him one simply by opening the door and handing him his hat,/ "Do not come to me/ when she throws you down"/ she said./ "That fly-by-season has not got a brain in her head,/ She can not cook or sew./ Her upper register sounds/ like a streetcar taking a curve./ You can find out in any dictionary/ that the crow is the smartest and most capable of birds--or was/ till you became one."/ "You are simply a jealous woman"/ said the male crow./ He tossed her a few dollars./ "Here"/ he said,/ "go buy yourself some finery./ You look like the bottom of an old tea kettle."/ And off he went to look for the oriole./

This was in springtime/ and he met her coming north with an oriole/ he had never seen before./ The crow stopped the female Oriole and pleaded his cause/ or should we say cawed his plea?/ At any rate, he courted her in a harsh grating voice,/ which made her laugh merrily./ "You sound like a window shutter"/ she said,/ and she snapped her finger at him./ "I am bigger and stronger than your gentleman friend,"/ said the crow./ "I have a vocabulary larger than his./ All the orioles in the country could not even lift the corn I own./ I am a fine sentinel/ and my voice can be heard for miles in case of danger."/ "I do not see how that could interest anybody but another crow,"/ said the female oriole,/ and she laughed at him and flew on toward the north./ The male oriole tossed the crow some coins./ "Here"/ he said,/ "go buy yourself a blazer or something./ You look like the bottom of an old coffee pot."/

The crow flew back sadly to his nest,/ but his wife was not there./ He found a note pinned to the front door./ "I have gone away with Bert,"/ it read./ "You will find some arsenic in the medicine chest."/

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APPENDIX C

| <u>Candidate Clause</u>                                  | <u>Source</u>  | <u>Type and Duration of the Stuttering Event</u>   |
|--|----------------|--|
| 1. Crow/I have a vocabulary larger than his/All          | Stutterer (GT) | Prolongation of 'l' in the 'larger.' Duration of prolongation 950 milliseconds   |
| 2. A seal/who lay basking on a smooth rock/said          | Stutterer (GT) | Three repetitions of 'ba' in 'basking.' 'ba' (240 msec) - pause (160 msec), 'ba' (260 msec) - pause (210 msec), 'ba' (430 msec) Total duration of the stuttering event 1300 msec |
| 3. That/he began to founder at once/since                | Stutterer (KG) | Two repetitions (one prolonged) of the fricative /f/, in 'founder'<br>1 repetition - 100 msec<br>2 repetitions - 550 msec<br>Total duration of the stuttering event - 650 msec   |
| 4. A seal/who lay basking on a smooth rock/said          | Stutterer (KG) | 'Hardcontact' (prolongation of /ba/ in 'basking.' Duration of the low frequency voicing activity ("buzz") associated with the hard contact was 1980 msec                         |
| 5. Read/you will find some arsenic in the medicine chest | Stutterer (JB) | Single repetition of the word 'some' with prolongation of /s/. Total duration of the stuttering event - 320 msec   |
| 6. I own/I am a fine sentinel/and                        | Stutterer (CR) | Prolongation of /s/ in the word 'sentinel' of /s/. Total duration of prolongation - 150 msec   |

| <u>Candidate Clause</u>  | <u>Source</u>  | <u>Type and Duration of the Stuttering Event</u>    |
|--|----------------|---|
| 7. Come/you can find out in any dictionary/that  | Stutterer (CR) | Multiple repetitions of /i/ in the word 'in.'       |
|  |                | 1 repetition - 80 msec                              |
|  |                | pause - 80 msec                                     |
|  |                | 2 repetition - 60 msec                              |
|  |                | pause - 100 msec                                    |
|  |                | 3 repetition - 40 msec                              |
|  |                | pause - 120 msec                                    |
|  |                | 4 repetition - 120 msec                             |
|  |                | pause - 760 msec                                    |
|  |                | 5 repetition - 60 msec                              |
|  |                | pause - 60 msec                                     |
| 8. Oriole/He had seen her flying past her nest every spring on her way north and every autumn on her way south/and | Stutterer (CR) | Multiple repetitions of /a/ in the word 'and'       |
|  |                | 1 repetition - 60 msec                              |
|  |                | pause - 100 msec                                    |
|  |                | 2 repetition - 80 msec                              |
|  |                | pause - 100 msec                                    |
|  |                | 3 repetition - 100 msec                             |
|  |                | pause - 2,100 msec                                  |
|  |                | 4 repetition - 100 msec                             |
|  |                | pause - 2,000 msec                                  |
|  |                | 5 repetition - 60 msec                              |
|  |                | pause - 100 msec                                    |
| 6 repetition - 80 msec   |                |   |
| pause - 120 msec   |                |   |
| 7 repetition - 120 msec  |                |   |
|  |                | Total duration of the stuttering event - 2,060 msec |
|  |                | Total duration of the stuttering event - 5,120 msec |

The two selected clauses produced fluently by the eight speakers five times in succession were:

1. Swim/none of the other seals can swim any better/than I
2. Circus/Within two years the seal had become a great balancer/He

#### APPENDIX D

r = multiple repetitions of sounds and syllables

p = prolongations of sounds and syllables

rp = combination of repetitions and prolongations

cum = total number of stuttterings for each reading collapsed  
across categories r, p, rp

R1, R2, R3, R4, R5 = the five readings

| SUBJECTS: CR + JR + GT + KG |    |    |    |     |
|-----------------------------|----|----|----|-----|
|                             | r  | p  | rp | cum |
| R1                          | 23 | 11 | 1  | 35  |
| R2                          | 14 | 2  | 3  | 19  |
| R3                          | 7  | 2  | 1  | 10  |
| R4                          | 6  | 2  | 0  | 8   |
| R5                          | 6  | 5  | 1  | 12  |

| SUBJECT: CR |    |   |    |     |
|-------------|----|---|----|-----|
|             | r  | p | rp | cum |
| P1          | 18 | 5 | 1  | 24  |
| R2          | 14 | 0 | 2  | 16  |
| R3          | 7  | 1 | 0  | 8   |
| R4          | 5  | 2 | 0  | 7   |
| R5          | 6  | 2 | 1  | 9   |

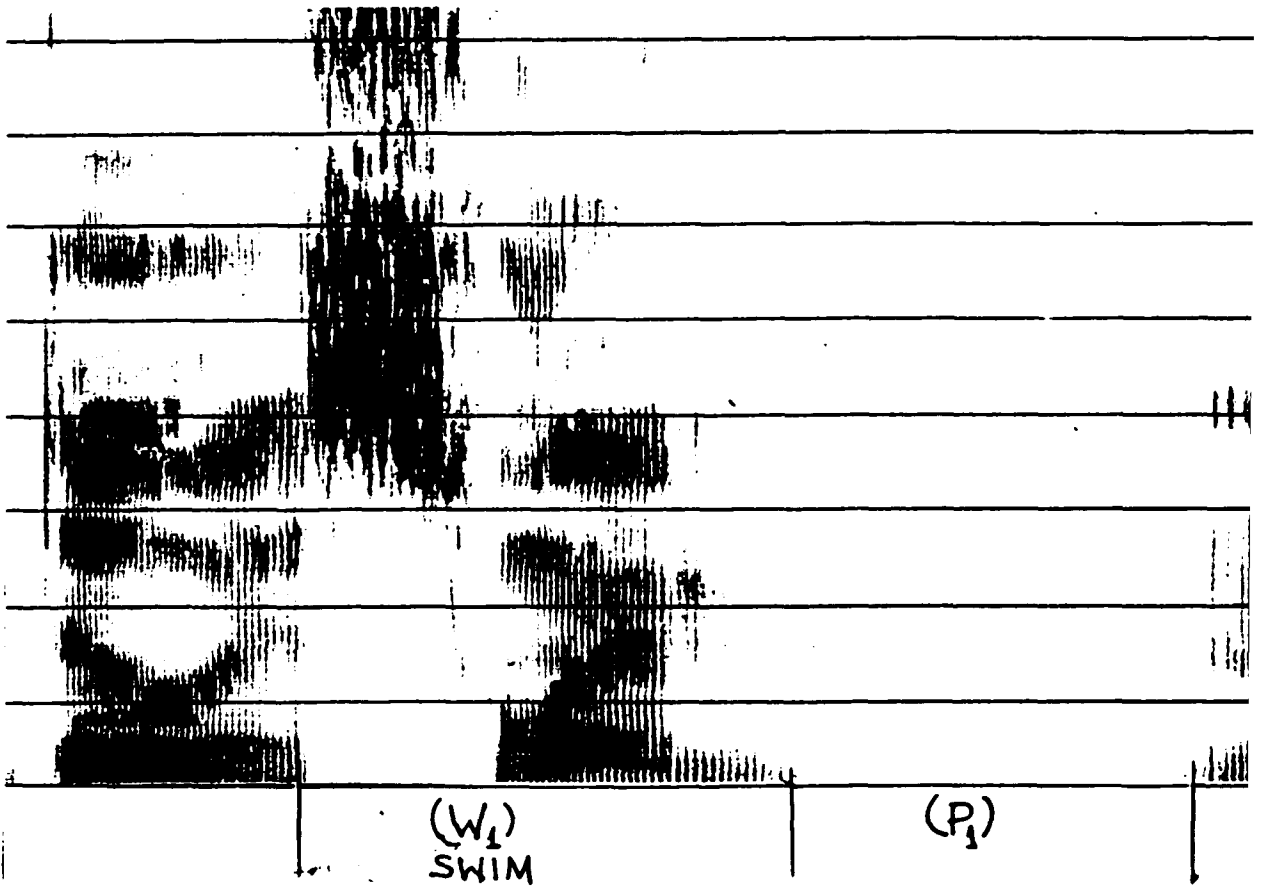
| SUBJECT: JB |   |   |    |     |
|-------------|---|---|----|-----|
|             | r | p | rp | cum |
| R1          | 4 | 0 | 0  | 4   |
| R2          | 0 | 1 | 1  | 2   |
| R3          | 0 | 0 | 0  | 0   |
| R4          | 1 | 0 | 0  | 1   |
| R5          | 0 | 3 | 0  | 3   |

| SUBJECT: GT |   |   |    |     |
|-------------|---|---|----|-----|
|             | r | p | rp | cum |
| R1          | 1 | 3 | 0  | 4   |
| R2          | 0 | 1 | 0  | 1   |
| R3          | 0 | 1 | 0  | 1   |
| R4          | 0 | 0 | 0  | 0   |
| R5          | 0 | 0 | 0  | 0   |

| SUBJECT: KG |   |   |    |     |
|-------------|---|---|----|-----|
|             | r | p | rp | cum |
| R1          | 0 | 3 | 0  | 3   |
| R2          | 0 | 0 | 0  | 0   |
| R3          | 0 | 0 | 0  | 0   |
| R4          | 0 | 0 | 0  | 0   |
| R5          | 0 | 0 | 0  | 0   |

## APPENDIX E

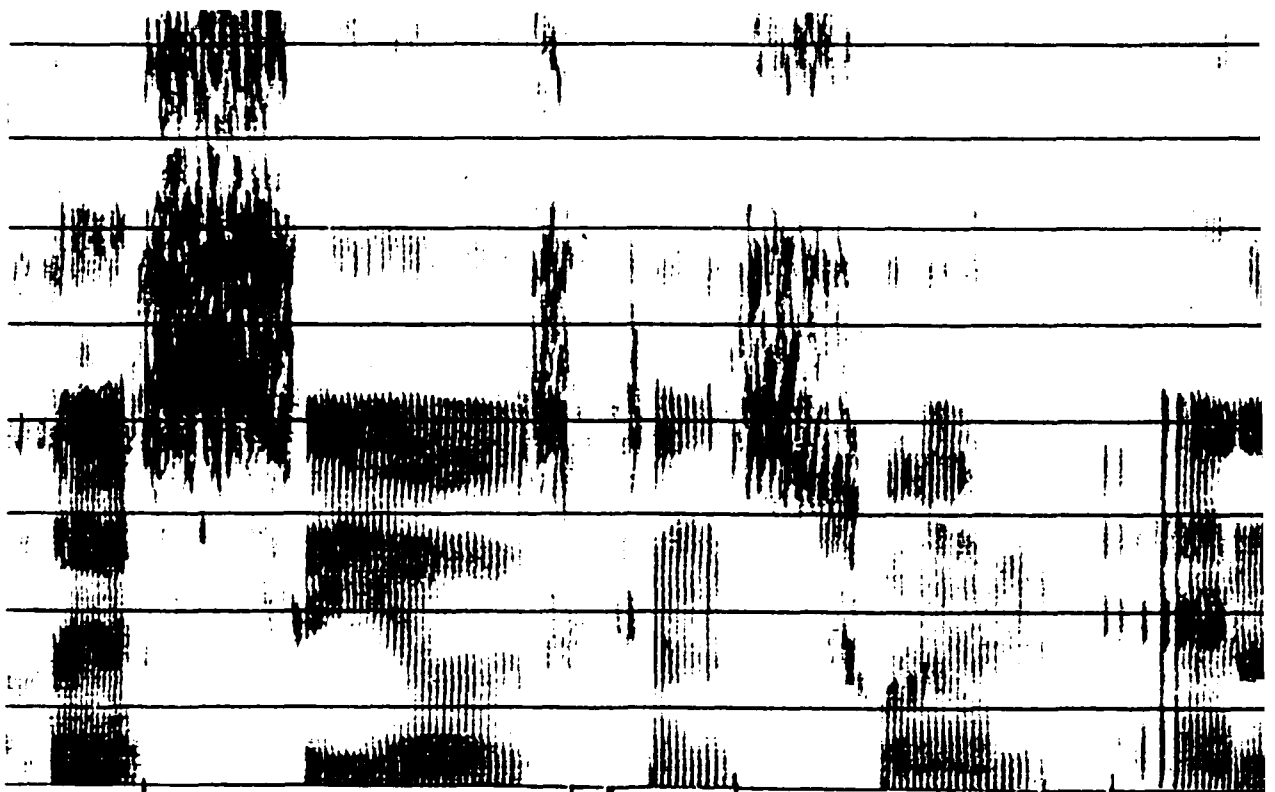
Note: Appendix E contains two broadband spectrograms of a single utterance of a candidate clause, the last word of the previous clause and first word of the secondary clause. The spectrograms were segmented into words (W) and pauses (P). Total articulation time was defined as the sum of the duration of words within the candidate clause ( $W2 + W3 + W4 + W5 + W6 + W7 + W8$ ). Total pause time was defined as the sum of the duration of pauses within the candidate clause and at its boundaries ( $P1 + P2 + P3 + P4 + P5$ ).











(W<sub>4</sub>)  
SEALS

(P<sub>2</sub>)

(W<sub>6</sub>)  
CAN

(W<sub>6</sub>)  
SWIM

(P<sub>3</sub>)

(W<sub>7</sub>)  
ANY



|                           |                   |                          |                   |                             |                   |                            |
|---------------------------|-------------------|--------------------------|-------------------|-----------------------------|-------------------|----------------------------|
| (W <sub>6</sub> )<br>SWIM | (P <sub>3</sub> ) | (W <sub>7</sub> )<br>ANY | (P <sub>4</sub> ) | (W <sub>8</sub> )<br>BETTER | (P <sub>5</sub> ) | (W <sub>9</sub> )<br>THANI |
|---------------------------|-------------------|--------------------------|-------------------|-----------------------------|-------------------|----------------------------|



APPENDIX F

| Xp     | <u>X-2</u> | <u>X-1</u> | <u>X</u> | <u>X+1</u> | <u>X+2</u>      | Xf    |
|--------|------------|------------|----------|------------|-----------------|-------|
| seal   | -          | who lay    | basking  | on a       | smooth          | said  |
| seal   | -          | who lay    | basking  | on a       | smooth          | said  |
| crow   | a          | vocabulary | larger   | than       | his             | All   |
| read   | You will   | find       | some     | arsenic    | in              | -     |
| that   | he began   | to         | founder  | at         | once            | since |
| I own  | a          | fine       | sentinel | -          | -               | and   |
| Oriole | on her way | north      | and      | every      | autumn          | and   |
| curve  | find       | out        | in       | any        | dic-<br>tionary | that  |

## APPENDIX G

A NOTE ON APPENDIX G: Every reading (R) is associated with two digits. The first digit stands for the subjects and the second for the reading number. Invariably, "1" stands for a stutterer and "2" for his fluent match. "W" stands for word and "P" for pause. Time for words and pauses is represented in milliseconds.

Sets: SFS/FSS II

Subjects: KG/JO

| Locations |                            |       |                            |    |             |   |                       |     |             |   |                  |   |                  |     |                            |     |     |    |                       |     |                                      |     |        |  |
|-----------|----------------------------|-------|----------------------------|----|-------------|---|-----------------------|-----|-------------|---|------------------|---|------------------|-----|----------------------------|-----|-----|----|-----------------------|-----|--------------------------------------|-----|--------|--|
| Utterance | W                          | P     | W                          | P  | W           | P | W                     | P   | W           | P | W                | P | W                | P   | W                          | P   | W   | P  | W                     | P   | W                                    | P   | W      |  |
|           | c<br>i<br>r<br>c<br>u<br>s |       | W<br>i<br>t<br>h<br>i<br>n |    | t<br>w<br>o |   | y<br>e<br>a<br>r<br>s |     | t<br>h<br>e |   | s<br>e<br>a<br>l |   | h<br>e<br>a<br>d |     | b<br>e<br>c<br>o<br>m<br>e |     | a   |    | g<br>r<br>e<br>a<br>t |     | b<br>a<br>l<br>a<br>n<br>c<br>e<br>r |     | H<br>e |  |
| R11       | 500                        | 1,080 | 390                        | 30 | 130         | 0 | 500                   | 110 | 70          | 0 | 310              | 0 | 220              | 0   | 470                        | 350 | 170 | 0  | 270                   | 610 | 590                                  | 800 | 90     |  |
| R12       | 580                        | 810   | 320                        | 20 | 140         | 0 | 480                   | 80  | 50          | 0 | 310              | 0 | 290              | 80  | 240                        | 0   | 110 | 20 | 290                   | 200 | 610                                  | 520 | 70     |  |
| R13       | 600                        | 1,720 | 370                        | 40 | 160         | 0 | 430                   | 30  | 40          | 0 | 300              | 0 | 150              | 40  | 300                        | 0   | 100 | 40 | 260                   | 120 | 580                                  | 250 | 70     |  |
| R14       | 520                        | 1,080 | 310                        | 30 | 140         | 0 | 410                   | 20  | 80          | 0 | 240              | 0 | 120              | 60  | 290                        | 0   | 70  | 60 | 240                   | 150 | 550                                  | 360 | 60     |  |
| R15       | 600                        | 950   | 290                        | 20 | 160         | 0 | 450                   | 0   | 60          | 0 | 260              | 0 | 140              | 40  | 380                        | 0   | 70  | 80 | 290                   | 330 | 610                                  | 710 | 60     |  |
| R21       | 670                        | 1,000 | 250                        | 60 | 180         | 0 | 520                   | 90  | 50          | 0 | 350              | 0 | 120              | 110 | 300                        | 60  | 40  | 60 | 170                   | 130 | 500                                  | 670 | 70     |  |
| R22       | 570                        | 1,090 | 220                        | 40 | 140         | 0 | 380                   | 70  | 40          | 0 | 290              | 0 | 110              | 80  | 270                        | 0   | 80  | 20 | 160                   | 100 | 480                                  | 740 | 50     |  |
| R23       | 590                        | 1,020 | 180                        | 60 | 130         | 0 | 420                   | 0   | 40          | 0 | 270              | 0 | 130              | 70  | 270                        | 0   | 50  | 50 | 170                   | 110 | 480                                  | 700 | 80     |  |
| R24       | 630                        | 1,090 | 170                        | 50 | 180         | 0 | 400                   | 50  | 50          | 0 | 360              | 0 | 130              | 100 | 270                        | 0   | 50  | 50 | 150                   | 110 | 450                                  | 800 | 50     |  |
| R25       | 610                        | 1,040 | 220                        | 50 | 140         | 0 | 430                   | 50  | 40          | 0 | 310              | 0 | 120              | 80  | 300                        | 0   | 40  | 60 | 150                   | 90  | 500                                  | 620 | 60     |  |

Sets: SFS/FSS II

Subjects: CR/MX

| Locations |                            |       |                            |    |             |   |                       |     |             |   |                  |   |                  |     |                            |       |     |     |                       |       |                                      |       |        |  |
|-----------|----------------------------|-------|----------------------------|----|-------------|---|-----------------------|-----|-------------|---|------------------|---|------------------|-----|----------------------------|-------|-----|-----|-----------------------|-------|--------------------------------------|-------|--------|--|
| Utterance | W                          | P     | W                          | P  | W           | P | W                     | P   | W           | P | W                | P | W                | P   | W                          | P     | W   | P   | W                     | P     | W                                    | P     | W      |  |
|           | c<br>i<br>r<br>c<br>u<br>s |       | W<br>i<br>t<br>h<br>i<br>n |    | t<br>w<br>o |   | y<br>e<br>a<br>r<br>s |     | t<br>h<br>e |   | s<br>e<br>a<br>l |   | h<br>e<br>a<br>d |     | b<br>e<br>c<br>o<br>m<br>e |       | a   |     | g<br>r<br>e<br>a<br>t |       | b<br>e<br>l<br>i<br>e<br>v<br>e<br>r |       | H<br>e |  |
| R11       | 570                        | 2,280 | 340                        | 60 | 150         | 0 | 450                   | 100 | 90          | 0 | 520              | 0 | 210              | 80  | 440                        | 360   | 70  | 80  | 290                   | 240   | 500                                  | 1,910 | 160    |  |
| R12       | 550                        | 740   | 280                        | 60 | 120         | 0 | 530                   | 710 | 80          | 0 | 320              | 0 | 150              | 70  | 400                        | 0     | 70  | 50  | 200                   | 110   | 500                                  | 1,080 | 80     |  |
| R13       | 540                        | 820   | 290                        | 70 | 140         | 0 | 480                   | 80  | 80          | 0 | 330              | 0 | 170              | 80  | 390                        | 0     | 110 | 50  | 210                   | 100   | 480                                  | 1,050 | 110    |  |
| R14       | 630                        | 250   | 320                        | 80 | 110         | 0 | 420                   | 120 | 90          | 0 | 290              | 0 | 150              | 70  | 310                        | 0     | 50  | 40  | 180                   | 100   | 440                                  | 660   | 60     |  |
| R15       | 540                        | 670   | 310                        | 40 | 120         | 0 | 430                   | 70  | 110         | 0 | 310              | 0 | 170              | 70  | 310                        | 0     | 110 | 70  | 250                   | 590   | 510                                  | 660   | 40     |  |
| R21       | 520                        | 1,050 | 330                        | 60 | 140         | 0 | 600                   | 550 | 70          | 0 | 380              | 0 | 200              | 110 | 470                        | 110   | 60  | 130 | 160                   | 1,590 | 500                                  | 1,570 | 100    |  |
| R22       | 600                        | 1,160 | 330                        | 70 | 140         | 0 | 590                   | 700 | 50          | 0 | 320              | 0 | 170              | 130 | 480                        | 920   | 60  | 90  | 170                   | 150   | 450                                  | 820   | 70     |  |
| R23       | 530                        | 1,720 | 330                        | 70 | 170         | 0 | 680                   | 440 | 60          | 0 | 330              | 0 | 170              | 0   | 400                        | 0     | 70  | 90  | 160                   | 110   | 470                                  | 1,700 | 120    |  |
| R24       | 590                        | 2,400 | 330                        | 70 | 180         | 0 | 600                   | 520 | 70          | 0 | 310              | 0 | 180              | 120 | 490                        | 50    | 70  | 120 | 140                   | 140   | 400                                  | 1,110 | 80     |  |
| R25       | 570                        | 1,330 | 310                        | 80 | 160         | 0 | 640                   | 420 | 60          | 0 | 300              | 0 | 160              | 120 | 520                        | 1,310 | 70  | 130 | 170                   | 150   | 480                                  | 790   | 90     |  |

Sets: SFS/FSS 11

Subjects: GT/JJ

| Locations |                            |       |     |                            |     |             |     |                       |     |             |     |                  |     |                  |     |                            |     |     |     |                       |     |                                      |    |        |
|-----------|----------------------------|-------|-----|----------------------------|-----|-------------|-----|-----------------------|-----|-------------|-----|------------------|-----|------------------|-----|----------------------------|-----|-----|-----|-----------------------|-----|--------------------------------------|----|--------|
| Utterance | W                          | P     | W   | P                          | W   | P           | W   | P                     | W   | P           | W   | P                | W   | P                | W   | P                          | W   | P   | W   | P                     | W   | P                                    | W  |        |
|           | c<br>i<br>r<br>c<br>u<br>s |       |     | W<br>i<br>t<br>h<br>i<br>n |     | t<br>w<br>o |     | y<br>e<br>a<br>r<br>s |     | t<br>h<br>e |     | s<br>e<br>a<br>l |     | h<br>e<br>a<br>d |     | b<br>e<br>c<br>o<br>m<br>e |     | a   |     | g<br>r<br>e<br>a<br>t |     | b<br>a<br>l<br>a<br>n<br>c<br>e<br>r |    | H<br>e |
| R11       | 680                        | 150   | 360 | 100                        | 190 | 0           | 430 | 0                     | 80  | 0           | 380 | 550              | 170 | 0                | 340 | 0                          | 30  | 100 | 220 | 380                   | 690 | 690                                  | 70 |        |
| R12       | 620                        | 510   | 280 | 80                         | 220 | 0           | 400 | 0                     | 50  | 0           | 360 | 0                | 120 | 110              | 300 | 0                          | 60  | 130 | 160 | 170                   | 600 | 530                                  | 80 |        |
| R13       | 700                        | 710   | 330 | 120                        | 210 | 0           | 400 | 30                    | 60  | 0           | 350 | 0                | 150 | 100              | 340 | 0                          | 80  | 50  | 180 | 200                   | 680 | 70                                   | 80 |        |
| R14       | 680                        | 1,520 | 400 | 90                         | 220 | 0           | 670 | 170                   | 50  | 0           | 410 | 0                | 200 | 80               | 340 | 0                          | 100 | 70  | 190 | 180                   | 700 | 730                                  | 60 |        |
| R15       | 650                        | 690   | 320 | 100                        | 210 | 0           | 550 | 0                     | 100 | 0           | 390 | 0                | 200 | 110              | 340 | 0                          | 100 | 70  | 200 | 230                   | 640 | 840                                  | 60 |        |
| R21       | 680                        | 400   | 230 | 20                         | 170 | 0           | 300 | 0                     | 60  | 0           | 240 | 0                | 140 | 50               | 310 | 0                          | 80  | 50  | 150 | 100                   | 530 | 240                                  | 40 |        |
| R22       | 680                        | 590   | 250 | 0                          | 180 | 0           | 270 | 0                     | 50  | 0           | 210 | 0                | 120 | 70               | 330 | 0                          | 80  | 50  | 150 | 110                   | 530 | 130                                  | 50 |        |
| R23       | 620                        | 100   | 250 | 30                         | 150 | 0           | 310 | 0                     | 50  | 0           | 180 | 0                | 90  | 70               | 290 | 0                          | 70  | 70  | 140 | 100                   | 460 | 470                                  | 50 |        |
| R24       | 520                        | 80    | 230 | 40                         | 150 | 0           | 330 | 0                     | 50  | 0           | 250 | 0                | 90  | 80               | 310 | 0                          | 70  | 50  | 140 | 110                   | 450 | 370                                  | 30 |        |
| R25       | 540                        | 90    | 240 | 60                         | 140 | 0           | 280 | 0                     | 70  | 0           | 180 | 0                | 80  | 50               | 270 | 0                          | 70  | 50  | 150 | 90                    | 440 | 410                                  | 40 |        |

Sets: SFS/FSS II

Subjects: JB/TA

| Locations |                            |       |                            |     |             |   |                  |     |             |   |                  |     |                  |     |                       |     |     |     |                       |     |   |       |        |
|-----------|----------------------------|-------|----------------------------|-----|-------------|---|------------------|-----|-------------|---|------------------|-----|------------------|-----|-----------------------|-----|-----|-----|-----------------------|-----|---|-------|--------|
| Utterance | W                          | P     | W                          | P   | W           | P | W                | P   | W           | P | W                | P   | W                | P   | W                     | P   | W   | P   | W                     | P   | W   | P     | W      |
|           | c<br>i<br>r<br>c<br>u<br>s |       | W<br>i<br>t<br>t<br>i<br>n |     | o<br>n<br>t |   | e<br>r<br>e<br>e |     | e<br>r<br>t |   | s<br>e<br>e<br>l |     | h<br>e<br>a<br>d |     | b<br>e<br>c<br>e<br>e |     | a   |     | g<br>r<br>e<br>e<br>t |     | b<br>e<br>l<br>l<br>e<br>n<br>c<br>e<br>r |       | H<br>e |
| R11       | 680                        | 1,610 | 520                        | 140 | 240         | 0 | 680              | 120 | 100         | 0 | 470              | 130 | 160              | 80  | 400                   | 570 | 220 | 60  | 320                   | 260 | 800                                       | 960   | 90     |
| R12       | 710                        | 1,570 | 430                        | 70  | 260         | 0 | 660              | 170 | 70          | 0 | 460              | 80  | 120              | 90  | 420                   | 360 | 110 | 80  | 270                   | 260 | 550                                       | 630   | 70     |
| R13       | 680                        | 1,590 | 320                        | 70  | 220         | 0 | 570              | 100 | 80          | 0 | 420              | 0   | 140              | 100 | 400                   | 360 | 90  | 90  | 240                   | 230 | 600                                       | 450   | 50     |
| R14       | 700                        | 1,740 | 360                        | 50  | 170         | 0 | 430              | 0   | 70          | 0 | 340              | 0   | 120              | 100 | 340                   | 80  | 150 | 80  | 210                   | 190 | 530                                       | 600   | 70     |
| R15       | 630                        | 1,780 | 380                        | 50  | 220         | 0 | 590              | 180 | 70          | 0 | 350              | 0   | 120              | 90  | 350                   | 380 | 90  | 120 | 220                   | 350 | 590                                       | 650   | 60     |
| R21       | 600                        | 1,220 | 460                        | 90  | 180         | 0 | 470              | 0   | 60          | 0 | 330              | 0   | 120              | 120 | 470                   | 280 | 90  | 30  | 250                   | 170 | 540                                       | 670   | 60     |
| R22       | 660                        | 1,290 | 330                        | 0   | 180         | 0 | 500              | 90  | 90          | 0 | 390              | 0   | 150              | 100 | 330                   | 0   | 50  | 60  | 180                   | 150 | 520                                       | 640   | 50     |
| R23       | 670                        | 1,460 | 320                        | 40  | 180         | 0 | 370              | 0   | 80          | 0 | 310              | 0   | 160              | 90  | 390                   | 0   | 80  | 70  | 220                   | 150 | 550                                       | 820   | 50     |
| R24       | 670                        | 1,140 | 320                        | 50  | 170         | 0 | 640              | 340 | 60          | 0 | 340              | 0   | 150              | 110 | 340                   | 0   | 50  | 100 | 220                   | 180 | 580                                       | 740   | 50     |
| R25       | 690                        | 1,280 | 320                        | 60  | 170         | 0 | 490              | 70  | 80          | 0 | 410              | 0   | 150              | 110 | 350                   | 150 | 50  | 90  | 200                   | 170 | 570                                       | 1,100 | 70     |

Sets: SFS/FSS II

Subjects: GT/JJ

| Locations |      |     |         |   |           |       |       |     |     |    |      |     |     |     |           |    |        |
|-----------|------|-----|---------|---|-----------|-------|-------|-----|-----|----|------|-----|-----|-----|-----------|----|--------|
| Utterance | W    | P   | W       | P | W         | P     | W     | P   | W   | P  | W    | P   | W   | P   | W         | P  | W      |
|           | swim |     | None of |   | the other |       | seals |     | can |    | swim |     | any |     | net to be |    | than I |
| R11       | 510  | 70  | 550     | 0 | 330       | 0     | 520   | 460 | 180 | 0  | 320  | 20  | 270 | 90  | 230       | 80 | 320    |
| R12       | 650  | 200 | 620     | 0 | 500       | 220   | 580   | 50  | 130 | 30 | 330  | 0   | 200 | 100 | 250       | 70 | 320    |
| R13       | 610  | 220 | 420     | 0 | 450       | 90    | 520   | 50  | 130 | 0  | 480  | 180 | 200 | 130 | 240       | 80 | 310    |
| R14       | 640  | 440 | 380     | 0 | 420       | 1,360 | 690   | 230 | 140 | 0  | 320  | 0   | 210 | 120 | 290       | 60 | 350    |
| R15       | 530  | 380 | 430     | 0 | 310       | 0     | 460   | 70  | 150 | 0  | 440  | 370 | 220 | 100 | 230       | 70 | 310    |
| R21       | 400  | 520 | 260     | 0 | 230       | 0     | 300   | 30  | 130 | 0  | 240  | 190 | 170 | 70  | 180       | 50 | 240    |
| R22       | 380  | 540 | 280     | 0 | 270       | 0     | 250   | 40  | 130 | 0  | 250  | 0   | 200 | 70  | 160       | 0  | 270    |
| R23       | 360  | 430 | 260     | 0 | 280       | 0     | 330   | 30  | 140 | 0  | 240  | 0   | 150 | 70  | 160       | 0  | 280    |
| R24       | 390  | 390 | 220     | 0 | 270       | 0     | 260   | 50  | 130 | 0  | 200  | 80  | 180 | 70  | 180       | 40 | 250    |
| R25       | 420  | 380 | 240     | 0 | 260       | 90    | 250   | 50  | 120 | 0  | 230  | 0   | 160 | 60  | 230       | 30 | 260    |

Sets: SFS/FSS II

Subjects: CR/MX

| Locations |      |       |            |     |              |    |      |     |     |    |      |     |     |     |        |     |           |
|-----------|------|-------|------------|-----|--------------|----|------|-----|-----|----|------|-----|-----|-----|--------|-----|-----------|
| Utterance | W    | P     | W          | P   | W            | P  | W    | P   | W   | P  | W    | P   | W   | P   | W      | P   | W         |
|           | swim |       | non<br>for |     | repto<br>eet |    | seel |     | can |    | swim |     | any |     | better |     | teet<br>I |
| R11       | 370  | 1,160 | 400        | 0   | 380          | 0  | 620  | 260 | 180 | 0  | 400  | 500 | 230 | 100 | 330    | 430 | 310       |
| R12       | 410  | 1,120 | 330        | 0   | 360          | 0  | 460  | 80  | 180 | 0  | 390  | 60  | 200 | 90  | 330    | 330 | 320       |
| R13       | 360  | 960   | 300        | 0   | 320          | 0  | 420  | 60  | 150 | 30 | 380  | 40  | 170 | 90  | 310    | 110 | 290       |
| R14       | 440  | 660   | 310        | 0   | 320          | 0  | 440  | 80  | 160 | 0  | 320  | 0   | 220 | 100 | 210    | 90  | 250       |
| R15       | 400  | 810   | 320        | 0   | 320          | 0  | 410  | 60  | 160 | 30 | 400  | 160 | 160 | 90  | 250    | 60  | 280       |
| R21       | 330  | 1,430 | 420        | 0   | 320          | 0  | 620  | 300 | 160 | 30 | 400  | 80  | 200 | 100 | 170    | 0   | 320       |
| R22       | 320  | 1,620 | 350        | 0   | 310          | 0  | 630  | 200 | 160 | 0  | 410  | 240 | 180 | 110 | 180    | 50  | 250       |
| R23       | 350  | 1,330 | 460        | 110 | 280          | 50 | 490  | 80  | 130 | 0  | 380  | 530 | 170 | 100 | 170    | 60  | 280       |
| R24       | 320  | 1,160 | 360        | 0   | 270          | 0  | 500  | 60  | 110 | 20 | 380  | 80  | 170 | 110 | 160    | 40  | 240       |
| R25       | 420  | 1,080 | 340        | 80  | 280          | 60 | 490  | 60  | 130 | 0  | 480  | 90  | 190 | 120 | 180    | 40  | 270       |

Sets: SFS/FSS II

Subjects: KG/JO

| Locations |     |                  |     |                            |     |                                      |     |                       |     |             |     |                  |     |             |     |                            |     |
|-----------|-----|------------------|-----|----------------------------|-----|--------------------------------------|-----|-----------------------|-----|-------------|-----|------------------|-----|-------------|-----|----------------------------|-----|
| Utterance | W   | P                | W   | P                          | W   | P                                    | W   | P                     | W   | P           | W   | P                | W   | P           | W   | P                          | W   |
|           |     | s<br>w<br>i<br>m |     | N<br>o<br>n<br>e<br>o<br>f |     | t<br>h<br>e<br>o<br>t<br>h<br>e<br>r |     | s<br>e<br>e<br>l<br>s |     | c<br>a<br>n |     | s<br>w<br>i<br>m |     | a<br>n<br>y |     | b<br>e<br>t<br>t<br>e<br>r |     |
| R11       | 530 | 890              | 300 | 0                          | 350 | 0                                    | 620 | 90                    | 180 | 0           | 540 | 210              | 310 | 400         | 320 | 240                        | 250 |
| R12       | 450 | 1,280            | 240 | 0                          | 310 | 0                                    | 470 | 60                    | 150 | 0           | 400 | 0                | 180 | 90          | 210 | 70                         | 310 |
| R13       | 490 | 690              | 250 | 0                          | 270 | 0                                    | 390 | 50                    | 130 | 0           | 360 | 0                | 170 | 90          | 170 | 60                         | 270 |
| R14       | 360 | 1,540            | 240 | 0                          | 290 | 0                                    | 410 | 50                    | 140 | 0           | 270 | 0                | 160 | 80          | 170 | 50                         | 280 |
| R15       | 470 | 360              | 190 | 0                          | 250 | 0                                    | 350 | 40                    | 140 | 0           | 330 | 0                | 160 | 90          | 170 | 50                         | 260 |
| R21       | 420 | 1,030            | 330 | 0                          | 350 | 0                                    | 650 | 190                   | 140 | 0           | 340 | 70               | 180 | 90          | 240 | 0                          | 270 |
| R22       | 420 | 980              | 220 | 0                          | 330 | 40                                   | 420 | 50                    | 100 | 0           | 310 | 0                | 170 | 100         | 210 | 50                         | 250 |
| R23       | 430 | 900              | 240 | 0                          | 320 | 40                                   | 430 | 40                    | 100 | 0           | 280 | 0                | 180 | 100         | 180 | 60                         | 240 |
| R24       | 380 | 990              | 230 | 0                          | 310 | 0                                    | 410 | 80                    | 150 | 0           | 300 | 60               | 160 | 100         | 210 | 0                          | 290 |
| R25       | 390 | 990              | 230 | 0                          | 350 | 0                                    | 420 | 50                    | 100 | 0           | 320 | 0                | 180 | 110         | 200 | 70                         | 240 |

Sets: SSS/FSS II

Subjects: JB/TA

| Locations |      |       |         |    |           |     |       |     |     |   |      |     |     |     |        |     |        |
|-----------|------|-------|---------|----|-----------|-----|-------|-----|-----|---|------|-----|-----|-----|--------|-----|--------|
| Utterance | W    | P     | W       | P  | W         | P   | W     | P   | W   | P | W    | P   | W   | P   | W      | P   | W      |
|           | swim |       | None of |    | the other |     | seals |     | can |   | swim |     | any |     | better |     | than I |
| R11       | 550  | 970   | 460     | 70 | 410       | 90  | 560   | 90  | 170 | 0 | 440  | 460 | 300 | 160 | 300    | 170 | 350    |
| R12       | 450  | 780   | 520     | 0  | 390       | 100 | 510   | 50  | 180 | 0 | 430  | 370 | 310 | 150 | 300    | 70  | 430    |
| R13       | 490  | 570   | 510     | 0  | 400       | 0   | 560   | 300 | 210 | 0 | 430  | 330 | 220 | 90  | 350    | 90  | 290    |
| R14       | 510  | 420   | 480     | 0  | 360       | 0   | 460   | 30  | 130 | 0 | 320  | 70  | 270 | 130 | 290    | 70  | 300    |
| R15       | 470  | 520   | 460     | 0  | 420       | 0   | 480   | 50  | 150 | 0 | 350  | 360 | 240 | 140 | 330    | 90  | 300    |
| R21       | 510  | 820   | 360     | 0  | 350       | 40  | 500   | 60  | 180 | 0 | 390  | 0   | 210 | 90  | 310    | 280 | 270    |
| R22       | 480  | 1,260 | 370     | 0  | 330       | 0   | 390   | 60  | 170 | 0 | 410  | 0   | 180 | 90  | 240    | 40  | 320    |
| R23       | 550  | 930   | 330     | 0  | 350       | 0   | 450   | 60  | 150 | 0 | 400  | 0   | 170 | 80  | 250    | 50  | 310    |
| R24       | 520  | 780   | 380     | 0  | 360       | 0   | 440   | 60  | 160 | 0 | 440  | 0   | 220 | 100 | 230    | 40  | 320    |
| R25       | 520  | 1,030 | 300     | 0  | 350       | 0   | 440   | 60  | 170 | 0 | 450  | 0   | 200 | 100 | 250    | 60  | 310    |

Sets: SSS/FSS I

Subjects: GT/JJ

| Locations | Xp   |       | X-1    |     | X       |     | X+1 |   | X+2    |    | X+3  |     | Xf   |
|-----------|------|-------|--------|-----|---------|-----|-----|---|--------|----|------|-----|------|
| Utterance | W    | P     | W      | P   | W       | P   | W   | P | W      | P  | W    | P   | W    |
|           | seal |       | Wholey |     | basking |     | ona |   | smooth |    | rock |     | said |
| R11       | 530  | 1,070 | 520    | 0   | 500     | 430 | 230 | 0 | 520    | 50 | 280  | 0   | 300  |
| R12       | 470  | 0     | 380    | 0   | 650     | 0   | 220 | 0 | 540    | 40 | 300  | 90  | 240  |
| R13       | 500  | 0     | 380    | 130 | 520     | 320 | 180 | 0 | 520    | 0  | 300  | 100 | 260  |
| R14       | 570  | 0     | 350    | 0   | 490     | 110 | 220 | 0 | 400    | 50 | 300  | 0   | 240  |
| R15       | 490  | 0     | 370    | 110 | 490     | 0   | 210 | 0 | 490    | 0  | 270  | 0   | 230  |
| R21       | 330  | 0     | 370    | 70  | 440     | 0   | 160 | 0 | 290    | 0  | 300  | 0   | 150  |
| R22       | 260  | 0     | 290    | 60  | 390     | 0   | 130 | 0 | 330    | 0  | 220  | 0   | 130  |
| R23       | 240  | 60    | 250    | 60  | 410     | 0   | 190 | 0 | 320    | 40 | 210  | 0   | 160  |
| R24       | 280  | 0     | 260    | 90  | 410     | 0   | 120 | 0 | 340    | 0  | 220  | 0   | 170  |
| R25       | 380  | 0     | 260    | 80  | 380     | 0   | 150 | 0 | 250    | 40 | 290  | 0   | 150  |

Sets: SSS/FSS I

Subjects: KG/JO

| Locations | Xp               |     | X-1                        |     | X                               |     | X+1         |   | X+2                   |     | X+3              |     | Xr               |
|-----------|------------------|-----|----------------------------|-----|---------------------------------|-----|-------------|---|-----------------------|-----|------------------|-----|------------------|
| Utterance | W                | P   | W                          | P   | W                               | P   | W           | P | W                     | P   | W                | P   | W                |
|           | e<br>e<br>e<br>l |     | W<br>h<br>o<br>l<br>e<br>y |     | b<br>e<br>a<br>k<br>i<br>n<br>g |     | o<br>n<br>e |   | h<br>o<br>o<br>m<br>e |     | k<br>n<br>o<br>w |     | s<br>a<br>i<br>d |
| R11       | 630              | 150 | 610                        | 0   | 560                             | 300 | 170         | 0 | 540                   | 520 | 420              | 580 | 260              |
| R12       | 490              | 170 | 450                        | 60  | 490                             | 0   | 250         | 0 | 430                   | 0   | 340              | 130 | 300              |
| R13       | 440              | 60  | 320                        | 50  | 420                             | 0   | 210         | 0 | 410                   | 0   | 260              | 70  | 270              |
| R14       | 390              | 0   | 350                        | 80  | 430                             | 0   | 200         | 0 | 410                   | 0   | 230              | 60  | 210              |
| R15       | 450              | 90  | 410                        | 680 | 460                             | 0   | 180         | 0 | 370                   | 0   | 250              | 60  | 220              |
| R21       | 410              | 120 | 410                        | 120 | 420                             | 0   | 210         | 0 | 440                   | 0   | 180              | 90  | 220              |
| R22       | 330              | 90  | 250                        | 130 | 360                             | 0   | 170         | 0 | 400                   | 0   | 180              | 80  | 200              |
| R23       | 340              | 80  | 270                        | 110 | 410                             | 0   | 180         | 0 | 430                   | 0   | 210              | 100 | 220              |
| R24       | 330              | 100 | 260                        | 100 | 410                             | 0   | 170         | 0 | 390                   | 0   | 210              | 110 | 190              |
| R25       | 320              | 90  | 270                        | 100 | 440                             | 0   | 170         | 0 | 390                   | 0   | 270              | 110 | 200              |

Sets: SSS/FSS I

Subject: KG/30

| Locations | Xp               |   |        |    | X-2                   |    | X-1    |     | X                               |       | X+1    |     | X+2              |       | Xf                    |
|-----------|------------------|---|--------|----|-----------------------|----|--------|-----|---------------------------------|-------|--------|-----|------------------|-------|-----------------------|
| Utterance | W                | P | W      | P  | W                     | P  | W      | P   | W                               | P     | W      | P   | W                | P     | W                     |
|           | t<br>h<br>a<br>t |   | H<br>e |    | b<br>e<br>g<br>a<br>n |    | t<br>o |     | f<br>o<br>u<br>n<br>d<br>e<br>r |       | a<br>t |     | o<br>n<br>c<br>e |       | S<br>i<br>n<br>c<br>e |
| R11       | 120              | 0 | 100    | 50 | 420                   | 0  | 260    | 600 | 510                             | 1,020 | 180    | 530 | 340              | 1,110 | 240                   |
| R12       | 100              | 0 | 100    | 50 | 410                   | 0  | 120    | 0   | 480                             | 0     | 160    | 40  | 450              | 900   | 260                   |
| R13       | 100              | 0 | 120    | 40 | 470                   | 0  | 120    | 0   | 450                             | 0     | 100    | 40  | 450              | 390   | 230                   |
| R14       | 120              | 0 | 90     | 60 | 370                   | 0  | 90     | 0   | 460                             | 0     | 80     | 0   | 470              | 600   | 180                   |
| R15       | 120              | 0 | 80     | 60 | 360                   | 0  | 90     | 0   | 480                             | 0     | 170    | 0   | 420              | 530   | 200                   |
| R21       | 100              | 0 | 60     | 60 | 370                   | 50 | 80     | 0   | 450                             | 0     | 90     | 90  | 450              | 780   | 130                   |
| R22       | 40               | 0 | 60     | 60 | 360                   | 0  | 100    | 0   | 450                             | 0     | 70     | 50  | 490              | 680   | 160                   |
| R23       | 50               | 0 | 70     | 70 | 370                   | 0  | 80     | 0   | 410                             | 0     | 90     | 90  | 500              | 840   | 190                   |
| R24       | 50               | 0 | 70     | 80 | 370                   | 0  | 80     | 0   | 430                             | 0     | 60     | 80  | 440              | 850   | 190                   |
| R25       | 100              | 0 | 60     | 60 | 390                   | 0  | 90     | 0   | 390                             | 0     | 80     | 70  | 450              | 830   | 170                   |

Set: SSS/FSS I

Subjects: JB/TA

| Locations | XP   |     | X-2 |                            | X-1 |                  | X   |                  | X+1 |                                 | X+2 |        | X+3 |             | X+4 |                                      | X+5 |
|-----------|------|-----|-----|----------------------------|-----|------------------|-----|------------------|-----|---------------------------------|-----|--------|-----|-------------|-----|--------------------------------------|-----|
| Utterance | W    | P   | W   | P                          | W   | P                | W   | P                | W   | P                               | W   | P      | W   | P           | W   | P                                    | W   |
|           | read |     |     | Y<br>O<br>U<br>W<br>I<br>L |     | f<br>I<br>N<br>D |     | s<br>O<br>M<br>E |     | a<br>R<br>S<br>E<br>N<br>I<br>C |     | i<br>N |     | t<br>H<br>E |     | m<br>E<br>D<br>I<br>C<br>I<br>N<br>E |     |
| R11       | 300  | 450 | 330 | 0                          | 470 | 260              | 230 | 0                | 590 | 370                             | 190 | 110    | 130 | 0           | 590 | 470                                  | 500 |
| R12       | 330  | 450 | 260 | 0                          | 340 | 0                | 220 | 640              | 660 | 530                             | 210 | 0      | 180 | 0           | 530 | 110                                  | 410 |
| R13       | 330  | 620 | 250 | 0                          | 350 | 0                | 190 | 60               | 550 | 200                             | 230 | 60     | 110 | 0           | 510 | 120                                  | 400 |
| R14       | 370  | 370 | 210 | 0                          | 340 | 0                | 220 | 0                | 580 | 150                             | 190 | 0      | 180 | 0           | 470 | 0                                    | 470 |
| R15       | 330  | 360 | 210 | 0                          | 350 | 0                | 230 | 0                | 650 | 850                             | 200 | 70     | 120 | 0           | 500 | 30                                   | 380 |
| R21       | 220  | 660 | 160 | 0                          | 350 | 0                | 260 | 70               | 540 | 150                             | 90  | 0      | 50  | 0           | 460 | 40                                   | 400 |
| R22       | 290  | 730 | 190 | 0                          | 380 | 0                | 220 | 30               | 570 | 370                             | 140 | 0      | 50  | 0           | 500 | 20                                   | 400 |
| R23       | 330  | 520 | 150 | 0                          | 300 | 0                | 210 | 0                | 510 | 40                              | 120 | 0      | 50  | 0           | 450 | 0                                    | 390 |
| R24       | 320  | 530 | 150 | 0                          | 350 | 0                | 230 | 0                | 580 | 50                              | 100 | 0      | 40  | 0           | 470 | 0                                    | 530 |
| R25       | 280  | 580 | 160 | 0                          | 310 | 0                | 210 | 0                | 530 | 0                               | 130 | 0      | 30  | 0           | 430 | 0                                    | 450 |

Sets: SSS/FSS I

Subjects: GT/JJ

| Locations | Xp  |      | X-4 |   | X-3 |                  | X-2 |     | X-1 | X  |     | X+1                        |     | X+2              |     |             | Xf  |
|-----------|-----|------|-----|---|-----|------------------|-----|-----|-----|--|-----|----------------------------|-----|------------------|-----|-------------|-----|
| Utterance | W   | P    | W   | P | W   | P                | W   | P   | W   | P  | W   | P                          | W   | P                | W   | P           | W   |
|           |     | crow |     | I |     | h<br>e<br>v<br>e |     | e   |     | v<br>o<br>c<br>a<br>b<br>u<br>l<br>a<br>r<br>y |     | l<br>a<br>r<br>g<br>e<br>r |     | t<br>h<br>e<br>n |     | h<br>i<br>s |     |
| R11       | 440 | 630  | 270 | 0 | 590 | 0                | 180 | 110 | 860 | 0  | 530 | 0                          | 150 | 0                | 500 | 160         | 240 |
| R12       | 330 | 610  | 80  | 0 | 290 | 0                | 90  | 70  | 740 | 170  | 480 | 0                          | 150 | 0                | 480 | 720         | 270 |
| R13       | 360 | 750  | 110 | 0 | 310 | 0                | 90  | 60  | 760 | 140  | 440 | 0                          | 160 | 0                | 490 | 350         | 230 |
| R14       | 280 | 570  | 60  | 0 | 230 | 0                | 80  | 70  | 740 | 280  | 420 | 0                          | 140 | 0                | 470 | 490         | 270 |
| R15       | 270 | 560  | 60  | 0 | 260 | 0                | 80  | 80  | 610 | 100  | 390 | 0                          | 160 | 0                | 370 | 90          | 190 |
| R21       | 260 | 450  | 40  | 0 | 110 | 0                | 80  | 0   | 820 | 820  | 420 | 0                          | 80  | 0                | 250 | 80          | 300 |
| R22       | 270 | 440  | 50  | 0 | 120 | 0                | 70  | 0   | 710 | 100  | 380 | 0                          | 90  | 0                | 400 | 440         | 170 |
| R23       | 260 | 440  | 100 | 0 | 130 | 0                | 110 | 0   | 740 | 50   | 370 | 0                          | 80  | 0                | 320 | 500         | 150 |
| R24       | 240 | 370  | 50  | 0 | 60  | 0                | 40  | 0   | 700 | 50   | 370 | 0                          | 50  | 0                | 290 | 1,250       | 160 |
| R25       | 280 | 510  | 90  | 0 | 140 | 0                | 80  | 0   | 800 | 60   | 370 | 0                          | 90  | 0                | 240 | 70          | 190 |

Sets: SSS/FSS I

Subjects: CR/MX

| Locations | XP                    |       | X-4 |             | X-3 |             | X-2 |                  | X-1 |             | X   |        | X+1 |             | X+2 |  | XF  |
|-----------|-----------------------|-------|-----|-------------|-----|-------------|-----|------------------|-----|-------------|-----|--------|-----|-------------|-----|--|-----|
| Utterance | W                     | P     | W   | P           | W   | P           | W   | P                | W   | P           | W   | P      | W   | P           | W   | P  | W   |
|           | c<br>u<br>r<br>v<br>e |       |     | Y<br>o<br>u |     | c<br>a<br>n |     | f<br>i<br>n<br>d |     | o<br>u<br>t |     | i<br>n |     | a<br>n<br>y |     | d<br>i<br>c<br>t<br>i<br>o<br>n<br>a<br>r<br>y |     |
| R11       | 370                   | 450   | 100 | 60          | 150 | 0           | 300 | 0                | 290 | 0           | 750 | 0      | 490 | 0           | 620 | 490  | 110 |
| R12       | 340                   | 740   | 90  | 70          | 130 | 0           | 300 | 0                | 280 | 240         | 320 | 0      | 240 | 0           | 690 | 520  | 140 |
| R13       | 370                   | 710   | 80  | 50          | 150 | 0           | 390 | 80               | 270 | 170         | 150 | 0      | 200 | 0           | 650 | 1,030  | 100 |
| R14       | 370                   | 870   | 90  | 60          | 140 | 0           | 290 | 0                | 260 | 140         | 140 | 0      | 230 | 0           | 710 | 530  | 100 |
| R15       | 360                   | 920   | 90  | 70          | 170 | 0           | 430 | 0                | 330 | 120         | 120 | 0      | 240 | 0           | 740 | 130  | 90  |
| R21       | 360                   | 1,240 | 140 | 70          | 160 | 0           | 370 | 0                | 300 | 290         | 110 | 90     | 330 | 220         | 600 | 580  | 80  |
| R22       | 370                   | 1,890 | 140 | 70          | 140 | 0           | 430 | 0                | 280 | 410         | 120 | 80     | 200 | 100         | 530 | 1,420  | 90  |
| R23       | 360                   | 1,270 | 100 | 80          | 150 | 50          | 350 | 0                | 200 | 60          | 150 | 0      | 240 | 120         | 610 | 920  | 90  |
| R24       | 350                   | 1,610 | 90  | 90          | 170 | 0           | 350 | 0                | 240 | 630         | 120 | 100    | 210 | 110         | 650 | 1,210  | 100 |
| R25       | 370                   | 1,080 | 100 | 70          | 160 | 0           | 400 | 0                | 210 | 0           | 120 | 120    | 210 | 110         | 610 | 960  | 100 |

Sets: SSS/FSS I

Subjects: CR/MX

| Locations | XP                         |       | X-11             |    | X-10             |   | X-9         |     | X-8                        |     | X-7              |     | X-6         |    | X-5              |       | X-4                   |
|-----------|----------------------------|-------|------------------|----|------------------|---|-------------|-----|----------------------------|-----|------------------|-----|-------------|----|------------------|-------|-----------------------|
| Utterance | W                          | P     | W                | P  | W                | P | W           | P   | W                          | P   | W                | P   | W           | P  | W                | P     | W                     |
|           | o<br>r<br>i<br>o<br>l<br>e |       | H<br>e<br>a<br>d |    | s<br>e<br>e<br>n |   | h<br>e<br>r |     | f<br>l<br>y<br>i<br>n<br>g |     | p<br>a<br>s<br>t |     | h<br>i<br>s |    | n<br>e<br>s<br>t |       | e<br>v<br>e<br>r<br>y |
| R11       | 630                        | 1,550 | 260              | 50 | 420              | 0 | 180         | 60  | 400                        | 70  | 470              | 0   | 160         | 0  | 410              | 480   | 240                   |
| R12       | 510                        | 1,120 | 220              | 0  | 380              | 0 | 420         | 80  | 490                        | 450 | 340              | 0   | 210         | 0  | 360              | 60    | 290                   |
| R13       | 530                        | 1,210 | 260              | 0  | 410              | 0 | 230         | 0   | 600                        | 150 | 310              | 0   | 190         | 0  | 400              | 360   | 270                   |
| R14       | 570                        | 830   | 450              | 0  | 310              | 0 | 210         | 0   | 510                        | 70  | 380              | 0   | 250         | 0  | 400              | 450   | 260                   |
| R15       | 510                        | 720   | 220              | 0  | 370              | 0 | 190         | 0   | 460                        | 80  | 330              | 0   | 150         | 0  | 290              | 100   | 260                   |
| R21       | 340                        | 1,020 | 230              | 60 | 300              | 0 | 220         | 0   | 480                        | 480 | 540              | 280 | 140         | 30 | 380              | 570   | 290                   |
| R22       | 340                        | 1,000 | 270              | 40 | 340              | 0 | 240         | 0   | 440                        | 100 | 380              | 0   | 110         | 0  | 380              | 550   | 290                   |
| R23       | 280                        | 1,390 | 400              | 30 | 370              | 0 | 260         | 0   | 440                        | 120 | 330              | 30  | 120         | 50 | 400              | 340   | 270                   |
| R24       | 290                        | 1,000 | 250              | 50 | 380              | 0 | 330         | 100 | 420                        | 110 | 260              | 80  | 70          | 60 | 370              | 770   | 270                   |
| R25       | 340                        | 1,630 | 300              | 0  | 320              | 0 | 180         | 0   | 530                        | 100 | 380              | 0   | 140         | 0  | 400              | 2,060 | 310                   |

Sets: SSS/FSS I (Cont'd.)

Subjects: CR/MX

| Locations |   | X-3                   |       | X-2                   |     | X-1         |     | X           |     | X+1                   |    | X+2                   |     | X+3                             |     | X+4                   |       | Xf          |
|-----------|---|-----------------------|-------|-----------------------|-----|-------------|-----|-------------|-----|-----------------------|----|-----------------------|-----|---------------------------------|-----|-----------------------|-------|-------------|
| Utterance | P | W                     | P     | W                     | P   | W           | P   | W           | P   | W                     | P  | W                     | P   | W                               | P   | W                     | P     | W           |
|           |   | g<br>l<br>i<br>n<br>g |       | h<br>e<br>r<br>e<br>y |     | n<br>o<br>n |     | a<br>n<br>d |     | e<br>v<br>e<br>r<br>y |    | a<br>b<br>o<br>u<br>t |     | n<br>o<br>n<br>e<br>r<br>e<br>y |     | a<br>b<br>o<br>u<br>t |       | a<br>n<br>d |
| R11       | 0 | 490                   | 560   | 460                   | 0   | 330         | 0   | 280         | 0   | 390                   | 0  | 440                   | 0   | 1,020                           | 0   | 360                   | 660   | 100         |
| R12       | 0 | 490                   | 640   | 400                   | 0   | 370         | 390 | 100         | 0   | 330                   | 0  | 470                   | 0   | 730                             | 0   | 370                   | 580   | 140         |
| R13       | 0 | 440                   | 0     | 450                   | 0   | 330         | 560 | 80          | 0   | 260                   | 0  | 370                   | 0   | 800                             | 0   | 380                   | 560   | 130         |
| R14       | 0 | 430                   | 0     | 520                   | 0   | 330         | 210 | 110         | 0   | 270                   | 0  | 450                   | 0   | 620                             | 620 | 340                   | 720   | 100         |
| R15       | 0 | 460                   | 710   | 460                   | 0   | 350         | 890 | 90          | 0   | 340                   | 0  | 320                   | 0   | 480                             | 0   | 420                   | 450   | 90          |
| R21       | 0 | 470                   | 610   | 590                   | 150 | 330         | 770 | 230         | 100 | 220                   | 40 | 290                   | 470 | 510                             | 0   | 400                   | 690   | 130         |
| R22       | 0 | 490                   | 640   | 520                   | 0   | 340         | 350 | 100         | 70  | 290                   | 50 | 370                   | 550 | 450                             | 0   | 360                   | 1,290 | 150         |
| R23       | 0 | 410                   | 410   | 400                   | 0   | 320         | 640 | 160         | 0   | 290                   | 90 | 240                   | 720 | 420                             | 0   | 360                   | 750   | 180         |
| R24       | 0 | 430                   | 1,310 | 590                   | 0   | 340         | 740 | 130         | 50  | 280                   | 80 | 250                   | 470 | 390                             | 0   | 320                   | 1,350 | 170         |
| R25       | 0 | 560                   | 250   | 580                   | 700 | 320         | 170 | 180         | 40  | 320                   | 50 | 370                   | 940 | 480                             | 0   | 400                   | 870   | 160         |

Seta: SSS/FSS I

Subjects: CR/MX

| Locations | Xp               |       | X-3         |   | X-2 |   | X-1              |     | X                                    |       | Xr          |
|-----------|------------------|-------|-------------|---|-----|---|------------------|-----|--------------------------------------|-------|-------------|
| Utterance | W                | P     | W           | P | W   | P | W                | P   | W                                    | P     | W           |
|           | I<br>o<br>w<br>n |       | I<br>a<br>m |   | a   |   | f<br>i<br>n<br>e |     | a<br>e<br>n<br>t<br>i<br>n<br>e<br>l |       | a<br>n<br>d |
| R11       | 570              | 800   | 250         | 0 | 90  | 0 | 480              | 0   | 680                                  | 420   | 260         |
| R12       | 560              | 670   | 210         | 0 | 100 | 0 | 290              | 0   | 580                                  | 240   | 170         |
| R13       | 530              | 1,270 | 150         | 0 | 70  | 0 | 400              | 0   | 520                                  | 470   | 200         |
| R14       | 540              | 1,040 | 270         | 0 | 90  | 0 | 300              | 0   | 560                                  | 530   | 220         |
| R15       | 590              | 1,070 | 560         | 0 | 90  | 0 | 290              | 0   | 530                                  | 630   | 200         |
| R21       | 560              | 380   | 190         | 0 | 60  | 0 | 370              | 0   | 780                                  | 140   | 150         |
| R22       | 510              | 1,860 | 330         | 0 | 50  | 0 | 640              | 370 | 670                                  | 1,430 | 120         |
| R23       | 460              | 1,460 | 270         | 0 | 50  | 0 | 590              | 0   | 700                                  | 890   | 160         |
| R24       | 470              | 1,260 | 370         | 0 | 50  | 0 | 480              | 0   | 710                                  | 430   | 150         |
| R25       | 440              | 1,080 | 310         | 0 | 50  | 0 | 580              | 0   | 700                                  | 990   | 180         |

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