A STUDY OF THE EFFECTS OF DELAYED SIDE-TONE ON FOUR ASPECTS OF STUTTERERS' SPEECH DURING ORAL READING AND SPONTANEOUS SPEECH

DISSERTATION

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BY

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CHAPTER I
THE PROBLEM

Statement of the Problem

Investigators have shown that changes in the side-tone of stutterers influence speech fluency and rate. Shane and Maraist and Hutton masked the side-tone of stutterers by feeding white noise of approximately 90 db (re 0.0002 microbar) to their ears during oral reading. For example, the effect was to reduce the frequency of stuttering blocks and the duration of the oral reading passage.\(^1\)


Again, Naylor reported negative correlations, \(r\), of -.64 and -.70 (\(N=24\)) between the increase (per cent) in oral reading time incurred by delayed side-tone and ratings of the subjects' pre-experimental stuttering. In other words, the severe stutterers changed the least in oral reading time as an effect of delayed side-tone while the mild stutterers changed the most in oral reading time.\(^2\)


Also, the writer and others have observed in the laboratory that the speech of several severe stutterers seemed facilitated as an
effect of delayed side-tone; seemingly they reduce the number and severity of blocks in concurrence with a reduction in rate of speaking. The participants reported that speaking was easier and they felt more relaxed than when speaking under their normal side-tone. On the other hand, several mild stutterers were observed to be more disturbed in speech while talking under delayed side-tone. In most instances, it appeared that the mild stutterers had an increase in stuttering frequency and their rate of speech was retarded.

Another observation by the writer was that the effects of delayed side-tone persisted in some stutterers' speech. Several severe stutterers reported that after a period of relative freedom from stuttering blocks under a condition of delayed side-tone, there was a gradual re-occurrence of their stuttering blocks after the delay was eliminated from their side-tone. This was consistent with the writer's observations. Black found with non-stuttering speakers that retarded oral reading rate persisted 150 seconds after the delay was eliminated from the side-tone.3


Fairbanks reported higher fundamental frequencies of voice on the part of non-stuttering individuals who experience delayed side-tone.4 Presumably this higher pitch attended an increase in "stress".

that the subjects experiences as a reaction to the delayed side-tone. There is a possibility that "stress" may be reduced in the instance of severe stutterers under delayed side-tone.

The researches cited, as well as the observations of behavior, contributed to the design of the study. The purposes of the study were (1) to investigate the effects of delayed side-tone on the fluency of stutterers, i.e., frequency of stuttering blocks, duration of stuttering blocks, and rate of speaking during oral reading and spontaneous speech; (2) to determine the extent by which the fundamental frequency of voice of stutterers was affected by delayed side-tone; (3) to compare the "most severe" stutterers and the "least severe" stutterers with regard to the effects of delayed side-tone on the aspects of speech listed in (1) and (2); and (4) to determine whether or not the effects of delayed side-tone persisted in stutterers' speech after the delay was eliminated from their side-tone.

In order to determine the extent by which the stuttering blocks are affected by delayed side-tone, the present study employed three criteria for measuring the severity of stuttering. Bloodstein reported that frequency of stuttering blocks, duration of stuttering blocks, and rate of speaking (words per minute) are similar measures of the severity of stuttering. He found a correlation of \( r = .95 \) between the total frequency of stuttering blocks and the total duration of voice was considered to be the average fundamental frequency of four different vowels sustained by the stutterers under the influence of the given experimental conditions in the study and immediately after oral reading and after spontaneous speaking.

\[ \text{5The fundamental frequency of voice was considered to be the average fundamental frequency of four different vowels sustained by the stutterers under the influence of the given experimental conditions in the study and immediately after oral reading and after spontaneous speaking.} \]
of stuttering blocks of stutterers during oral reading; also negative
correlations, $r = -.66$ and $-.85$ between over-all reading rate (words
per minute) and frequency and duration of stuttering. In the present

6 Oliver N. Bloodstein, "The Relationship Between Oral Reading
and Severity of Stuttering," Journal of Speech Disorders, 9:161-
173, 1944.

study, rate of oral reading and of spontaneous speaking was defined
as the duration of oral responses of stutterers during the speaking
tasks and included their stuttering blocks.

Because of the fact that stutterers read or spoke in successive
experimental conditions during oral reading and spontaneous speech,
the effects of adaptation were considered in the experimental design
and methodology. Adaptation has been defined by Wischner in the case
of stuttering as "a progressive decrease in frequency of stut­
tering with repeated readings of the same material or continued read­
ings of changing material over a period of time." Adaptation has been

7 George J. Wischner, "Stuttering Behavior and Learning: A
Program of Research" (Ph.D. dissertation, The State University of
Iowa, Iowa City, 1947).

found to occur more with repeated readings of the same material than
with either successive readings of different material or changing
topics of spontaneous speech. On the other hand, Soderberg found no
statistically significant adaptation in terms of frequency of stuttering blocks (reading errors included) and reading time for stutterers $(N = 15)$ during five successive readings of different passages.\footnote{George A. Soderberg, "A Comparative Study of Adaptation Trends in the Oral-Reading of Stutterers, Inferior Readers, and Superior Readers" (unpublished Master's thesis, The Ohio State University, Columbus, 1953).}

In the present study, the stimulus materials were continuously changed during the successive experimental conditions of oral reading and spontaneous speech to minimize the adaptation effect. Also, subjects were made familiar with the situational surroundings, the experimenter, and the experimental procedures prior to the speaking tasks.

The study may have implications to the area of stuttering theory. Importance has been attached to the hearing of one's side-tone as a causal factor in stuttering behavior. In some measure the study tests this point of view.

Hypotheses to be Tested

Hypotheses were formulated with respect to three aspects of stutterers' speech in oral reading, three aspects of spontaneous speech, and the average fundamental frequency of vowels after oral reading and after spontaneous speaking under each of the given
conditions in each instance were (1) undelayed side-tone, (2) delayed side-tone, (3) delayed side-tone (sic), (4) undelayed side-tone, and (5) undelayed side-tone preceded by six minutes of silence. The four measures were (a) mean frequency of stuttering blocks, (b) mean duration of stuttering blocks, (c) mean rate of speaking, and (d) mean fundamental frequency of voice. The null hypotheses were as follows:

1) There are no statistically significant differences among the mean values of the five experimental conditions for stutterers (N = 30).

2) There is no statistically significant interaction between the mean values of the five experimental conditions and the "most severe - least severe" dichotomy of stutterers.

3) There are no statistically significant differences among the mean values of the five experimental conditions for the "most severe" stutterers.

4) There are no statistically significant differences among the mean values of the five experimental conditions for the "least severe" stutterers.

Organization of Dissertation

The problem. Chapter I states the problem and hypotheses.

Review of literature. Chapter II includes a summary of the research reports related to the present study.

Experimental procedures. Chapter III discusses the subjects, equipment, determination of delay times, nature of the oral tasks, experimental conditions, measures of stutterers' speech, and determination of the severity groups.
Reliability of the measures. Chapter IV reports the reliability of the measures.

Results. Chapter V reports the statistical tests of hypotheses.

Discussion of results. Chapter VI discusses and interprets the empirical findings.

Summary. Chapter VII summarizes the study.
The review of literature will be divided into treatments of three topics which pertain directly to the present study. The first topic will be concerned with the investigations involving the side-tone of non-stutterers; the second, the investigations involving the side-tone of stutterers; and third, the investigations involving the side-tone of cerebral palsied speakers.

Investigations Involving the Side-Tone of Non-Stutterers

Wiener hypothesized that the simple mechanical servo-system with feedback serves a model for an explanation of the central nervous system.\(^{10}\) In much the same way that the thermostatic control of a furnace regulates the temperature of a room, the central nervous system controls human performance. In simple tasks, such as tracing or tracking, an individual receives information concerning his motor activity through visual or proprioceptive feedback. The information thus received through feedback enables him in some way to control his performance.

A more specific example is to be found in talking. The speaker monitors his speech performance, primarily through side-tone, and in some measure modifies subsequent behavior because of the information...

thus received. Fairbanks referred to this circularity of information and response as the feedback loop.\(^{11}\)  


Pathways transmitting side-tone from the speech mechanism to the hearing mechanism are (1) internal by bone-conduction, and (2) external by air-conduction, directly from mouth to ear and indirectly by mouth to ear via reflected sound waves. Bekesy reported that one's side-tone by bone-conduction is of the same order of magnitude as the side-tone heard by air-conduction.\(^{12}\) Strømsta estimated the propagation of bone-conducted side-tone to be 0.0003 second and air-conducted side-tone (larynx to mouth to ear directly) to be 0.001 second.\(^{13}\) Although the sensations arriving from the various pathways do not have the same transit time, it is presently thought that the signals are integrated at the receptors to be heard as a single auditory experience.

Peters found that the normal air-conducted side-tone of non-stutterers may have a retarding influence on the speaking process.
When the air-conducted side-tone was accelerated, the oral reading rate of experimental subjects was facilitated. \(^{14}\) Davidson reported that oral reading rate of subjects increased under a shorter-than-normal delay time but decreased under a longer-than-normal delay time. Although a greater extent and rate of inflection was found to occur in speech under the shorter-than-normal delay time, no difference in precision of articulation or number of word inflections accompanied particular delay times. \(^{15}\)


\(^{15}\) Donald G. Davidson, "Effect of Side-Tone Delay on Reading Rate, Articulation, and Pitch" (unpublished Ph.D. dissertation, The Ohio State University, Columbus, 1955).

Experimentally, when air-conducted side-tone is abnormally delayed to the receptors, the resulting effect is that the non-stuttering speaker is unable to proceed with his normal pattern of speaking. Black reported that oral reading was progressively retarded as the experimental subjects' side-tone was delayed progressively from 0 to .18 second. The words were stretched out and vocal intensity was also increased. \(^{16}\)

\(^{16}\) John W. Black, "The Effect of Delayed Side-Tone on Vocal Rate and Intensity," *Journal of Speech and Hearing Disorders*, 16:56-60, 1951.
Spilka tested subjects over a range of delays from .09 to .38 second and found no difference among the responses to the various delay times; he used as criterion measures, syllable duration, phonation time, and vocal intensity. Major differences between these two


studies arose from dissimilar reading materials. As a consequence Black measured only speaking time; whereas, Spilka measured the combined breathing and speaking time consumed during the passage.

Lee pointed out that an individual must consciously slow down his speech in order to achieve the cadence demanded by the delayed side-tone. Failure to achieve the proper cadence results in artificial stuttering or erratic speech.


Deutsch and Clarkson found that vibrato, the oscillation in frequency of a singer's voice 7-12 times per second and of a semitone or more in extent, is affected by delayed side-tone. When the side-tone was delayed by .37 second, the musical notes sustained by the singers fluctuated more than when the notes were sustained under undelayed side-tone.

Other effects of delayed side-tone noted by Fairbanks are articulatory errors and higher fundamental frequency of voice. Fairbanks theorized the following:

... Articulatory errors and increased duration may be regarded as direct effects of delayed auditory feedback, while increased sound pressure level and fundamental frequency are indirect effects. It appears the direct effects are determined by the phase relationships of input and feedback.\(^{20}\)

\(^{20}\)Fairbanks, loc. cit.

In a later report, Fairbanks and Guttman stated that the indirect effects are an effort on the part of the speaker to maintain system control and resist experimental interference with the response.\(^{21}\)


Other researchers have attempted to construe the disturbed feedback loop caused by delayed side-tone in non-stuttering speakers. Stromsta wrote:

Conceivably, the delay in time may be reviewed as a phase shift of the air-conduction side-tone experience to that of the bone-tissue side-tone experience or to the original signal. Using a complex non-periodic signal such as connected speech, a cycle representing 360 degrees of phase shift would be the period of a phoneme, syllable, word, or phrase, depending on one's point of view. As the delay period exceeded the signal period the phase shift would be within or exceed 360 degrees.\(^{22}\)

\(^{22}\)Courtney P. Stromsta, "Experimental Blockage of Phonation by Distorted Side-Tone" (Technical Report of Public Service Research Grant, Number B-1331, The Ohio State University, Columbus, p. 11,
Chase stated that changes in temporal relations between signals, changes in the physical aspects of the signals themselves, and complex changes in the acoustic environment around the speaker's ear are important considerations.\textsuperscript{23}


In regard to the physical aspects of the signal, Brubaker reported that the sound pressure level of the delayed side-tone must exceed that of the undelayed signal in order that speech be disturbed.\textsuperscript{24} Butler and Galloway found a linear relationship between the disturbance of speech under delayed side-tone and the intensity of the delayed side-tone signal.\textsuperscript{25}


Stromsta reported that a sustained vowel stopped significantly more often, as did the total time consumed by the stoppage when the spectrum of the air-conduction side-tone signal contained 62.5 percent non-linear distortion. In this study the placement of the
microphone simulated a normal delay of the air-conduction signal, based on the fact that the signals emitted by the earphones were in phase with the signal following the microphone. The vowel stoppage, although it occurred only with signal distortion, seemed to be affected by the phase of the fundamental frequency. The experimental subjects who experienced the vowel stoppage reported tension at the site of the larynx, breath-control disturbances, and in some instances lip tremor.  

26 Stromsta, op. cit., pp. 9-10.

McCroskey studied the combined and separate effects of altered auditory and tactile feedback upon the speech of non-stutterers. The criterion measures of rate of speech, accuracy of articulation, and intelligibility were obtained from speakers under (1) undelayed sidetone, (2) delayed sidetone, (3) anesthetized articulators, and (4) delayed sidetone plus anesthesia. The results of the study indicated that delayed sidetone interfered with rate of speaking but not intelligibility and accuracy of articulation. Further analysis revealed that altered tactile feedback alone lowered intelligibility and word accuracy but did not influence rate of speaking.  


Studies have reported the 'adaptation' of non-stutterers to the effects of delayed sidetone. The term adaptation, in this instance,
refers to the decrease of deviation from normal speech performance under a condition of abnormal delayed side-tone after a period of vocalization. Atkinson found no adaptation for either sound pressure level or duration of speech during the reading of consecutive lists of short phrases by experimental subjects for 300 seconds under conditions of delayed side-tone. Tiffany and Hanley also found no adaptation in terms of duration of speech for subjects reading a 45-word prose passage twelve times in succession under delayed side-tone. However, Winchester et al. reported that as many as 400 syllables of reading under delayed side-tone has to be accomplished before adaptation in terms of duration of speech occurs.

Studies have also reported the effects of delayed side-tone in connection with different stimulus materials. Black found that phrases of vowel-consonant syllables were read with greater duration as an effect of delayed side-tone than were phrases of consonant-vowel syllables. The disparity increased as the amount of delayed side-tone was increased to .21 second. Syllables and phrases of

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different length were responded to alike; there was no interaction between the structure of the phrase and the amount of delay.  


Spilka employed eight passages ranging in length from 73 to 259 words as stimulus materials. A significant interaction in the effects of delayed side-tone upon syllable duration was found between the passages and the delay times used in the study.  

32 Spilka, op. cit., p. 46.

Investigations Involving the Side-Tone of Stutterers

Of first-order importance to the present study is the possible relationship between the effects of delayed side-tone on normal speech and the phenomenon of stuttering. Chase, for example, hypothesized that the kind of disturbed feedback loop produced in non-stutterers by delayed side-tone is constantly present in some types of stuttering. In a five-second period, non-stuttering subjects repeated a sound more times under a delayed side-tone condition than under an undelayed side-tone condition. The delayed side-tone in this instance was said to have facilitated the circulation and recirculation of speech sounds in the speech-auditory feedback loop. Chase identifies these factors with the dynamics of stuttering.  

33 Chase, op. cit., p. 589.
Stromsta reported that stutterers tended to have a larger inter-ear phase discrepancy than non-stutterers for bone-tissue side-tone. The following explanation was given by Stromsta:

If external side-tone can be assumed to be equal for both stutterers and non-stutterers it can be stated that a condition existed within the stutterers, at 2000 cps, comparable to a delay of their external side-tone, a phenomenon which has been demonstrated to disrupt the speech of non-stutterers. . . . It was postulated that the simultaneous stimulation of the bilateral receptors by in-phase external side-tone and out-of-phase internal side-tone could possibly be preserved in the neural pattern that stimulates the cortical centers. This could conceivably cause a central phenomenon conducive to out-of-phase action potentials at paired peripheral muscles during a stuttering block.

Although these findings were statistically significant only at 2000 cps, it was hypothesized that the phase differential was progressively greater near the fundamental frequency of the stutterer’s voice. The reason given was that a larger per cent of the stutterers could not cancel the 500 cycle sinusoidal stimulus as compared to non-stutterers. According to Cherry et al., the masking of the low tones of stutterers’ voices reduces the frequency of stuttering blocks. Experimental subjects who talked in the presence of 100 db of white noise (re 0.0002 microbar) with all frequencies above 500 cps filtered out, stuttered less than when they talked in quiet. However, when filtered white noise masked out all hearing except

frequencies below 500 ops, stuttering was not generally reduced.\[35\]


Stromsta reported that changes in fundamental frequency of voice occurred for a group of rather severe stutterers as the fundamental frequency of a 100 db (re 0.0002 microbar) masking signal (square-wave noise) was fed to their ears during oral reading. As the frequency of this masking signal decreased from 500 to 300 to 100 ops, a progressive increase in fundamental frequency of voice and reduction in frequency of stuttering blocks occurred for the group. The product-moment correlation technique revealed that the mean fundamental frequency of the voice was inversely related to the mean frequency of stuttering blocks ($r = -0.91$).\[36\]

\[36\] Courtney P. Stromsta, "The Effects of Altering the Fundamental Frequency of Auditory Masking on the Speech Performance of Stutterers: A Preliminary Experimental Study--Role of Bone-Conducted Side-Tone to Stuttering" (unpublished Technical Report of Public Service Research Grant, Number B-1331, The Ohio State University, Columbus, 1956).

Investigations Involving the Side-Tone of Cerebral Palsied Speakers

Another area of interest to the present study is the effects of delayed side-tone upon the speech of cerebral palsied speakers, individuals who are considered to have involvements of the central nervous system and of the proprioceptive feedback capacities.
House compared the effects of delayed side-tone upon the speech of non-cerebral palsied speakers and cerebral palsied speakers. With the cerebral palsied group, the delay times of .03, .06, .12, and .18 facilitated the speaking rate, whereas the speaking rate of non-cerebral palsied speakers was only facilitated under .03 second delay.

A second phase of the study indicated that cerebral palsied speakers were also more intelligible under delayed side-tone. However, there appeared to be a specific delay time that was effective for each cerebral palsied speaker.\(^{37}\)

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\(^{37}\)James B. House, "Some Effects of Varied Conditions of Delayed Side-Tone on the Rate and Intelligibility of Cerebral Palsied Speakers" (paper read at the American Speech and Hearing Association convention, Cincinnati, Ohio, 1957).

**Summary**

The studies of side-tone reviewed in this chapter indicated the following:

1) The speech of non-stutterers is disrupted by the effects of delayed side-tone. This disturbance is described variously in terms of increased vocal intensity, syllable duration, pitch, and articulatory errors; also greater fluctuation of frequency in vibrato. It was hypothesized that these effects are the result of a disturbed speech-auditory feedback loop.

2) The disturbed feedback loop produced in non-stutterers by delayed side-tone may be constantly present in some stutterers.
The speech of stutterers is facilitated by the effects of auditory masking. This facilitation is described as a reduction of stuttering blocks and duration of speaking when the perception of the stutterer's speech is masked by high level noise. It was suggested that the reduction of stuttering blocks under conditions of auditory masking may be related to a simultaneous rise in fundamental frequency of voice.

3) Cerebral palsied speakers, individuals with known involvements of the central nervous system and proprioceptive capacities, are facilitated in speech by delayed side-tone. This facilitation is described as decreased duration of speaking and improved intelligibility.
CHAPTER III

EXPERIMENTAL PROCEDURES

The purposes of the study were (1) to investigate the effects of delayed side-tone on the fluency of stutterers during oral reading and spontaneous speaking; (2) to determine the extent by which the fundamental frequency of voice of stutterers is affected by delayed side-tone; (3) to compare the "most severe" stutterers and the "least severe" stutterers with regard to the aspects of speech listed in (1) and (2) as affected by delayed side-tone; and (4) to determine whether or not the effects of delayed side-tone persisted in stutterers' speech during an oral task after the delay was eliminated from their side-tone.

The following paragraphs explain the experimental procedures of the study.

Subjects

The experimental subjects, 30 males, were stutterers diagnosed as such by the writer or other personnel at the Ohio State University Speech and Hearing Clinic. The criterion involved in diagnosis was the stutterers' manifestation of disturbed behavior and awareness to the repetitions and hesitations in his forward flow of speech. Such overt behavior may consist of tensions, facial grimaces, and forcings of words. The subjects ranged in age from 14 to thirty-five years and were receiving or had received speech therapy at the University Speech and Hearing Clinic. Six of the subjects held full-time jobs, seven were high school students, and 17 were college students.
Equipment

The following equipment was employed in the experiment:

Audio-signal delaying unit. The audio-signal delaying unit, custom made and designed by Marple and Morrill, consisted of a magnetic tape recorder and reproducer in which the distance between the record head and the playback head was adjusted to yield delay times from .03 to .30 second. The record head was by-passed to provide the condition of no delay. The amplification at the speaker's ears was set to yield a sound pressure level of 30-35 db above the "normal" speaking level of the participants.

Microphone. The delay unit was fed by an Altec 21 B condenser microphone, six inches removed from the mouth of the speaker.

The first five experimental subjects spoke with the microphone fixed to the headset and positioned near the mouth. Two of the stutterers reported greater fluency with this positioning, possibly due to the acceleration of their side-tone. However, the microphone was removed six inches from the mouth for the remaining 25 subjects.

Figure I shows a photograph of the microphone positioned to the experimental subject. Measurements made throughout the experiment indicated that subjects maintained their position relative to the microphone during speaking tasks.

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39  The first five experimental subjects spoke with the microphone fixed to the headset and positioned near the mouth. Two of the stutterers reported greater fluency with this positioning, possibly due to the acceleration of their side-tone. However, the microphone was removed six inches from the mouth for the remaining 25 subjects.
FIGURE 1

A PHOTOGRAPH SHOWING THE ARRANGEMENT OF THE MICROPHONE POSITIONED SIX INCHES FROM THE MOUTH OF AN EXPERIMENTAL SUBJECT
Earphones. The output of the delay unit was terminated on Permaflux PDR3 earphones mounted in David Clark, Straightaway muff, Model 3728CM. The latter are extremely tight-fitting muff and prevented feedback from the earphones to the microphone.

Tape recorder. The delay unit was linked to a Magnaorder, Model PT6V, for recording the speech of experimental subjects.

Signal light. A custom made signal light was used by the experimenter to signal a subject to begin reading.

Electric timer. A Standard Electric Timer, Type S-10, was used by experimental subjects to time a vowel sustained by them for a period of five seconds.

Electronic counter. The output of the tape recorder was bridged to a Hewlett Packard Electronic Counter, Model 522 B, to assess the fundamental frequency of the sustained vowels. The operation of this instrument will be explained later on in this chapter.

Power level recorder. The output of the tape recorder was bridged to a Sound Apparatus Company power level recorder, Model HPL, 50 db potentiometer, 10 mm per second, for measuring duration of oral reading and spontaneous speech. The operation of this instrument will be explained later on in the chapter.

Polygraph. A Lafayette Company polygraph was used by the experimenter to record frequency and duration of stuttering blocks of subjects. The operation of the instrument will also be discussed later.

Figure II illustrates the schematic diagram for the delayed side-tone unit and accessory equipment.
FIGURE 2

SCHEMATIC DIAGRAM OF DELAYED SIDE-TONE UNIT AND ACCESSORY EQUIPMENT: (1) Earphones, (2) Microphone, (3) Delay Unit, (4) Amplifier, (5) Tape Recorder, (6) Power Level Recorder, and (7) Electronic Counter
Determination of the Delay Times

Each experimental subject read, spoke, and sustained vowels only under one condition of delayed side-tone in the study. The delay time was determined from one week to one day prior to the experiment.

The experimental subjects, in the presence of the writer, read several sentences from a passage under each of the following delay times: .06, .10, .14, .18, and .22 second. The testing always began with .14 second, a mean delay time found to reduce or modify the severity of stuttering blocks. The experimenter regulated the delay times until the subject indicated that one of the delay times seemed to reduce or modify his stuttering the most. The technique may be considered a modified "method of adjustment" as the experimenter adjusted the delay times while the subject made the judgment. At no time did the subject know under which delay time he was reading. If the subject experienced no difference in severity of stuttering among the delay times, or if none of the delays seemed to help his speech, he performed in the experiment with the delay time of .14 second.

The instructions to subjects and reading passage are found in Appendix A and the condition of delayed side-tone under which each subject talked in the study is listed in Appendix B.
Nature of the Oral Tasks

Two kinds of speaking and the vocalizing of vowels were the oral tasks in the study. The first speaking task was the oral reading of 10-syllable phrases. The second was the making of short statements or descriptions about pictures. The vocalizing task was the sustaining of four different vowels by subjects for five seconds each after oral reading and after spontaneous speaking.

The experimental subjects participated individually in the experiment while sitting in a small isolated room. The room was five feet square and eight feet in height. The experimenter operated the equipment from an adjacent area outside the room. The subjects were given practice just prior to the speaking tasks. The oral reading task always preceded the spontaneous speech tasks and both tasks occurred successively on the same day.

Oral reading task. The experimental subject read five different lists of 10-syllable phrases. The materials, adapted from passages assembled and adapted by Robinson, were composed of short biographies of "famous men". Approximately twenty-seven 10-sylla-

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41 Frank Robinson, "Effects of Changes in the Relationship Between the Speech and External Side-Tone Level on the Oral Reading Rate of Stutterers and Non-Stutterers" (unpublished Ph.D. dissertation, Ohio State University, Columbus, 1953), p. 99.

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ble phrases were constructed from each of the passages without impairing the continuity of the stories (See Appendix C). Each phrase in a list was typed on a 5 by 7 inch card and the phrases were read successively by the subject.
The training procedure for the oral reading part of the experiment consisted of the subject reading twelve 10-syllable phrases.

**Spontaneous speech task.** The experimental subject described five different sets of pictures. The stimuli for the spontaneous speech task consisted of 25 vividly colored pictures from the Saturday Evening Post, one of which is photographically reproduced in Figure 3. Each picture was mounted on a 11 x 11 inch card. During the experiment, the subject made six different statements or descriptions of each of five pictures in a set. The spontaneous speech task always followed the oral reading task as the latter task served as a model for subjects for making statements of approximately ten syllables about pictures.

The training procedures consisted of the subject reading six sample statements or descriptions about a picture, and making six original statements about a second picture.

The pictures and phrases instituted five sets of stimulus materials each. The order for presentation of the stimulus materials was random for the five experimental conditions in the oral reading and spontaneous speech tasks (see Appendix C).

**Vowel vocalizing task.** After oral reading and after spontaneous speaking the subjects sustained four different vowels under the experimental conditions in the speaking tasks. The four vowels were /e/, /a/, /i/, and /u/. Each vowel was sustained once for a five-second period. In every case, subjects sustained /e/ first, /a/ second, /i/ third, and /u/ fourth.
FIGURE 3

A PHOTOGRAPHIC REPRODUCTION OF ONE OF THE PICTURES DESCRIBED BY SUBJECTS DURING SPONTANEOUS SPEECH
The training period for sustaining vowels occurred after the practice period for oral reading. At this time, the subject practiced vocalizing the vowels listed above for a period of five seconds each.

Appendix D includes the practice phrases and instructions to subjects for the oral reading and the associated sustaining of vowels tasks. Appendix E includes the instructions to subjects for the spontaneous speech and the associated sustaining vowels tasks.

Experimental Conditions

The subjects read, spoke, and sustained vowels under five serially ordered sequential experimental conditions of side-tone. Figure 4 illustrates the five conditions of side-tone employed in the oral tasks. In every case, subjects read, spoke, and sustained vowels under Condition I first, Condition II second, Condition III third, Condition IV fourth, and Condition V fifth. The conditions of side-tone are as follows:

Condition One. The subject read, spoke, and sustained vowels under undelayed side-tone. The purpose of this condition was to obtain a representative sample of each stutterer's speech.

Condition Two. The subject read, spoke, and sustained vowels under a delay time approximating .14 second. The purpose of this condition was to determine whether or not delayed side-tone affected stutterers' speech.

Condition Three. The subject read, spoke, and sustained vowels under a delay time approximating .14 second. The purpose of this
I. UNDELAYED SIDE-TONE
   A. Subjects read 10-syllable phrases and sustained vowels.
   B. Subjects described pictures and sustained vowels.

II. DELAYED SIDE-TONE (Approximating .14 second)
   A. Subjects read 10-syllable phrases and sustained vowels.
   B. Subjects described pictures and sustained vowels.

III. DELAYED SIDE-TONE (Approximating .14 second)
   A. Subjects read 10-syllable phrases and sustained vowels.
   B. Subjects described pictures and sustained vowels.

IV. UNDELAYED SIDE-TONE
   A. Subjects read 10-syllable phrases and sustained vowels.
   B. Subjects described pictures and sustained vowels.

SIX MINUTES OF SILENCE
   A. Earphones removed from subjects.
   B. All materials placed out of sight.
   C. Subject remained seated and silent.

V. UNDELAYED SIDE-TONE
   A. Subjects read 10-syllable phrases and sustained vowels.
   B. Subjects described pictures and sustained vowels.

FIGURE 4
AN ILLUSTRATION OF THE FIVE SEQUENTIAL EXPERIMENTAL CONDITIONS
OF SIDE-TONE IN WHICH SUBJECTS READ 10-SYLLABLE PHRASES,
DESCRIBED PICTURES, AND SUSTAINED VOWELS AFTER
READING AND DESCRIBING
condition was to determine whether or not the effects of delayed side-tone in Condition III were consistent with those in Condition II.

**Condition Four.** The subjects read, spoke, and sustained vowels under undelayed side-tone. The delay in Condition III was eliminated from the side-tone of the subject without giving him prior notification. Almost immediately the subject was signaled to begin performing in Condition IV. The purpose of this condition was to determine whether or not the effects of delayed side-tone persisted in stutterers' speech.

**Condition Five.** The subjects read, spoke, and sustained vowels under undelayed side-tone. The persistence effects of delayed side-tone were thought to be short-lived in stutterers' speech; six minutes of silence preceded the fifth condition. During this period, the earphones were removed from the subject and he remained seated in the chair. The reading or speaking materials were placed out of sight and the subject was asked to remain silent. The purpose of this condition was to determine the extent of adaptation under the conditions of the study.

**The Measures of Stutterers' Speech**

The four criterion measures of each stutterer's speech were (1) the total frequency of stuttering blocks, (2) the total duration of stuttering blocks, (3) the accumulated time for reading 10-syllable phrases and making statements of approximately 10-syllables about pictures, and (4) the average fundamental frequency of four
different sustained vowels. The measures were obtained during oral reading, spontaneous speech, and the sustaining of vowels after oral reading and after spontaneous speaking under each of the given conditions. The experimental conditions in each instance were those discussed in the preceding paragraphs.

**Frequency and duration of stuttering blocks.** The experimenter while listening to tape recordings of subjects used a mechanical stylus on a polygraph to mark the beginning and end of each stuttering block on a tape moving at a constant speed of three millimeters per second. The reliability of the experimenter for scoring stuttering blocks is reported in the next chapter.

A stuttering block was considered to be an auditory experience of non-fluency, i.e., a detected repetition of a sound or a word, use of a "starter," or presence of a "hard contact" of the articulators in the forward flow of speech. The frequency of stuttering blocks for each subject was determined by tabulating the number of stuttering occurrences marked on the polygraph tape for two hundred words of oral reading or spontaneous speech. The duration of stuttering blocks for each subject was determined by measuring the beginning and end of the stuttering blocks on the polygraph tape in millimeters and converting the measures into seconds.

**Rate of oral reading and spontaneous speaking.** The rate of oral reading or spontaneous speaking was the accumulated time consumed by a subject in reading twenty-five 10-syllable phrases or in making twenty-five short statements about pictures, each approxi-
mating 10-syllables. The length of both samples of speech totaled 250 syllables. The total durations were obtained by feeding the output signal of the tape recorder into the power level recorder and measuring the graphic tracings of the acoustically recorded responses in seconds based on the paper speed in millimeters. The samples of speech were measured individually and accumulated for the purpose of measuring only the speaking time of the experimental subjects.

Fundamental frequency of sustained vowels. The fundamental frequency of the subject's voice for each experimental condition was taken as the average fundamental frequency of four vowels sustained under each of the experimental conditions of the study. The output signal of the tape recorder was fed in turn through an Allison 2AR low-pass filter, a Hewlett Packard amplifier, Model 450A, and a second Allison low-pass filter. Both filters were set at 200 cps to attenuate higher-order harmonics of the vowels. The signal was then applied to the input of the electronic counter that displayed instantly and automatically, in direct reading form, the fundamental frequency in cycles per second.\(^1\)

\(^1\)Essentially, the electronic counter amplifies the input signal and subsequently shapes or changes its waveform to fast-rise constant amplitude pulses while at the same time preserving its frequency, the pulses activate decade counting units.

Three readings of the fundamental frequency of each vowel were taken from the counter during the five seconds that it was sustained.
The average of the three readings was taken to represent the fundamental frequency of the vowel.

**The Differentiation of the Most Severe-Least Severe Stutterers**

The two sub-groups, the "most severe" stutterers and the "least severe" stutterers, were formed on the basis of the mean frequency of stuttering blocks exhibited by the stutterers during the first and fifth non-delayed side-tone conditions in a speaking task. These conditions were selected for measuring severity of stuttering as they were considered by the writer to be representative of the stutterers' "normal" speech behavior. The mean frequency of stuttering blocks for the two conditions in each speaking task was tabulated for each stutterer. These individuals were then ranked from the most severe to the least severe stutterers. The upper fifteen stutterers in a speaking task represented the "most severe" stutterers for a particular speaking task. The lower fifteen stutterers represented the "least severe" stutterers for a particular speaking task.

Some stutterers who were found to be severe in spontaneous speech were found to be not severe in oral reading. In other cases the reverse of this was true. Generally, the stutterers were in the same sub-groups for both speaking tasks. Appendix G includes the mean frequency of stuttering blocks for each stutterer in the two sub-groups for both speaking tasks.
CHAPTER IV

RELIABILITY OF THE MEASURES

Each subject who participated in the study read lists of 10-syllable phrases, made statements about sets of five pictures, and sustained four different vowels. From the recordings of these oral tasks, the writer secured measures of four aspects of speech. The four measures were (1) frequency of stuttering blocks, (2) duration of stuttering blocks, (3) rate of speaking, and (4) fundamental frequency of voice.

The stuttering blocks were observed by the writer. A block was considered to be an auditory experience of non-fluency, i.e., a detected repetition of a sound or a word, use of a "starter," or presence of a "hard contact" of the articulators in the forward flow of speech. A tally of the presence of a stuttering block provided one measure; the duration of a block provided another. The reliability of these measures was considered to be the consistency with which the writer detected them. This reliability was determined by the amount of agreement between the writer and a second observer, and the writer and himself in observing frequency and duration of stuttering blocks.

The rate of oral reading or spontaneous speaking was the accumulated time consumed by a subject in reading twenty-five 10-syllable phrases or in making short statements, each approximating 10-syllables, about pictures. The length of both speech samples of speech totaled 250 syllables. The instrument used to measure the
total durations of phrases or statements was the power level recorder. The reliability of the power level recorder was determined by assessing the disparity between it and a logger, Audio Instrument Company, Modell124F, with an accompanying direct writing oscillograph, Edin, Model 8003.\(^4\) for measuring rate or duration of speaking.

\(^4\) The logger is a vacuum tube voltmeter having a range of 50 db on a single scale, combined with a linear rectifier and a DC driving amplifier. It uses a linear to logarithmic converter (logarithmic element), a linear vacuum tube voltmeter, and a linear rectifier-DC amplifier. Likewise, use of a rectifier and DC amplifier permits the operation of a direct writing oscillograph of high pen speed.

The fundamental frequency of voice was the average fundamental frequency of four different vowels sustained by a subject for a period of five seconds each. The instrument used to measure fundamental frequency of voice was the electronic counter. The reliability of the counter was determined by assessing the disparity between it and a direct writing oscillograph, Edin, Model 8003, for measuring fundamental frequency of sustained vowels. The tape speed of the recorded vowels was reduced 8:1 before they were re-recorded on the oscillograph.

Frequency of Stuttering Blocks

One method used to determine the reliability of the writer in scoring frequency of stuttering blocks was percent agreement. The formula for computing this statistic was recommended by Festinger:

\[
\frac{\text{SUM OF AGREEMENTS} \times 100}{\text{SUM OF AGREEMENTS PLUS SUM OF DISAGREEMENTS}}
\]
This ratio can be computed for two observers.

A second method used to determine the reliability of the writer was Pearson product-moment correlations.

The second scorings of the writer and the scorings of one other observer, experienced in working in stuttering, were individually compared with the original scorings of the writer. The observers listened independently to the tape recordings of each of five lists of 10-syllable phrases from four experimental subjects. The subjects were picked by lot from the group of stutterers. The observations were made only on the first 200 words of a list of 10-syllable phrases. The original records of the writer were first compared with the records of the other observer and then with the second records of the writer. The total number of agreements and disagreements of the presence of stuttering blocks occurring in sections of the records representing 10-syllable phrases was tallied for all the subjects. The result of this composite tabulation for four subjects was reported in terms of per cent agreement between the writer and the second observer, and the two scorings of the writer.

This method of determining reliability indicated that the writer agreed with the second observer 78 per cent \( \frac{398 \times 100}{398 + 115} \). The writer agreed with himself 83 per cent \( \frac{411 \times 100}{411 + 86} \). A comparable agreement
between two observers reported by Bloodstein was 74.6 per cent

\[
\frac{(3,202 \times 100)}{3,202 + 1,092} = 45
\]

\[45\text{ Bloodstein, op. cit., p. 164.}\]

It was also noted the extent to which two observers agreed
when the reliability of the writer was given in terms of correlation.
Using the same subjects as previous, Pearson moment-product correlations, \( r \), were computed between the original scorings of the writer and the second observer, and the two scorings of the writer.

The records of the subjects were grouped together into seventy-one consecutive sections of four 10-syllable phrases. The number of stuttering blocks within each of the seventy-one sections was compared with the number of stuttering blocks within each of the 71 sections for the second observer.

The product-moment correlation computed between the scorings of the writer and the second observer was \( r = .92 \) \((N = 71)\). The coefficient for the writer and himself was \( r = .96 \) \((N = 71)\).

Table I pertains to the data for the reliability of writer in scoring frequency of stuttering blocks.

**Duration of Stuttering Blocks**

Pearson product-moment correlations, \( r \), were computed between the original measurements of the writer and the second observer, and the two measurements of the writer.

The combined records of the four experimental subjects used previously were scored for duration of stuttering blocks. The total
duration of stuttering blocks within each section of one observer's record was compared with the total duration of stuttering blocks within the same section of the second observer's records.

The product-moment correlation computed between the measurements of the writer and the second observer was $r = .93$ ($N = 71$). The coefficient for the writer's two measurements was $r = .97$ ($N = 71$). These correlations compare favorably with those obtained by the writer and another observer in an earlier study. The over-all coefficients reported in the earlier study for four subjects were $r = .91$ for the writer and the second observer, and $r = .93$ for the writer's two measurements.\(^4^6\)


Table I, in addition to the frequency results, includes the data pertaining to the reliability of the writer for measuring duration of stuttering blocks.

Rate of Speaking

The reliability of the power level recorder for measuring rate of oral reading and spontaneous speaking was determined by assessing the disparity between it and the logger with an accompanying direct writing oscillograph.

The recordings of two of the four experimental subjects used previously were employed for determining the reliability of the power level recorder. Only two lists of 10-syllable phrases were used for
<table>
<thead>
<tr>
<th>Observers*</th>
<th>Per Cent Agreement</th>
<th>N**</th>
<th>Product-Moment Correlations (r)</th>
<th>N***</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0^1 - 0^2)</td>
<td>.78</td>
<td>513</td>
<td>.92</td>
<td>71</td>
</tr>
<tr>
<td>(0^1 - 0^1)</td>
<td>.83</td>
<td>497</td>
<td>.96</td>
<td>71</td>
</tr>
</tbody>
</table>

** Frequency of Stuttering Blocks**

** Duration of Stuttering Blocks**

\(0^1 - 0^2\) | .93 | 71 |
\(0^1 - 0^2\) | .97 | 71 |

* \(0^1\) was the writer and \(0^2\) was the second observer.

** N represents the number of possible stuttering blocks observed by both observers for 4 subjects.

*** N represents the number of sections of polygraph tape observed by the two observers for 4 subjects.
each subject. The first had been read under undelayed side-tone while the second had been read under delayed side-tone. The lists of acoustically recorded 10-syllable phrases were then reproduced and visually recorded via the logger on the direct writing oscillograph, with a paper speed of 25 millimeters per second. The tracings on the paper were measured in millimeters by the writer and converted into seconds. The total times for the two sets of 10-syllable phrases for Subject I were 122.80 seconds under undelayed side-tone and 1.77 seconds under delayed side-tone. The disparity between the power level recorder and the logger with an accompanying direct writing oscillograph for the first list of 10-syllable phrases was .20 second; the second list, .46 second. For Subject II, the total times for the two lists of 10-syllable phrases were 95.96 second under undelayed side-tone and 122.32 seconds under delayed side-tone. The disparity between the power level recorder and the logger with an accompanying direct writing oscillograph for the first list of 10-syllable phrases was .46 second; the second list, .82 second.

The small disparities observed between the measurements of the two instruments indicated that the power level recorder was a reliable instrument in measuring duration or rate of speaking.

Table II compares the values obtained by the two instruments for two experimental subjects.
TABLE II

THE DISPARITY BETWEEN THE POWER LEVEL RECORDER AND THE LOGGER WITH AN ACCOMPANYING DIRECT WRITING OSCILLOGRAPH IN MEASURING THE TOTAL DURATION IN SECONDS OF LISTS OF 10-SYLLABLE PHRASES BY TWO EXPERIMENTAL SUBJECTS UNDER UNDELAYED SIDE-TONE AND DELAYED SIDE-TONE

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Condition of Reading Set of 10-Syllable phrases</th>
<th>Power Level Recorder (Sound Appr. Co.)</th>
<th>Direct Writing Oscillograph (Edin)</th>
<th>Logger (Audio Instrument Co.), with Direct Writing Disparity (sec.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Undelayed Side-Tone</td>
<td>122.60</td>
<td>122.80</td>
<td>.20</td>
</tr>
<tr>
<td></td>
<td>Delayed Side-Tone</td>
<td>177.70</td>
<td>177.24</td>
<td>.46</td>
</tr>
<tr>
<td>2</td>
<td>Undelayed Side-Tone</td>
<td>95.50</td>
<td>95.96</td>
<td>.46</td>
</tr>
<tr>
<td></td>
<td>Delayed Side-Tone</td>
<td>121.50</td>
<td>122.32</td>
<td>.82</td>
</tr>
</tbody>
</table>
Fundamental Frequency of Voice

The reliability of the electronic counter for measuring the fundamental frequency of voice was determined by assessing the disparity between it and the direct writing oscillograph.

The recordings of two of the four experimental subjects used previously were utilized for determining the reliability of the electronic counter. Only two sets of vowels were used for each subject. The first had been sustained under undelayed side-tone, while the second had been sustained under delayed side-tone. The vowels, previously recorded at seven and a half inches per second (Magnagorder, Model Pt6V), were re-recorded at 30 inches per second (Ampex Corporation, Model 350-3r), and played back and recorded at three and three-fourth inches per second (Wollensak, Model T-1500) on the paper of the direct writing oscillograph traveling at a speed of 25 millimeters per second. By this process the fundamental frequency of the recorded vowels was also reduced in the ratio from 8 to 1. The fundamental frequency of each different vowel was measured (number of waves per unit of time) at three intervals along the graphic record of the vowel.

The average fundamental frequencies of the two sets of vowels for Subject I was 87.62 cycles under undelayed side-tone and 91.90 cycles under delayed side-tone. The disparity between the electronic counter and the direct writing oscillograph for the first set of vowels was 2.06 cycles; the second set, 1.67 cycles. For Subject II, the average fundamental frequencies for the two sets of vowels were 95.96 under undelayed side-tone and 122.32 cycles under delayed side-tone. The
disparity between the electronic counter and the direct writing oscillograph was .62 cycle for the first set of vowels and .43 cycle for the second set of vowels.

The small disparities observed between the measurements of the two instruments indicated that the electronic counter was a reliable instrument in measuring fundamental frequency of voice.

Table III compares the values obtained by the two instruments for two experimental subjects.

Summary

The reliability data suggested the following:

1) The reliability values in this study for the writer observing frequency and duration of stuttering blocks compared favorably with those found in other studies.

2) The power level recorder and the logger with an accompanying direct writing oscillograph showed a slight disparity for measuring the total durations of lists of 10-syllable phrases.

3) The electronic counter and the direct writing oscillograph (tape speed of recorded vowels reduced from 8:1) showed a slight disparity for measuring the average fundamental frequency of four different sustained vowels.
TABLE III

THE DISPARITY BETWEEN THE ELECTRONIC COUNTER AND THE DIRECT WRITING OSCILLOGRAPH IN MEASURING THE AVERAGE FUNDAMENTAL FREQUENCY OF SETS OF VOWELS SUSTAINED BY TWO EXPERIMENTAL SUBJECTS UNDER UNDELAYED SIDE-TONE AND DELAYED SIDE-TONE

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Condition of Sustaining Sets of Vowels</th>
<th>Cycles</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Electronic Counter (Hewlett Packard)</td>
<td>Direct Writing Oscillograph (Edim)</td>
<td>Disparity (ops)</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Undelayed Side-Tone</td>
<td>89.68</td>
<td>87.62</td>
<td>2.06</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Delayed Side-Tone</td>
<td>93.57</td>
<td>91.90</td>
<td>1.67</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Undelayed Side-Tone</td>
<td>128.70</td>
<td>128.08</td>
<td>.62</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Delayed Side-Tone</td>
<td>148.25</td>
<td>147.82</td>
<td>.43</td>
<td></td>
</tr>
</tbody>
</table>

* Tape speed of recorded vowels was reduced 8:1 before they were re-recorded on the direct writing oscillograph.
CHAPTER V
RESULTS

Statistical Tests of Hypotheses

An analysis of variance, designated by Lindquist Type I (mixed design), was the major analytical procedure in the study. The design was utilized because it provides a means of testing the statistical significance of differences among treatments as well as differentiating groups with respect to the treatments.\footnote{E. F. Lindquist, Design and Analysis of Experiments in Psychology and Education (Boston: Houghton Mifflin Co., 1953), p. 267.}

The successive experimental conditions were (1) undelayed side-tone, (2) delayed side-tone, (3) delayed side-tone \textsuperscript{sic}, (4) undelayed side-tone, and (5) undelayed side-tone preceded by six minutes of silence. The four aspects of stutterers' speech that were measured were (a) mean frequency of stuttering blocks, (b) mean duration of stuttering blocks, (c) mean rate of oral reading or spontaneous speaking, and (d) mean fundamental frequency of voice. Thus, eight analyses were required, these being for the four measures listed above in two kinds of speaking.

In the analyses in which the F-ratios that pertained to the five experimental conditions were statistically significant, the \textit{t} tests were made to indicate critical differences. The critical differences, corresponding to a particular level of significance, were computed from the following formula:
As implied above, the analysis of variance provided a test of
the interaction between the experimental conditions and two sub-groups
of stutterers: the "most severe" stutterers and the "least severe"
stutterers among the thirty participants. Severity of stuttering was
measured by the frequency of the stutterer's blocks observed by the
writer during the first and last non-delayed side-tone conditions in
a speaking task.

Hypotheses tested in oral reading and spontaneous speech. Hy­
potheses were formulated and tested with respect to three aspects of
oral reading, three aspects of spontaneous speech, and the average
fundamental frequency of vowels sustained after oral reading and after
spontaneous speaking under each of the given conditions. The experi­
mental conditions in each instance were the ones enumerated in the
second paragraph of this chapter.

1) There are no statistically significant differences among the
mean values of the five experimental conditions for stutterers
(N = 30).

Throughout, in oral reading and the associated sustaining of
vowels and in spontaneous speech and the associated sustaining of
vowels, the hypothesis was rejected for all measures of speech at the
five per cent levels.

In the former instance, the F-ratios with 12 and 112 degrees of
freedom were 12.83 for frequency of stuttering blocks, 6.79 for
duration of stuttering blocks, 13.47 for oral reading rate, and 15.04
for fundamental frequency of voice. In the latter instance, the F-ratios with 12 and 112 degrees of freedom were 19.10 for frequency of stuttering blocks, 7.10 for duration of stuttering blocks, 18.43 for fundamental frequency of voice, and 2.53 for rate of spontaneous speaking.

Table IV includes summaries of analyses of variance applied to test Hypothesis One.

The mean values are listed in Table V. The t-test was applied to test the differences among the mean values of the five conditions of side-tone. Summaries of statistical differences among the mean values are shown in Table VI.

In general, the mean values are statistically significantly different between conditions of delayed side-tone and non-delayed side-tone, and not different in other comparisons. This outcome is more consistent in oral reading than in spontaneous speech.

2) There is no statistically significant interaction between the mean values of the five experimental conditions for the "most severe" stutterers and those for the "least severe" stutterers among the thirty participants. The two groups were formed on the basis of the frequency of their stuttering blocks during the first and last non-delayed side-tone conditions in a speaking task.

In both speaking tasks, the hypothesis was rejected for frequency of stuttering blocks, duration of stuttering blocks, and rate of oral reading or spontaneous speaking at the five per cent levels. In the instances of the sustained vowels associated with both of the
TABLE IV


<table>
<thead>
<tr>
<th>Sources of Variation</th>
<th>Degrees of Freedom</th>
<th>Oral Reading</th>
<th>Spontaneous Speech</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groups (G)</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error (b)</td>
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<td></td>
</tr>
<tr>
<td>Conditions (C)</td>
<td>4</td>
<td>1634.49</td>
<td>2171.69</td>
</tr>
<tr>
<td>GC Interaction</td>
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<td>2455.99</td>
<td>2090.56</td>
</tr>
<tr>
<td>Error (w)</td>
<td>112</td>
<td>127.38</td>
<td>113.69</td>
</tr>
<tr>
<td>Total</td>
<td>129</td>
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<td></td>
</tr>
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</table>

Between-Subjects 29

Between-Subjects 29

Between-Subjects 29

Between-Subjects 29

Between-Subjects 29

Frequency of Stuttering Blocks

Duration of Stuttering Blocks

Rate of Speaking

Average Fundamental Frequency of Sustained Vowels Associated With Oral Reading and Spontaneous Speech

* F-ratio significant at the one-tenth of one percent level.
** F-ratio significant at the five percent level.
TABLE V

THE MEANS OF THE FOUR MEASURES OF STUTTERERS' SPEECH DURING ORAL READING, SPONTANEOUS SPEECH, AND ASSOCIATED SUSTAINING OF VOWELS UNDER FIVE CONDITIONS OF SIDE-TONE

<table>
<thead>
<tr>
<th>Four Measures of Stutterers' Speech</th>
<th>Conditions of Side-Tone*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
</tr>
<tr>
<td>-------------------------------------</td>
<td>---</td>
</tr>
<tr>
<td><strong>Oral Reading</strong></td>
<td></td>
</tr>
<tr>
<td>Frequency of Stuttering Blocks in 200 words</td>
<td>24.97</td>
</tr>
<tr>
<td>Duration of Stuttering Blocks (Seconds) in 200 words</td>
<td>25.10</td>
</tr>
<tr>
<td>Rate of Oral Reading (Accumulated seconds for reading twenty-five 10-syllable phrases)</td>
<td>83.08</td>
</tr>
<tr>
<td>Average Fundamental Frequency of four Sustained Vowels (ops)</td>
<td>123.78</td>
</tr>
<tr>
<td><strong>Spontaneous Speech</strong></td>
<td></td>
</tr>
<tr>
<td>Frequency of Stuttering Blocks in 200 words</td>
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</tr>
<tr>
<td>Duration of Stuttering Blocks (seconds) in 200 words</td>
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</tr>
<tr>
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<td>132.99</td>
</tr>
<tr>
<td>Average Fundamental Frequency of Four Sustained Vowels (ops)</td>
<td>125.39</td>
</tr>
</tbody>
</table>

*Experimental conditions of side-tone were (1) undelayed side-tone, (2) delayed side-tone, (3) delayed side-tone (sic), (4) undelayed side-tone, and (5) undelayed side-tone preceded by six minutes of silence.
TABLE VI

THE DIFFERENCES BETWEEN THE MEANS OF THE MEASURES OF THE SPEECH OF STUTTERERS FOUND TO BE SIGNIFICANT DURING ORAL READING, SPONTANEOUS SPEECH, AND ASSOCIATED SUSTAINING OF VOWELS UNDER FIVE CONDITIONS OF SIDE-TONE

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Rate of Speaking</th>
<th>Measures of Stutterers' Speech</th>
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<tbody>
<tr>
<td></td>
<td>Frequency of Blocks in (accumulated)</td>
<td>Duration of Blocks (sec.)</td>
</tr>
<tr>
<td>Side-Tone</td>
<td>Stuttering States (sec.)</td>
<td>Stuttering phrases or statements)*** Vowels (ops)****</td>
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<tr>
<td>1 - 2</td>
<td>11.07</td>
<td>19.85</td>
</tr>
<tr>
<td>1 - 3</td>
<td>14.77</td>
<td>19.45</td>
</tr>
<tr>
<td>1 - 4</td>
<td>3.70</td>
<td>.62</td>
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<td>1.40</td>
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<tr>
<td>2 - 4</td>
<td>10.37</td>
<td>19.23</td>
</tr>
<tr>
<td>2 - 5</td>
<td>14.07</td>
<td>20.72</td>
</tr>
<tr>
<td>3 - 4</td>
<td>11.07</td>
<td>18.83</td>
</tr>
<tr>
<td>3 - 5</td>
<td>14.77</td>
<td>20.32</td>
</tr>
<tr>
<td>4 - 5</td>
<td>3.70</td>
<td>1.49</td>
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</table>

Oral Reading

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>1 - 2</td>
<td>18.67</td>
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<td>1 - 4</td>
<td>7.13</td>
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<tr>
<td>1 - 5</td>
<td>3.33</td>
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<td>2 - 3</td>
<td>.70</td>
</tr>
<tr>
<td>2 - 4</td>
<td>11.51</td>
</tr>
<tr>
<td>2 - 5</td>
<td>15.31</td>
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<tr>
<td>3 - 4</td>
<td>10.81</td>
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<td>3 - 5</td>
<td>14.64</td>
</tr>
<tr>
<td>4 - 5</td>
<td>3.80</td>
</tr>
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</table>

* Differences of 5.70 (.05) and 8.09 (.01) within a column are significant for oral reading; whereas, differences of 5.39 (.05) and 7.64 (.01) within a column are significant for spontaneous speech.

** Differences of 11.51 (.05) and 16.32 (.01) within a column are significant for oral reading; whereas, differences of 18.39 (.05) and 26.09 (.01) within a column are significant for spontaneous speech.

*** Differences of 15.31 (.05) and 21.76 (.01) within a column are significant for oral reading; whereas, differences of 27.38 (.05) and 38.84 (.01) within a column are significant for spontaneous speech.

**** Differences of 4.16 (.05) and 5.90 (.01) within a column are significant for oral reading; whereas, differences of 3.23 (.05) and 4.59 (.01) within a column are significant for spontaneous speech.
speaking tasks, the hypothesis was not rejected for fundamental frequency of voice.

Table IV shows that in oral reading and sustaining of vowels, the F-ratios with 4 and 112 degrees of freedom were 19.28 for frequency of stuttering blocks, 7.44 for duration of stuttering blocks, 2.67 for oral reading rate, and 1.74 for fundamental frequency of voice. In spontaneous speech and sustaining of vowels, the F-ratios with 4 and 112 degrees of freedom were 18.38 for frequency of stuttering blocks, 7.05 for duration of stuttering blocks, 8.77 for rate of spontaneous speaking, and .15 for fundamental frequency of voice.

The consistent values of the interaction in Table IV indicated that the two sub-groups, when separated on the basis of their frequency of stuttering blocks, responded differently to the experimental conditions. The mean values of the conditions for each group were analyzed separately (subjects by conditions analysis of variance). These analyses tested a sub-hypothesis.

1) In the instances of the "most severe" stutterers, there are no statistically significant differences among the mean values of the five experimental conditions (N = 15).

In both kinds of speaking and the associated sustaining of vowels, the hypothesis was rejected for frequency of stuttering blocks, duration of stuttering blocks, and fundamental frequency of voice at the five per cent levels. The hypothesis was not rejected for either rate of oral reading or spontaneous speaking.
Table VII shows that the F-ratios with 4 and 56 degrees of freedom 17.03 for frequency of stuttering blocks, 7.13 for duration of stuttering blocks, 4.59 for fundamental frequency of voice, and .39 for oral reading rate in the instances of oral reading and sustaining of vowels. In spontaneous speech and sustaining of vowels, the F-ratios were 19.33 for frequency of stuttering blocks, 7.08 for duration of stuttering blocks, 11.67 for fundamental frequency of voice, and 1.74 for rate of spontaneous speaking.

The hypothesis was rejected for the "least severe" stutterers (N = 15) in oral reading and associated sustaining of vowels for frequency of stuttering blocks, fundamental frequency of voice, and oral reading rate, but not rejected for duration of stuttering blocks. In spontaneous speech and associated sustaining of vowels, the hypothesis was rejected for fundamental frequency of voice and rate of spontaneous speaking, but not rejected for frequency and duration of stuttering blocks.

Table VIII shows that the F-ratios with 4 and 56 degrees of freedom were 3.63 for frequency of stuttering blocks, 4.05 for fundamental frequency of voice, 78.10 for oral reading rate, and 2.07 for duration of stuttering blocks in oral reading and sustaining of vowels. In spontaneous speech and sustaining of vowels, the F-ratios were 99.72 for rate of spontaneous speaking, 7.77 for fundamental frequency, .64 for frequency of stuttering blocks, and .22 for duration of stuttering blocks.

The mean values of the sub-groups are listed in Tables IX and X. Summaries of statistical differences among the mean values are shown in Tables XI and XII.
TABLE VII


<table>
<thead>
<tr>
<th>Sources of Variation</th>
<th>Degrees of Freedom</th>
<th>Oral Reading</th>
<th>Spontaneous Speech</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>F Variance</td>
<td>F Variance</td>
</tr>
<tr>
<td>Frequency of Stuttering Blocks</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Subjects (S)</td>
<td>14</td>
<td>4031.32</td>
<td>4259.15</td>
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<tr>
<td>Conditions (C)</td>
<td>4</td>
<td>17.03*</td>
<td>19.33*</td>
</tr>
<tr>
<td>SC Interaction</td>
<td>56</td>
<td>236.70</td>
<td>220.32</td>
</tr>
<tr>
<td>Total</td>
<td>74</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duration of Stuttering Blocks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subjects (S)</td>
<td>14</td>
<td>7357.78</td>
<td>18711.25</td>
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<tr>
<td>Conditions (C)</td>
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<td>7.13*</td>
<td>7.08*</td>
</tr>
<tr>
<td>SC Interaction</td>
<td>56</td>
<td>1031.59</td>
<td>2641.75</td>
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<td>Total</td>
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<td>Rate of Speaking</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Subjects (S)</td>
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<td>504.17</td>
<td>9785.29</td>
</tr>
<tr>
<td>Conditions (C)</td>
<td>4</td>
<td>.39</td>
<td>1.74</td>
</tr>
<tr>
<td>SC Interaction</td>
<td>56</td>
<td>1280.84</td>
<td>5621.35</td>
</tr>
<tr>
<td>Total</td>
<td>74</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Fundamental Frequency of Sustained Vowels Associated With Oral Reading and Spontaneous Speech</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subjects (S)</td>
<td>14</td>
<td>322.90</td>
<td>387.03</td>
</tr>
<tr>
<td>Conditions (C)</td>
<td>4</td>
<td>4.59**</td>
<td>11.67*</td>
</tr>
<tr>
<td>SC Interaction</td>
<td>56</td>
<td>70.28</td>
<td>33.16</td>
</tr>
<tr>
<td>Total</td>
<td>74</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*F-ratio significant at the one-tenth of the one per cent level of confidence.

**F-ratio significant at the five-tenths of the one per cent level of confidence.
<table>
<thead>
<tr>
<th>Sources of Variation</th>
<th>Degrees of Freedom</th>
<th>Variance</th>
<th>F</th>
<th>Variance</th>
<th>F</th>
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<td>Spontaneous Speech</td>
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<td></td>
</tr>
<tr>
<td>Frequency of Stuttering Blocks</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Subjects (S)</td>
<td>14</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conditions (C)</td>
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<td>59.17</td>
<td>3.63**</td>
<td>3.10</td>
<td>.44</td>
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<tr>
<td>SC Interaction</td>
<td>56</td>
<td>16.31</td>
<td>7.08</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>74</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Duration of Stuttering Blocks |
| Subjects (S)         | 14                |           |       |          |       |
| Conditions (C)       | 4                 | 4.77      | 2.07  | .26      | .22   |
| SC Interaction       | 56                | 3.18      | 1.17  |          |       |
| Total                | 74                |           |       |          |       |

| Rate of Speaking |
| Subjects (S)         | 14                |           |       |          |       |
| Conditions (C)       | 4                 | 18776.78  | 78.10*| 23300.60 | 99.72*|
| SC Interaction       | 56                | 240.42    | 233.65|          |       |
| Total                | 74                |           |       |          |       |

| Average Fundamental Frequency of Sustained Vowels Associated With Oral Reading and Spontaneous Speech |
| Subjects (S)         | 14                |           |       |          |       |
| Conditions (C)       | 4                 | 496.26    | 4.05**| 402.81   | 7.77* |
| SC Interaction       | 56                | 122.29    | 51.83 |          |       |
| Total                | 74                |           |       |          |       |

*F-ratio significant at the one-tenth of the one per cent level of confidence.
**F-ratio significant at the one per cent level of confidence.
TABLE IX

THE MEANS OF THE FOUR MEASURES OF THE MOST SEVERE STUTTERERS' SPEECH DURING ORAL READING, SPONTANEOUS SPEECH, AND ASSOCIATED SUSTAINING OF VOWELS UNDER FIVE CONDITIONS OF SIDE-TONE

<table>
<thead>
<tr>
<th>Four Measures of Stutterers' Speech</th>
<th>Conditions of Side-Tone*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
</tr>
<tr>
<td><strong>Oral Reading</strong></td>
<td></td>
</tr>
<tr>
<td>Frequency of Stuttering Blocks in 200 words</td>
<td>45.20</td>
</tr>
<tr>
<td>Duration of Stuttering Blocks (seconds) in 200 words</td>
<td>48.19</td>
</tr>
<tr>
<td>Rate of Oral Reading (Accumulated seconds for reading twenty-five 10-syllable phrases)</td>
<td>109.19</td>
</tr>
<tr>
<td>Average Fundamental Frequency of Four Sustained Vowels (ops)</td>
<td>122.54</td>
</tr>
<tr>
<td><strong>Spontaneous Speech</strong></td>
<td></td>
</tr>
<tr>
<td>Frequency of Stuttering Blocks in 200 words</td>
<td>52.00</td>
</tr>
<tr>
<td>Duration of Stuttering Blocks (seconds) in 200 words</td>
<td>99.90</td>
</tr>
<tr>
<td>Rate of Spontaneous Speaking (Accumulated seconds for making twenty-five approximately 10-syllable statements about pictures)</td>
<td>199.35</td>
</tr>
<tr>
<td>Average Fundamental Frequency of Four Sustained Vowels (ops)</td>
<td>125.62</td>
</tr>
</tbody>
</table>

*The experimental conditions were (1) undelayed side-tone, (2) delayed side-tone, (3) delayed side-tone, (4) undelayed side-tone, and (5) undelayed side-tone preceded by six minutes of inactivity.
### Table X

**The Means of the Four Measures of the Least Severe Stutterers' Speech During Oral Reading, Spontaneous Speech, and Associated Sustaining of Vowels Under Five Conditions of Side-Tone**

<table>
<thead>
<tr>
<th>Four Measures of Stutterers' Speech</th>
<th>Conditions of Side-Tone*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
</tr>
<tr>
<td><strong>Oral Reading</strong></td>
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</tr>
<tr>
<td>Frequency of Stuttering Blocks in 200 words</td>
<td>4.73</td>
</tr>
<tr>
<td>Duration of Stuttering Blocks (seconds) in 200 words</td>
<td>2.01</td>
</tr>
<tr>
<td>Rate of Oral Reading (Accumulated seconds in reading twenty-five 10-syllable phrases)</td>
<td>56.98</td>
</tr>
<tr>
<td>Average Fundamental Frequency of Four Sustained Vowels (cps)</td>
<td>125.02</td>
</tr>
<tr>
<td><strong>Spontaneous Speech</strong></td>
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</tr>
<tr>
<td>Frequency of Stuttering Blocks in 200 words</td>
<td>5.20</td>
</tr>
<tr>
<td>Duration of Stuttering Blocks (seconds) in 200 words</td>
<td>1.83</td>
</tr>
<tr>
<td>Rate of Spontaneous Speaking (Accumulated seconds in making twenty-five approximately 10-syllable statements about pictures)</td>
<td>66.63</td>
</tr>
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</table>

*The experimental conditions were (1) undelayed side-tone, (2) delayed side-tone, (3) delayed side-tone, (4) undelayed side-tone, and (5) undelayed side-tone preceded by six minutes of inactivity.
TABLE XI


<table>
<thead>
<tr>
<th>Condition of Side Tone</th>
<th>Measures of Stutterers' Speech</th>
<th>Frequency of Stuttering Blocks in 200 words*</th>
<th>Duration of Stuttering Blocks (sec.)</th>
<th>Average Fundamental Frequency of Four Vowels (cps)***</th>
</tr>
</thead>
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<td><strong>Oral Reading</strong></td>
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<td></td>
</tr>
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<td>41.24</td>
<td>7.25</td>
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<td>31.20</td>
<td>39.28</td>
<td>8.06</td>
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<td>7.40</td>
<td>1.16</td>
<td>4.21</td>
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<td>1.57</td>
<td>2.72</td>
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<td>2 - 3</td>
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<td>25.40</td>
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<td>32.47</td>
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<td>38.12</td>
<td>3.85</td>
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<td>30.87</td>
<td>40.85</td>
<td>10.78</td>
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<td>4 - 5</td>
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<td>7.07</td>
<td>2.73</td>
<td>6.93</td>
</tr>
<tr>
<td><strong>Spontaneous Speech</strong></td>
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<td></td>
<td></td>
</tr>
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<td>1 - 2</td>
<td></td>
<td>36.73</td>
<td>82.90</td>
<td>9.46</td>
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<tr>
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<td>34.93</td>
<td>81.72</td>
<td>10.60</td>
</tr>
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<td>1 - 4</td>
<td></td>
<td>13.13</td>
<td>42.70</td>
<td>5.12</td>
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<td>1 - 5</td>
<td></td>
<td>5.73</td>
<td>30.59</td>
<td>.20</td>
</tr>
<tr>
<td>2 - 3</td>
<td></td>
<td>1.80</td>
<td>1.18</td>
<td>1.14</td>
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<tr>
<td>2 - 4</td>
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<td>23.60</td>
<td>40.20</td>
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<td>3 - 5</td>
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<td>29.20</td>
<td>51.13</td>
<td>10.80</td>
</tr>
<tr>
<td>4 - 5</td>
<td></td>
<td>7.10</td>
<td>12.11</td>
<td>5.32</td>
</tr>
</tbody>
</table>

* Differences of 11.02 (.05) and 15.62 (.01) within a column are significant for oral reading; whereas, differences of 10.62 (.05) and 15.07 (.01) within a column are significant for spontaneous speech.

** Differences of 22.98 (.05) and 32.60 (.01) within a column are significant for oral reading; whereas, differences of 36.78 (.05) and 52.17 (.01) within a column are significant for spontaneous speech.

*** Differences of 6.00 (.05) and 8.51 (.01) within a column are significant for oral reading; whereas, differences of 4.12 (.05) and 5.84 (.01) within a column are significant for spontaneous speech.
TABLE XII


<table>
<thead>
<tr>
<th>Conditions of Side-Tone</th>
<th>Measures of Stutterers' Speech</th>
<th>Rate of Speaking</th>
<th>Average Fundamental Frequency of Sustained Vowels (cps)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency of Stuttering Blocks in 200 words*</td>
<td>(accumulated time for 25 ten-syllable phrases or statements)**</td>
<td>***</td>
</tr>
</tbody>
</table>

**Oral Reading**

- 1 - 2: 4.67, 69.28, 15.40
- 1 - 3: 1.67, 64.05, 16.26
- 1 - 4: 0.00, 3.13, 5.18
- 1 - 5: .34, 3.49, 3.47
- 2 - 3: 3.00, 5.23, .86
- 2 - 4: 4.67, 66.15, 10.22
- 2 - 5: 4.33, 65.79, 11.93
- 3 - 4: 1.67, 60.92, 11.08
- 3 - 5: 1.33, 60.56, 12.79
- 4 - 5: .34, .36, 1.79

**Spontaneous Speech**

- 1 - 2: 72.66, 9.94
- 1 - 3: 71.65, 11.80
- 1 - 4: .21, 4.42
- 1 - 5: .36, 1.43
- 2 - 3: 1.51, 1.86
- 2 - 4: 72.45, 5.52
- 2 - 5: 73.02, 8.51
- 3 - 4: 70.94, 7.38
- 3 - 5: 71.51, 10.37
- 4 - 5: 57, 2.99

*Differences of 2.89 (.05) and 4.10 (.01) within a column are significant for oral reading.

**Differences of 11.10 (.05) and 15.74 (.01) within a column are significant for oral reading; whereas, differences of 10.94 (.05) and 15.52 (.01) within a column are significant for spontaneous speech.

***Differences of 7.91 (.05) and 11.22 (.01) within a column are significant for oral reading; whereas, differences of 5.15 (.05) and 7.30 (.01) are significant for spontaneous speech.
The two sub-groups of stutterers were formed for each speaking task separately on the basis of the mean frequency of stuttering blocks during the first and fifth experimental conditions. In most cases, the mean values of the "most severe" stutterers are statistically significantly different between conditions of delayed side-tone and non-delayed side-tone, and not different in other comparisons. This outcome is consistent in both oral reading and spontaneous speaking. However, in the instances of rate of oral reading and spontaneous speaking, the mean values of the conditions do not differ statistically.

The mean values of the "least severe" stutterers are statistically significantly different between conditions of delayed side-tone and non-delayed side-tone in the instances of rate of speaking and fundamental frequency of voice in both of the speaking tasks and the associated sustaining of vowels. In one condition of delayed side-tone during oral reading, the mean value for frequency of stuttering blocks differed significantly from those of the other conditions. Otherwise, the mean values for both frequency and duration of stuttering blocks did not differ statistically among the conditions in either of the speaking tasks.
CHAPTER VI
DISCUSSION OF RESULTS

The purposes of this study were (1) to investigate the effects of delayed side-tone upon the fluency of stutterers, i.e., frequency of stuttering blocks, duration of stuttering blocks, and rate of speaking during oral reading and spontaneous speech; (2) to determine the extent by which the fundamental frequency of voice of stutterers is affected by delayed side-tone; (3) to compare the "most severe" stutterers and the "least severe" stutterers of the group with respect to the aspects of speech listed in (1) and (2) as affected by delayed side-tone; and (4) to determine whether or not the effects of delayed side-tone persisted in stutterers' speech after the delay was eliminated from their side-tone.

Naylor reported that the rate of speaking of "mild" stutterers appeared to be more affected by delayed side-tone than was the rate of "severe" stutterers. \textsuperscript{48} Laboratory observations by the writer sug-

\textsuperscript{48}Naylor, \textit{loc. cit.}

gested that the stuttering blocks of both "severe" and "mild" stutterers appeared to be modified throughout a range of amounts of delayed side-tone. Severe stutterers were observed to reduce the severity of their stuttering blocks, whereas mild stutterers were observed to stutter somewhat more severely.
Fairbanks reported higher fundamental frequencies of voice on the part of non-stuttering individuals who experienced delayed side-tone. Presumably this higher pitch attended an increase of stress that the speakers experienced as a reaction to the delayed side-tone. There is a possibility that stress may be reduced for stutterers under delayed side-tone. In this event, the fundamental frequency of the voice of stutterers might not rise (in fact, it might become lower). It is also conceivable that "severe" stutterers may experience a greater reduction of stress than "mild" stutterers.

In the present study, stutterers (N = 30) read 10-syllable phrases, described pictures, and sustained vowels after oral reading and after spontaneous speaking in each of the following five serially ordered experimental conditions: (1) undelayed side-tone, (2) delayed side-tone, (3) delayed side-tone _, (4) undelayed side-tone, and (5) delayed side-tone preceded by six minutes of silence. The measures in each of the conditions were (1) mean frequency of stuttering blocks, (2) mean duration of stuttering blocks, (3) mean rate of speaking, and (4) mean fundamental frequency of voice.

Fundamental frequency of voice was considered to be the average fundamental frequency of four different vowels sustained by each of the stutterers after oral reading and after spontaneous speaking and under the conditions of the experiment.
The "most severe" stutterers and the "least severe" stutterers were formed on the basis of the mean number of stuttering blocks tallied and computed by the writer for each stutterer in a speaking task during the first and last undelayed side-tone conditions. These conditions were used for measuring severity of stuttering as they were considered by the writer to be representative of the stutterers' "normal" speech behavior. The stutterers were then ranked according to the severity of their stuttering and divided equally into two groups (15 per group).

The Immediate Effects of Delayed Side-Tone on the Speech of Stutterers

An aspect of stutterers' speech was considered to be affected by delayed side-tone when the mean value of either of the delayed side-tone conditions (II or III) was found to differ significantly from those of the non-delayed side-tone conditions (I, IV and V). Further support was given when the effects were observed to occur consistently for both conditions of delayed side-tone (II and III) and when the outcomes were similar for both speaking tasks and associated sustaining of vowels.

Frequency and duration of stuttering blocks. A comparison of the mean values listed in Table V of the preceding chapter indicate that stutterers as a group \( N = 30 \) reduced the frequency and duration of their stuttering blocks as an effect of delayed side-tone. Table VI discloses that the differences between the non-delayed side-tone conditions (I, IV, and V) and the delayed side-tone conditions (II and III) are statistically significant. These outcomes were found to be consistent for both of the speaking tasks.
Table IV has also shown that significant interactions were found to occur between the five experimental conditions and the two sub-groups of stutterers for both frequency and duration of stuttering blocks. These results posed two possibilities. One of the sub-groups accounted for all of the differences among the five experimental conditions for stutterers as a group (the other sub-group yielding the same scores throughout the experiment); or both sub-groups were affected differently by delayed side-tone.

It is seemingly apparent from the mean values listed in Tables IX and X that the "most severe" stutterers probably accounted for most of the significant decreases in frequency and duration of stuttering blocks incurred by the conditions of delayed side-tone for stutterers as a group.

The possibility that the two sub-groups were affected differently by delayed side-tone was also considered in the study. In comparison to the "most severe" stutterers, the "least severe" stutterers stuttered more frequently under delayed side-tone in oral reading. Table XII discloses, however, that significant differences were found only between the first condition of delayed side-tone (II) and the non-delayed side-tone conditions (I, IV, and V). This result did not occur in the spontaneous speech task that followed oral reading as no significant differences were found to occur among any of the five conditions.

Also, at no time during the speaking tasks was the duration of stuttering blocks significantly modified for the "least severe" stutterers under delayed side-tone.
Rate of speaking. Again, comparing the mean values in Table V, it shows that the stutterers as a group decreased their speaking rate under delayed side-tone. This outcome was more consistent in oral reading than in spontaneous speaking. Table VI discloses that significant differences in oral reading rate were found when the delayed side-conditions (II and III) were compared to the non-delayed side-tone conditions (I, IV, and V). In spontaneous speech, the difference in speaking rate was not statistically significant between the first non-delayed side-tone condition (I) and the two delayed side-tone conditions (II and III).

As Table IV showed significant interactions between the five experimental conditions of side-tone and the two sub-groups of stutterers for rate of speaking the two possibilities of the results were again considered.

It is seemingly apparent from the mean values listed in Tables IX and X that the "least severe" stutterers probably accounted for most of the significant decreases in rate of speaking incurred by the conditions of delayed side-tone for stutterers as a group.

The other possibility that the two sub-groups were affected differently by delayed side-tone is of equal importance. In comparison to the "least severe" stutterers, the "most severe" stutterers showed no significant change in speaking rate under delayed side-tone. This outcome was found to be consistent for both speaking tasks.
Fundamental frequency of voice. A comparison of mean values also in Table V indicate that stutterers as a group increased the fundamental frequency of their voice under delayed side-tone. Table VI revealed that the differences between the non-delayed side-tone (I, IV, and V) and the delayed side-tone conditions (II and III) were statistically significant. This outcome was found to be consistent in the vocalizing tasks associated with both kinds of speaking.

The increases in fundamental frequency of voice under delayed side-tone seemed to be substantial, indicating that stutterers as a group tend to react to the effects of delayed side-tone with some amount of stress. Table IV also disclosed that no significant interactions occurred between the experimental conditions and the subgroups of stutterers for fundamental frequency of voice. In other words, both sub-groups of stutterers responded to delayed side-tone similarly with respect to the pitch of their voices.

Possible interpretations of the findings. The studies reviewed in Chapter II may shed some light on interpreting the results of this study. It must be kept in mind, however, that these are merely hypotheses presented by the writer.

The investigations involving the side-tone of non-stutterers suggest that "mild" stutterers may behave much the same way as normal speakers under delayed side-tone, i.e., decreased rate of speaking, higher pitch, and stuttering symptoms. These effects on the speech of "mild" stutterers may be the result of a disturbed speech-auditory feedback loop.
The finding that the "least severe" stutterers initially increased the frequency of their stuttering blocks as a reaction to delayed side-tone and then experienced no further change in subsequent conditions throughout oral reading and spontaneous speech may be interpreted as a form of adaptation.\(^{51}\)

\(^{51}\) *Supra*, p. 16.

Other studies in Chapter II hypothesized that the disturbed feedback loop produced in non-stutterers by delayed side-tone may be constantly present in some stutterers. Stromsta's study implied that stutterers as a group had a larger inter-ear discrepancy for bone-conducted side-tone than non-stutterers. A condition was suggested to exist within the stutterers that simulated the delayed side-tone phenomenon in non-stutterers. It was also hypothesized that the phase discrepancy was greater near the fundamental frequency of the stutterers' voices.\(^{52}\) In a later study, he found that stutterers simultaneously raised the fundamental frequency of their voice and reduced the frequency of their stuttering blocks under conditions of auditory masking. An inverse relationship was found to exist between the mean fundamental frequency of the voice and the mean number of stuttering blocks under the conditions of the study.\(^{53}\)

\(^{52}\) *Stromsta, loc. cit.*

\(^{53}\) *Stromsta, loc. cit.*
Similarly, in this study, stutterers simultaneously raised the fundamental frequency of their voice and reduced the severity of their stuttering blocks under delayed side-tone. Since the "most severe" stutterers of the study accounted for probably all the significant decreases in stuttering severity under delayed side-tone, Pearson product-moment correlations were computed between the two aspects of speech for this sub-group of stutterers. The mean fundamental frequency of the voice under each of the conditions of the speaking tasks was correlated with both the mean frequency and duration of stuttering blocks under each of the conditions of the speaking tasks. The conditions in the tasks were combined for a total N of 10. Coefficients of $r = -0.77$ and $-0.57$ were found between the mean fundamental frequency of voice and the mean frequency and duration of stuttering blocks respectively.

The study by House may also have application to the results of the present study. He found that cerebral palsied speakers, individuals with known involvements of the central nervous system and proprioceptive feedback capacities, are facilitated in speech by delayed side-tone.\(^5\)\(^4\) Insofar as some types of stutterers have been hypothesized to have defective auditory feedback mechanisms, the findings in this study are in keeping with a physiological explanation of stuttering behavior.

\(^5\)\(^4\)House, loc. cit.
These speculations must be tempered by the fact that stuttering is a complex speech behavior and little is known about its etiology. The hypotheses suggested by the writer and those implied by other researches may not only be speculations, but over-simplifications of the phenomenon. At least, the study provides a direction for further research.

The Persistence of the Effects of Delayed Side-Tone on Stutterers' Speech

The persistence of the effects of delayed side-tone was studied in Condition IV. This condition followed immediately after the delay ceased to be present in the side-tone of the stutterers. The occurrence of persistence was suggested when statistically significant differences were found between the mean values of both pairs of conditions I and IV and IV and V. A significant difference found only between one of the pairs of conditions was not looked upon as supporting evidence of persistence.

Frequency and duration of stuttering blocks. A comparison of the mean values in Table V indicate that stutterers showed negligible decreases in frequency and duration of stuttering blocks as a persistence effect of delayed side-tone. Table VI discloses that the differences between the pairs of Conditions I and IV and IV and V were not concurrently statistically significant. These findings were consistent in both speaking tasks.
A comparison of the mean values in Tables IX and X also reveals negligible persistence effects for the two sub-groups of stutterers.

The main interest in this part of the study was to determine whether or not a decrease in stuttering severity continued for the "most severe" stutterers after the delay was eliminated from their side-tone. Although the phenomenon was observed for individual stutterers during the experiment, a possible explanation of the negative results may be partially due to the speaking materials used in the study. It has been commented before that the persistence effects of delayed side-tone were thought to be short-lived in stutterers' speech. As subjects read phrases or made statements about pictures, the time consumed between utterances may have minimized the occurrence of persistence. If continuous speaking would have followed the elimination of the delay in the stutterers' side-tone, it is conceivable that some significant persistence might have occurred.

Another explanation of the negative results may be possibly due to the fact that some stutterers were observed to stutter more severely after the delay was eliminated from their side-tone. It is conceivable that some stutterers after experiencing a period of relative freedom from stuttering blocks under delayed side-tone, were under some amount of stress that attended the recovery of their stuttering. Consequently, these individuals may have stuttered more severely as a reaction to the stress.
Rate of speaking. A comparison of mean values in Table V also reveals that persistence for rate of speaking is negligible. Table VI discloses the differences between the pairs of Conditions I and IV and Conditions IV and V were not concurrently statistically significant. This finding was consistent for both oral reading and spontaneous speech.

A comparison of the mean values in Tables IX and X also reveals that negligible persistence effects occurred for the two sub-groups of stutterers.

Fundamental frequency of voice. Table V shows that stutterers continued to raise the fundamental frequency of their voice during the sustaining of vowels after both speaking tasks in Condition IV. Table VI discloses that the differences between the pairs of Conditions I and IV and IV and V were concurrently statistically significant.

When the sub-groups of stutterers were analyzed separately, a significant persistence in this respect was not generally found during the vowel tasks associated with both kinds of speaking. However, the "most severe" stutterers showed some significant persistence in fundamental frequency of voice during the vowel tasks associated with spontaneous speech. See Tables IX and X for comparisons of mean values.

The persistence effects of delayed side-tone, for the most part, were non-significant with regard to the aspects of speech measured in this study. It is conceivable that with more controlled experiments, some significant persistence effects of delayed side-tone might be found with respect to the fluency of stutterers' speech.
Discussion of Adaptation Occurring in the Study

Adaptation, the progressive reduction of stuttering severity over a period of speaking, was under test in Condition V. It is conceivable that if a significant reduction of stuttering severity occurs between Conditions I and V in the speaking tasks, adaptation may be considered an important variable in the study. A comparison of the mean values listed in Table V reveals that adaptation was generally minimal for all the fluency measures of the study for stutterers as a group in both speaking tasks. Table VI discloses no statistically significant differences between the mean values in Conditions I and V for either speaking tasks.

When the two speaking tasks are compared, however, it is apparent that more adaptation occurred for spontaneous speech than for oral reading. This adaptation, although insignificant, was probably responsible to some extent for the inconsistent results found for the spontaneous speaking rate of stutterers as a group in comparison to their oral reading rate under the conditions of the study.

It is also seemingly apparent from the mean values listed in Tables IX and X that the "most severe" stutterers probably accounted for most of the adaptation in the study.

The outcomes of the study did not generally appear to be affected by adaptation. The larger reductions of stuttering blocks occurring between the delayed side-tone conditions and the non-delayed side-tone conditions can hardly be accounted for by the effects
of adaptation. Furthermore, the results were similar for two kinds of speaking.
CHAPTER VII
SUMMARY

The purposes of the study reported here were (1) to investigate the effects of delayed side-tone on the fluency of stutterers, i.e., frequency of stuttering blocks, duration of stuttering blocks, and rate of speaking during oral reading and spontaneous speech; (2) to determine the extent by which the fundamental frequency of voice was affected by delayed side-tone; (3) to compare the "most severe" stutterers and the "least severe" stutterers with respect to the two preceding measures, and (4) to determine whether or not the effects of delayed side-tone persisted in stutterers' speech after the delay was eliminated from their side-tone.

The stutterers (N = 30) who participated in the study read a list of 10-syllable phrases, described a set of pictures, and sustained vowels after the oral reading and after the spontaneous speaking in each of the following five serially ordered experimental conditions: (1) undelayed side-tone, (2) delayed side-tone, (3) delayed side-tone \( \text{sic} \), (4) undelayed side-tone, and (5) delayed side-tone preceded by six minutes of silence.

The condition of delayed side-tone under which the stutterers performed approximated .14 second. The precise delay time was determined prior to the experiment for each subject individually. Subjects judged whether or not one of the various conditions of delayed side-tone reduced the severity of their stuttering blocks. Those individ-
uals who experienced no difference among the delay times that were tried experimentally, talked in the experiment with the delay time of \( \frac{1}{4} \) second.

The recorded oral reading, spontaneous speech, and associated sustaining of vowels were analyzed by the writer. He listened to the recordings and scored the instances of stuttering by using a stylus on a Lafayette Company polygraph to mark the beginning and end of stuttering blocks on a tape moving at a constant speed of three mm per second. The first 200 words of each list of 10-syllable phrases or descriptions about a set of pictures were used for scoring frequency and duration of stuttering blocks.

Rate or duration of speaking was determined by reproducing the acoustically recorded speech samples visually on the paper of a power level recorder, Sound Apparatus Company, Model HPL, and measuring the tracings in seconds based on the paper speed of 10 mm per second. Rate of speaking was the accumulated time in reading a list of 10-syllable phrases or in making statements, approximately 10-syllables, about a set of pictures. The samples of speech in both instances totaled 250 syllables.

The fundamental frequency of voice was the average fundamental frequency of four different vowels sustained after oral reading and after spontaneous speaking and under the conditions of the experiment. The fundamental frequency of each vowel was measured by the electronic counter, Hewlett Packard, Model 522 B. The instrument displays a count of cycles per unit of time - in this instance one second - in direct reading form.
The reliability of the writer in scoring frequency of stuttering blocks was determined by comparing the original scorings of the writer with the scorings of a second observer and with the second scorings of the writer. The reliability values were based on the over-all per cent agreement of stuttering blocks occurring in the complete oral reading records of four experimental subjects picked by lot from the group of stutterers. The reliability values were computed from a formula recommended by Festinger:

\[
\frac{\text{SUM OF AGREEMENTS} \times 100}{\text{SUM OF AGREEMENTS} + \text{SUM OF DISAGREEMENTS}}
\]

55Festinger, loc. cit.

The writer agreed with the second observed 78 per cent
\[
\frac{398 \times 100}{398 + 115} \quad \text{The writer agreed with himself 83 per cent} \quad \frac{411 \times 100}{411 + 86}
\]

Pearson product-moment correlations, r, were also computed between the original frequency scorings of the writer and with the scorings of a second observer and the second scorings of the writer. The records of the four subjects were grouped together into 71 successive sections of four 10-syllable phrases. Each of the 71 sections for both observers were compared for frequency of stuttering blocks. The reliability value based on the coefficient for the writer and the second observer was r, .92. Based on the coefficient for the writer and his second scorings, r was .96.

The reliability values for the writer and the other observer, and the writer and himself in measuring duration of stuttering blocks was also determined by product-moment correlations. The same 71 sec-
tions of records used previously were utilized for comparing durations of stuttering blocks between observers. The reliability value based on the coefficient for the writer and the second observer was \( r = .93 \). Based on the coefficient for the writer and himself, \( r \) was .97.

The reliability of the power level recorder was determined by assessing the disparity between it and the logger, Audio Instrument Company, Model 124P, with an accompanying direct writing oscillograph, Edin, Model 8003, for measuring rate of speaking. Two lists of 10-syllable phrases from each of two subjects used previously were utilized for determining the reliability of the power level recorder. The measurement by the power level recorder of the first list for Subject I was 122.60 seconds; the same measurement by the logger and accompanying direct writing oscillograph was 122.80 seconds. The disparity between the two measures was .20 second. The second list for Subject I measured 177.70 seconds by the power level recorder and 177.24 by the second instrument. The disparity between the two measures was .46 second. For Subject II the first list measured by the power level recorder was 95.50 seconds; the second list 121.50 seconds. The first list measured by the logger and an accompanying direct writing oscillograph was 95.96 seconds; the second list 122.32 seconds. The disparity between the measures of the first set was .46 second; the second set .82 second.

The reliability of the electronic counter was determined by assessing the disparity between it and the writer's count of the visual-
ly reproduced waves. The visual traces were provided by the direct writing oscillograph, Edin, Model 8003 (tape speed of recorded vowels reduced from 8:1 before re-recorded on the oscillograph). Two sets of vowels from each of two subjects used previously were utilized to determine the reliability of the electronic counter. The measurement by the electronic counter of the first set for Subject I was 128.70 cycles; for the second, 148.25 cycles. The measurements by the other technique were 128.08 cycles for the first set and 147.82 cycles for the second set. The disparity between the measures of the first set was 0.62 cycle; the second set 0.43 cycle. For this, the counter had tallied the cycles of a "central" period in each of the four vowels. The writer did the same, working from the graphic records of the vowels provided by the direct writing oscillograph. For Subject II, the measurements by the electronic counter were 89.68 cycles for the first set of vowels and 92.72 cycles for the second set. The measurements for the other technique were 87.62 cycles for the first set and 91.90 cycles for the second set. The disparity between the measures of the first set was 2.06 cycles; the second set, 1.02 cycles.

The reliability values in the study indicated that the writer, and the two instruments, the power level recorder and electronic counter, were consistent in securing the basic measures.

Hypotheses were formulated and tested with respect to three aspects of oral reading, three aspects of spontaneous speech, and the average fundamental frequency of four different vowels sustained by the stutterers under the influence of the given conditions and immediately after oral reading and after spontaneous speech. The
experimental conditions in each instance were those enumerated in the second paragraph of this chapter. The measures were (1) mean frequency of stuttering blocks, (2) mean duration of stuttering blocks, (3) mean rate of speaking, and (4) mean fundamental frequency of voice.

An analysis of variance, designated by Lindquist as Type I, was the major analytical procedure in the study. This design provided tests of the statistical significance of differences among the mean values that accompanied the five experimental conditions; it also provided tests of differential effects of the five experimental conditions upon the sub-groups of stutterers. The sub-groups, the "most severe" stutterers and the "least severe" stutterers, were formed on the basis of the mean frequency of stuttering blocks tallied and computed by the writer for each stutterer during the first and last non-delayed side-tone conditions in a speaking task. The sub-groups were analyzed separately (conditions by subjects analysis of variance) with respect to the mean values that accompanied the five experimental conditions.

The following null hypotheses were under test in the study:

1) There are no statistically significant differences among the mean values of the five experimental conditions for stutterers \((N = 30)\). Throughout, in oral reading and associated sustaining of vowels and in spontaneous speech and associated sustaining of vowels, the hypothesis was rejected for all measures of speech.
In the former instance (oral reading), the F-ratios were 12.83 for frequency of stuttering blocks, 6.79 for duration of stuttering blocks, 13.47 for rate of oral reading, and 15.04 for fundamental frequency of voice with 4 and 112 degrees of freedom. In the latter instance (spontaneous speech), the F-ratios were 19.10 for frequency of stuttering blocks, 7.10 for duration of stuttering blocks, 2.53 for spontaneous speaking rate, and 18.13 for fundamental frequency of voice with 4 and 112 degrees of freedom.

2) There is no significant interaction between the five experimental conditions and the severity of stuttering on the part of the subjects ("most severe - least severe" dichotomy was used). Throughout, in oral reading and spontaneous speech, the hypothesis was rejected for all measures of fluency. In connection with the sustaining of vowels after oral reading and after spontaneous speech, the hypothesis was not rejected for fundamental frequency of voice.

In oral reading and the associated sustaining of vowels, the F-ratios were 19.28 for frequency of stuttering blocks, 7.14 for duration of stuttering blocks, 2.67 for rate of oral reading and 1.74 for fundamental frequency of voice with 4 and 112 degrees of freedom. In spontaneous speech and associated sustaining of vowels, the F-ratios were 18.38 for frequency of stuttering blocks, 7.05 for duration of stuttering blocks, 8.77 for rate of spontaneous speaking, and .15 for fundamental frequency of voice with 4 and 112 degrees of freedom.
The two foregoing sets of results showed that the mean values of a group of stutterers (N = 30) differed significantly among two or more of the five experimental conditions; also that the amount of this difference was not the same for a "most severe" sub-group and "least severe" sub-group of stutterers. This pair of results posed two possibilities: one of the sub-groups accounted for all of the differences among the five experimental conditions (the other sub-group yielding the same mean score throughout the experiment); or both sub-groups were affected by the experimental conditions, but to dissimilar degrees. The following sub-hypotheses were utilized to test the above assumptions:

1) In the instances of the "most severe" stutterers (N = 15), there are no statistically significant differences among the mean values of the five experimental conditions. In oral reading and associated sustaining of vowels, the hypothesis was rejected for all measures of speech except oral reading rate. In spontaneous speech and associated sustaining of vowels, the hypothesis was rejected for all measures of speech except rate of spontaneous speaking.

In the former instance (oral reading), the F-ratios were 17.03 for frequency of stuttering, 7.13 for duration of stuttering blocks, 4.59 for fundamental frequency of voice, and .39 for oral reading rate with 4 and 56 degrees of freedom. In the latter instance (spontaneous speech), the F-ratios were 19.33 for frequency of stuttering blocks, 7.08 for duration of stuttering blocks, 11.67 for fundamental frequency of voice, and 1.74 for rate of spontaneous speaking with 4 and 56 degrees of freedom.
2) There are no statistically significant differences among the mean values of the five experimental conditions for the "least severe" stutterers (N = 15). In oral reading and associated sustaining of vowels, the hypothesis was rejected for frequency of stuttering blocks, rate of oral reading, and fundamental frequency of voice, but not duration of stuttering blocks. In spontaneous speech and associated sustaining of vowels, the hypothesis was rejected for spontaneous speaking rate and fundamental frequency of voice, but not frequency and duration of stuttering blocks.

In oral reading and associated sustaining of vowels, the F-ratios were 3.63 for frequency of stuttering blocks, 2.07 for duration of stuttering blocks, 78.10 for rate of oral reading, and 4.05 for fundamental frequency of voice with 4 and 56 degrees of freedom. In spontaneous speech and associated sustaining of vowels, the F-ratios were .44 for frequency of stuttering blocks, .22 for duration of stuttering blocks, 99.72 for rate of spontaneous speaking, and 7.77 for fundamental frequency of voice with 4 and 56 degrees of freedom.

In the analyses in which the F-ratios that pertained to the five experimental conditions were statistically significant, the t-tests were made to test the significance of differences between mean values.

An aspect of stutterers' speech was considered to be affected by delayed side-tone when significant differences were found to occur between the delayed side-tone conditions (II and III) and the other undelayed side-tone conditions (I, IV and V). The persistence of the effects of delayed side-tone was studied in Condition IV as this con-
dition followed immediately after the delay was eliminated from the side-tone. An aspect of stutterers' speech was suggested to be affected by the persistence effects of delayed side-tone when significant differences were found to occur between Condition IV and both of the other undelayed side-tone conditions (I and V). Adaptation, the progressive reduction in stuttering severity over a period of speaking, was under test in Condition V. The occurrence of adaptation was considered when significant differences were found to occur between Conditions I and V.

The outcomes of the study indicated the following conclusions:

1) Stutterers \((N = 30)\) significantly reduced the frequency and duration of their stuttering blocks while significantly increasing their duration of words and fundamental frequency of voice as effects of delayed side-tone. The results were more consistent in oral reading than in spontaneous speech.

2) The "most severe" stutterers and the "least severe" stutterers responded differently to the effects of delayed side-tone. Significant interactions were found for all fluency measures but not in the case of fundamental frequency of voice. Both groups experienced significant "secondary" effects of delayed side-tone, i.e., higher fundamental frequency of voice.

3) The "most severe" stutterers \((N = 15)\) significantly reduced the frequency and duration of their stuttering blocks while not significantly changing their speaking rate in both speaking tasks under delayed side-tone.
4) The "least severe" stutterers (N = 15) showed a significant increase in stuttering frequency under delayed side-tone in oral reading. However, the effect was not consistent as no significant increase in stuttering was found to occur under the second delayed side-tone condition in oral reading nor in either of the delayed side-tone conditions in spontaneous speech. At no time was the duration of stuttering blocks significantly modified for the "least severe" stutterers under delayed side-tone. The "least severe" stutterers when compared to the "most severe" stutterers significantly decreased their rate of speaking under delayed side-tone in both oral reading and spontaneous speech.

From the analyses of the two sub-groups of stutterers, it was seemingly apparent that the "most severe" stutterers probably accounted for most of the significant reductions in frequency and duration of stuttering blocks under delayed side-tone when the stutterers were considered as a group. On the other hand, the "least severe" stutterers probably accounted for most of the significant decreases in rate of speaking under delayed side-tone when the stutterers were considered as a group.

5) The persistence effects of delayed side-tone were studied in Condition IV as this condition followed immediately after the delay was eliminated from the side-tone of the stutterers. There were no statistically significant persistence effects for any of the fluency measures. These findings were negative for stutterers as a group as well as for the sub-groups of stutterers during the sustaining of vowels associated with both speaking tasks.
In the instance of fundamental frequency of voice, persistence was found for stutterers as a group, but was not found generally when the sub-groups were analyzed separately.

6) Adaptation, the progressive reduction of stuttering severity over a period of speaking, was considered a controllable factor as far as the outcomes of the study were concerned. There were no statistically significant differences found between Conditions I and V for any of the measures of fluency in either speaking task.

The following interpretations were made of the outcomes of the study:

1) "Mild" stutterers may be affected in much the same way as normal speakers under delayed side-tone. The effects on speech may be the result of a disturbed speech-auditory feedback loop.

2) The disturbed feedback loop produced in non-stutterers may be constantly present in some types of stuttering. Stromsta's study implied that stutterers had a larger inter-ear disparity for bone-conducted side-tone than non-stutterers. A condition was suggested to exist within the stutterers that simulated the delayed side-tone phenomenon of non-stutterers. It was also hypothesized that the phase discrepancy was greater near the fundamental frequency of the stutterers' voices.57

57Stromsta, loc. cit.

The fact that the "most severe" stutterers of the group simultaneously reduced the severity of their stuttering and increased the
fundamental frequency of their voice under delayed side-tone may be related to the finding by Stromsta that stutterers simultaneously reduced the frequency of their stuttering blocks and increased the fundamental frequency of their voice under conditions of auditory masking. 58

58 Stromsta, loc. cit.

Or, insofar as some stutterers have been hypothesized to have a defective auditory feedback mechanism, the results of the study may have a relationship to the findings by House that cerebral palsied speakers, individuals with known involvements of the central nervous system and proprioceptive feedback capacities, are also facilitated in speech by delayed side-tone. 59

59 House, loc. cit.

The findings in this study seemed to be in keeping with a physiological explanation of stuttering behavior. However, the interpretations were tempered by the fact that little is known about the speech disorder of stuttering. The hypotheses suggested may not only have been speculations, but over-simplifications of the phenomenon.


Black, John W. "The Effect of Delayed Side-Tone on Vocal Rate and Intensity," Journal of Speech and Hearing Disorders, 16:56-60, 1951.


Davidson, Donald G. "Effect of Side-Tone Delay on Reading Rate, Articulation, and Pitch." Unpublished Ph.D. dissertation, The Ohio State University, Columbus, 1955.


House, James B. "Some Effects of Varied Conditions of Delayed Side-Tone on the Rate and Intelligibility of Cerebral Palsied Speakers." Paper read at the American Speech and Hearing Association Convention, Cincinnati, Ohio, 1957.


Stromsta, Courtney P. "A First Approximation of the Distance from the Vocal Cords to Cochlea and the Transit Time of Bone-Conducted Sound From the Region of the Vocal Cords to the Region of the Cochlea." Unpublished Master's thesis, The Ohio State University, Columbus, 1951.

"Experimental Blockage of Phonation by Distorted Side-Tone." Technical report of Public Service Research Grant, Number B-1331, The Ohio State University, Columbus, 1958. (To be published September, 1959, *Journal of Speech and Hearing Research*.)


Winchester, Richard A., Edward W. Gibbons, and Donald F. Krebs. 
"Adaptation to Sustained Delayed Side-Tone," Journal of Speech 

Wischner, G. J. "Stuttering Behavior and Research: A Program of 
of Iowa, Iowa City, 1947.
APPENDIX A

INSTRUCTIONS FOR SUBJECTS AND READING PASSAGE FOR DETERMINING THE DELAY TIMES

INSTRUCTIONS TO SUBJECTS

The instrument on the table is called an Audio-Signal Delaying Unit. This instrument delays your voice so that it sounds like an echo in your ears. You are going to read some sentences from a passage with your voice delayed to your ears so that you can determine a delay time under which it is easiest for you to read. Although your speech may be slowed down more than usual, indicate the delay time that seems to make you stutter less or make your stuttering blocks less severe. If none of the delay times seem to help your speech, or if you experience no difference among the delays, tell this to the experimenter. Are there any questions?

PASSAGE READ BY SUBJECTS

On a very cold night more than fifty years ago, a crowd was pouring out of the Majestic theatre in Chicago. It was a laughing happy crowd that had been entertained by Alexander Herman, the great magician of that day. On the sidewalk stood a shivering newsboy trying to sell copies of the Chicago Tribune to the crowd. He was having a difficult time of it and he looked very poor. He had no overcoat, he had no home, and he had no place to sleep that night. So after the crowd had disappeared he wrapped himself in newspapers and slept on top of an iron grating. The grating was kept slightly warm by heat from the furnace in the basement of the theatre. He was very cold and hungry but still he dreamed of himself becoming a great artist like Mister Herman some day. He longed to have crowds applauding him and have pretty girls waiting for him at the stage door. So he made a solemn vow that when he was a famous magician, he would come back as a headliner in the same theatre.

That boy was Howard Thurston and twenty years later he returned and fulfilled the promise. He was one of the world's really great magicians. He went all over the seven seas and performed his magic before many thousands of persons.
APPENDIX B

THE CONDITION OF DELAYED SIDE-TONE UNDER WHICH EACH SUBJECT TALKED IN THE STUDY

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</table>
APPENDIX C

LISTS OF TEN-SYLLABLE PHRASES READ BY SUBJECTS

LIST I

Miss Helen Keller is totally blind
She had read far more books than most people
She has probably read a hundred times
As many books as the average person
She has written eleven books herself
She made a motion picture of her life
She is a totally deafened person
She enjoys music more than most people
For nine years of her life she had no speech
She has given lectures in every state
This deaf and blind person was born normal
For the first year and a half of her life
She could see and her like other children
Then suddenly this young child was struck down
By an illness which left her deaf and dumb
At first she was a behavior problem
She smashed every object that displeased her
When someone tried to correct her for this
She would fling herself on the floor and scream
Her folks sent her to a school for the blind
Here she met Miss Virginia Sullivan
Who became her teacher at the blind school
Helen Keller was taught successfully
By the time she was twenty years of age
She could not only read and write real well
But also regained her power of speech

LIST II

Martin Johnson who photographs lions
Has killed only two of them in his life
During his last ten months in Africa
He saw more lions than ever before
But yet he never fired a rifle once
In fact he did not take along a gun
Many African hunters like to tell
Of their most fearful experiences
Martin Johnson believes that any man
Who really knows about wild animals
Can walk safely from Cairo to the Cape
Armed with nothing more than a bamboo stick
And never be afraid of any harm
The last time he went to wild Africa
He took along a fine radio set
So he could listen to news and music.
He listened a great deal for a few months,
Then he got very tired of listening
to long tiresome commercial announcements,
So he turned off the radio for months.
Martin Johnson started roaming the world
When he was about nine or ten years old.
His father owned a jewelry business.
As a young boy Martin unpacked the crates
That came from all corners of the compass.
He was fascinated by strange labels
And he was determined to find out more
About the places that he read about.

LIST III

A little over fifty years ago
A hobo rode the rods of a freight train.
He stopped in Buffalo to beg for food.
An officer stopped him for vagrancy.
A judge then sentenced him to thirty days
At hard labor in the city prison.
For those thirty days he broke many rocks.
He ate nothing but some bread and water.
Six years later this former bum and tramp
Was the most sought after man on the coast.
He was entertained by famed socialites.
He was hailed by writers and critics as
A bright star in the literary world.
This popular author was Jack London.
He wrote the book titled "Call of the Wild."
He started high school when he was nineteen.
He lived until he was forty years old.
Yet he left behind him fifty-three books.
When Jack London wrote the first mentioned book
He became a famous man overnight.
He made little money from his first hit.
He sold his rights for three thousand dollars.
The publishers made a million dollars.
This famous man died in nineteen sixteen.
Only eighteen years after his first book
In that time he had written an average
Of three books a year and many stories.
LIST IV

John Rockefeller did amazing things
The greatest thing he did was to acquire
The first largest fortune in all history
He started his life digging potatoes
In the hot sun for a few cents an hour
In those days there were not too many men
In all the United States who were worth
Even one million dollars or better
Eventually John D. Rockefeller
Managed to earn himself a large fortune
Said to be one or two billion dollars
Yet the first woman he fell in love with
Said she wanted nothing to do with him
The reason given was that her mother
Refused to let her daughter throw herself
At a man who had such poor aims in life
The next thing that John Rockefeller did
Was to give away much more money than
Anyone else has given in history
And the third thing about this man was that
He lived to the age of eighty-two years
He was much hated in America
He got letters threatening to kill him
He had to be protected day and night
He endured the heavy pressures and strains
Of building and bossing his empire
Woolworth was finished at sixty-seven
Yet Rockefeller still lived years longer

LIST V

Woodrow Wilson has been called a genius
He has also been called a great failure
He sailed for Europe in nineteen nineteen
He was called the savior of the ages
The bleeding world thought of him as a god
People burned candles before his picture
They offered prayers as though he were a saint
The whole world lay helplessly at his feet
Yet when he returned to this place later
He lost many friends and made enemies
Wilson was the best educated man
Who ever held office in the White House
Yet he could not even read, spell or write
Until he was just about ten years old
He preferred reading mystery books for fun
Most of his life he had been very poor
 His wage as a teacher was very small
 His wife sold pictures to help support him
 He never could afford to buy good clothes
 He only had one cigar in his life
 His only vice was buying costly books
 He started out in life as a lawyer
 At that he was just a complete failure
 He never conducted a case himself
 He handled property for few persons
 His ambition was to be a statesman
 To this end he practiced public speaking
APPENDIX D

ORDER OF PRESENTATION OF STIMULUS MATERIALS IN FIVE EXPERIMENTAL CONDITIONS OF ORAL READING AND SPONTANEOUS SPEECH

<table>
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<th>SUBJECTS</th>
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</table>
TRAINING INSTRUCTIONS

You are going to practice reading some phrases and vocalizing some vowels to familiarize yourself with the procedures in the experiment. When the signal light flashes, turn over the first card and read the phrase naturally. Then, place the card face up on the table, take one natural breath, and turn over the next card and read the second phrase. Follow this procedure for the remaining phrases. After reading the last phrase, vocalize each of the vowels once that are printed on the last card for a five second period. Vocalize the vowel naturally and try to keep it as constant in loudness as possible for the whole five second period. Begin vocalizing the vowel as the second hand passes 10. Follow this procedure for all the vowels. Are there any questions?

INSTRUCTIONS FOR EXPERIMENT

You are now ready to begin the first part of the experiment. Wait for the signal light to flash before reading. After completing the first group of phrases and vocalizing the vowels, wait for the signal light to flash again before reading a second group of phrases. There will be five groups of phrases for you to read in the experiment. Some of the groups of phrases will be read under delayed side-tone. Between readings four and five there will be a six minute rest interval. The earphones will be taken off at this time, you will not talk, and you will remain seated in your chair. Are there any questions?

THE PRACTICE PHRASES

The nose is brought down vary your pattern
Landing straight ahead as we get higher
You won't have to go ahead of the plane
Make the second crossing the wind line
Hold your position not cleared for take-off
It is nearly stalled make contact again
Follow the sequence that one which may vary
Enough flying speed number two to land
The plane is in flight about twenty feet
The throttle is closed we increase the rate
Student is getting straight and level flight
We can start our turn as soon as we clear
APPENDIX F

INSTRUCTIONS TO SUBJECTS FOR SPONTANEOUS SPEECH AND ASSOCIATED SUSTAINING OF VOWELS TASKS

TRAINING INSTRUCTIONS

This time you will make different statements or descriptions about pictures. When the signal light flashes, read the six sample statements typed on the bottom of this picture. Remember to take one natural breath before reading each statement. Next practice making six different statements of your own about this second picture. Make your different statements like those of the first practice picture. Are there any questions?

INSTRUCTIONS FOR EXPERIMENT

You are now ready to begin the second part of the experiment. Turn over the first picture when the signal light flashes. Make six different statements or descriptions about the picture. Be sure you take a breath between successive statements. When the signal light flashes again, you have completed making six statements about the picture. You need not count your own statements as the experimenter is doing this for you. Then, immediately turn over the next picture and make six statements about it. After making statements about the fifth picture, vocalize the four vowels that are printed on the last card. When the signal light flashes, begin making statements about the second group of five pictures. There will be five groups of pictures in the experiment. Some of the groups of pictures will be described under delayed side-tone. Between groups of pictures four and five there will be a six minute rest period. The earphones will be taken off at this time, you will not talk, and you will remain seated in your chair. Are there any questions?
APPENDIX G

THE RANKING OF THE "MOST SEVERE" STUTTERERS AND THE " LEAST SEVERE" STUTTERERS IN ORAL READING AND SPONTANEOUS SPEECH ON THE BASIS OF THE MEAN FREQUENCY OF STUTTERING BLOCKS OBTAINED DURING THE FIRST AND LAST CONDITIONS OF UNDELAYED SIDE-TONE

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AUTOBIOGRAPHY

I, George Arnold Soderberg, was born in Crystal Falls, Michigan, on June 19, 1930. After graduating from Crystal Falls High School in 1948, I enrolled to study Forestry at Northern Michigan College, Marquette, Michigan. The following year, 1949, I attended Central Michigan College in Mt. Pleasant, Michigan, and changed my course of study to Speech and Hearing Therapy. In June, 1952, I was graduated with a Bachelor of Arts degree. Also, during this year, "Relations of Stuttering in Spontaneous Speech to Speech Content and Verbal Output, by Wilbur E. Moore, George Soderberg, and Donna Powell was published in the Journal of Speech and Hearing Disorders.

In the fall of 1952 I entered the Ohio State University, where I received a Master of Arts Degree in Speech Science in December, 1953. My Master's thesis was "A Comparative Study of Adaptation Trends in the Oral-Reading of Stutterers, Inferior Readers, and Superior Readers." I spent the next two years in the United States Army Medical Corp at Madigan Army Hospital in Tacoma, Washington. After my discharge from the service, I returned to the Ohio State University to begin work on the Doctor of Philosophy degree. Except for teaching at Central Michigan College during the Winter Semester of 1956, my present graduate study has been uninterrupted.