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Selected visible and audible features of stuttered speech were studied to determine whether these phenomena suggested a basis for differentiating among stutterers. Forty-six visible and audible phenomena of stuttering were examined in 23 stutterers, using a frame-by-frame analysis of sound motion picture film. Significant inter-subject differences were found in 11 of these variables which included the following: adaptation, number of film frames in the moment of stuttering, simultaneous suspension of jaw and lip activity, eyelid closure, eyelid movement, total visible tension, number of anatomical areas involved in the moment, and several indices of unilateral facial deviations. A factor analysis of the correlations among audible and visible variables revealed 10 factors which accounted for 83% of the variance. Six of these factors were similar to stuttering dimensions which previously had been implied or hypothesized, but had not been empirically derived: overall stuttering severity, type of audible dysfluency, adaptation, type of unilateral deviation, tension, and stuttering differences between spontaneous speech and reading. Applications are presented of the results of this study to the differentiation and classification of stutterers. (Author/RD)

FINAL REPORT

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A STUDY OF THE BEHAVIORAL COMPONENTS OF STUTTERED SPEECH

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U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

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A STUDY OF THE BEHAVIORAL COMPONENTS OF STUTTERED SPEECH

SUMMARY

Studies of the neurological, personality, and speech characteristics of stutterers suggest that in these characteristics stutterers vary too greatly to conclude that stuttering results from a single cause. The recognition that stuttering is a disorder with a multiple etiology points to a need to identify sub-types of stuttering and stutterers. Clinical evidence lends support to the notion that sub-groups of stutterers exist which may be identifiable by differences in the speech symptoms they manifest. However, there has been no attempt to study, systematically, the overt visible and audible characteristics of stuttering as a basis for identifying different types of symptom patterns.

The purpose of this study was to describe selected visible and audible features of stuttered speech and to determine whether these phenomena suggest a basis for differentiating among stutterers.

Samples of speech under two conditions were obtained from 23 male stutterers (mean age = 17.0 years) enrolled in an eight-week summer residential program: 1) a 204-word passage was read five consecutive times by each subject and was recorded on audio-tape; 2) sound motion pictures were made of the oro-facial area of each subject as he performed a self-formulated speech task.

Audio-tape recordings of the first reading of the 204-word passage and the self-formulated speech task were analyzed for verbal output, number of words spoken per minute, frequency of occurrence of stuttered words, and frequency of occurrence of each of nine types of dysfluency. Measures of adaptation and consistency were obtained from the reading passage and a measure of cumulative stuttering time was obtained from the self-formulated speech task.

A frame-by-frame analysis of selected visible phenomena of stuttered speech was made for ten words stuttered upon by each subject during the filming of the self-formulated speech task. From this analysis 27 scores were obtained for each subject. The anatomical areas observed were the eyelids, jaw, lips, head, tongue, forehead, eyebrows, chin, neck, and nostrils. The types of phenomena scored were suspended movement, tension, excessive range of movement, unilateral deviations, excessive amount of movement, and repetitive oscillatory movements.

As a group, the subjects demonstrated heterogeneity in the occurrence of visible as well as audible phenomena. Statistical measures indicated that subjects differed significantly from one another in the distribution of their scores on the followin · variables: adaptation, number of film frames in the moment, simultaneous suspension of jaw and lip activity, eyelid closure, eyelid movement, total visible tension, number of anatomical areas involved in the moment, total unilateral deviations, jaw deviations left, lip deviations left, and total deviations left.

Contrary to expectations, inspection of the data did not support the suggestion that stutterers show clusters or sequences of visible phenomena which occur consistently during their stuttering moments. Possible reasons for this finding are discussed.

A factor analysis of the correlations among audible and visible variables suggested that for the data collected there are several relatively independent dimensions of stuttering behavior. Factors accounting for 83 percent of the variance included the following: severity of stuttering, type of audible dysfluency, adaptation, type of unilateral deviation, tension, and the coexistence of reading dysfluency and eyelid movement.

These results emphasize the differences among stutterers and the need to adopt a multidimensional approach to the description of stuttered speech. Applications of the results of this study to the classification of stuttering behavior are discussed.

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CHAPTER I

INTRODUCTION

A major emphasis in therapy for persons who stutter is to assist them in changing speech behaviors which interfere with effective communication. Clinical suggestions for providing this assistance (Travis, 1957; Eisenson, 1958) and estimating its effectiveness (Eisenson, 1958) have treated stutterers and their behavioral symptoms as if they had an essentially homogenous problem. The search for a common denominator among stutterers, however, has been largely unsuccessful. Although some studies have demonstrated group trends, individual variations are so frequently encountered that, as observed by St. Onge (1963), results of such studies point away from, rather than toward, a single syndrome. Little research attention has been directed toward systematic study of the visible and audible features of stuttered speech as a basis from which to describe and classify different symptom patterns and to evaluate change under conditions of therapy.

Between 1930 and 1960 numerous studies were undertaken to describe the audible characteristics of stuttering. Many of these studies attempted to establish group trends for audibly identified stuttering occurances, types of stuttering moments, and the adaptation and consistency of stuttering. Johnson (1961) made extensive studies of the audible characteristics of the speech of stutterers and nonstutterers. He published normative data for oral speaking and reading rates and for eight classifications of dysfluency. Adaptation, the tendency for the stuttering response to decrease in frequency on the average of about 50% from the first to the fifth consecutive reading of the same passage, has been demonstrated consistently as a group phenomena (Cullinan, 1963; Harris, 1942; Johnson and Inness, 1939; Johnson and Knott,1937; Leutenegger, 1957; Johnson, 1955). The rate and amount of adaptation have been shown to vary widely, however, from one stutterer to another. Moreover, recent studies (Newman, 1963; Prins and McQuistom, 1964) have questioned the value of using group trends of adaptation in characterizing the speech of stutterers. Newman (1963), following a reevaluation of the adaptation scores of 20 stutterers, suggested that stutterers be classified according to differences between their adaptation performance in self-formulated speech and in reading. Prins and McQuiston (1964) also found that not all stutterers show significant adaptation in reading and concluded that the adaptation phenomenon is not a characteristic of the nonfluent speech of all stutterers.

Attempts to use the type of dysfluency as a means of classifying stutterers have been made by several investigators, most recently Douglass and Quarrington (Douglass and Quarrington, 1952; Quarrington and Douglass, 1960) and Emerick (1966). Douglass and Quarrington (1952) described two types of stutterers whom they designated as "interiorized" and "exteriorized." Interiorized stuttering

was characterized as catestrophic in nature, short in duration, intense in severity, lacking in stereotyped or predictable pattern, and much like a true spasm. Exteriorized stuttering was characterized by automatic stuttering devices, a predictable pattern, and a lack of voluntary character. In a later article (Quarrington and Douglass, 1960), the same authors described two subtypes of external stuttering; predominantly "vocalized" and predominantly "nonvocalized" stuttering. Vocalized stuttering is characterized by excessively repetitive or prolonged phonation of speech sounds resulting from tonic or clonic spasm. It is generally an audibly perceived phenomenon. Nonvocalized stuttering, a predominantly visually perceived phenomenon, is characterized by suspension of vocalization and, frequently, struggle reactions.

Emerick's (1966) similar, but slightly altered, classification describes "tonic" and "clonic" stutterers. Tonic stutterers show stoppage or fixations of speech musculature attended by visible tensions with audible characteristics consisting of silent intervals and prolongations of sounds. It's presence is judged predominantly through the visual modality. Clonic stuttering is characterized by cyclic repetitions of sounds, syllables and words, and by tremors of the speech mechanism. It's presence is judged predominantly through the auditory modality.

The categories of Douglass and Quarrington and of Emerick were arrived at through clinical observation rather than through experimentation. They are, nevertheless, further evidence of the concept that stutterers may be identified by the differences in the nature of their speech symptoms.

A single study by Barr (1940), in addition to describing audible characteristics of stuttered speech, presented a summary of visible and myokinetic variations which characterized the speech of stutterers. For collection of data on the majority of characteristics, Barr's study utilized two judges recording from a check list of sutttering phenomena. Jaw movements, breathing movements, phonation time, and duration of the stuttering moment were recorded mechanically but no permanent record was made of other visible or audible characteristics. The use of methods which allowed no opportunity for reevaluation of original judgments probably resulted in the loss of and inaccurate information.

Recently, several writers (St. Onge, 1963; Luschsinger and Arnold, 1965; Newman, 1963; Prins, 1964; Graham and Brumlik, 1965; Cullinan, 1963) have indicated that variability among speech behaviors of stutterers may be a factor which can help delineate types of stuttering syndromes. The conclusion by St. Onge (1963) that research in stuttering should attempt to identify "pure" sub-types of stuttering received support from Newman (1963) who commented: "Further research, to test the hypothesis that there are several types of stuttering, may well provide fresh insights into the nature of the disorder." The implications of this possibility for continued research and for developing specificity in clinical treatment are significant.

The need for further systematic study of the speech behavior of stutterers is clearly indicated. The purpose of this research is to study variations in the visible and audible speech behavior of persons who stutter in order to help answer the following questions: (1) What are the nature and distribution of observable, visible and audible characteristics of stuttered speech? (2) Are there significant intersubject differences in the distribution of visible phenomena across moments of stuttering? (3) Are there patterns of consistency of visible phenomena which can be identified within and between a subject's moments of stuttering? (4) Are significant correlations apparent among the visible and audible characteristics of stuttering, and do factors emerge which would suggest a basis for describing different dimensions of stuttered speech?

CHAPTER II

METHODS OF PROCEDURE

SUBJECTS

The subjects were 23 male stutterers between 14 years, seven months, and 22 years, eight months of age, who were enrolled in an eight-week summer residential program at The University of Michigan Speech and Hearing Camp. The mean age of the group was 17 years. A wide range of stuttering severity was represented by the subjects.

SPEECH SAMPLES

Self-Formulated Speech

The Job Task (Johnson, 1961) was used to obtain a sample of self-formulated speech on sound film to be used in studying the observable characteristics of stuttering. The Job Task requires the subject to tell about the vocation he would like to have or a past job he has held. For this procedure, norms have been established for stutterers and nonstutterers for verbal output, speaking rate, and several indices of dysfluency (interjections, part-word repetitions, word repetitions, phrase repetitions, revisions, incomplete phrases, broken words, and prolonged sounds) (Johnson, 1961). Reliability has been established for self-agreement in scoring of these dysfluencies (Sander, 1961).

Reading

A 204-word reading passage (modified from a 300-word passage of Fairbanks, 1940, p. 143) was read five consecutive times by each subject for the purpose of obtaining scores of adaptation and consistency. Audio-tape recordings were made of each subject's reading of this passage.

COLLECTION AND STORAGE OF DATA

Filming Techniques and Equipment

An Auricon Super 1200 camera (single sound system) was used, operating with a synchronous motor at 24 frames per second with a 1200-foot magazine. Professional camera and sound technicians from The University of Michigan

audio-visual personnel required to operate this equipment. The camera-to-speaker distance was 10 feet and a 6.5 mm. lens was used to focus on an area from the mid-chest upward. Films were made during the first week of the eight-week summer camp period.

Sound motion pictures of the self-formulated speech task were obtained to provide data for the analysis of audible-visible characteristics of stuttering. Pilot films indicated that a close-up view, from the mid-chest upward, allowed the best possibility for observing the visible characteristics of stuttering in the oro-facial region. The collection and storage of data on sound film permitted repeated observation of audible and visible characteristics separately and in combination.

Recording of Reading Passage

A Wollensak Model T-1500 recorder and Model E-102-4 microphone were used in recording the readings of the 204-word adaptation passage. The microphone was adjusted to a distance of six to eight inches from the subject's face. All subjects stood while reading the passage.

MEASUREMENT OF AUDIBLE CHARACTERISTICS

Adaptation and Consistency of Stuttering

Audio tape recordings of the 204-word adaptation passage were analyzed to determine the frequency of occurrence of stuttered words. The Normal Deviate, Percentage, and Trend measures of adaptation (Tate and Cullinan, 1961) and the Normal Deviate measure of consistency (Tate and Cullinan, 1962) were derived for sixteen of the 23 subjects. Four subjects were unable to complete the five readings: three because of reading disability and one because of fatigue accompanying speaking. Three additional subjects stuttered on fewer than 2 percent of the words and scores were not determined for them.

Ten of the readings of the passage were selected at random and re-analyzed two months later by the writer and six months later by another trained listener to determine inter- and intra-listener reliability for judging stuttering occurrences. The reliability of observations was determined by the formula $r = C/\sqrt{xy}$ (Tuthil, 1946) in which C is the number of marked words common to the two observations, and x and y represent the number of words marked as stuttered on the first and second observations. The writer's reliability with herself varied from 0.80 to 0.96 for individual subjects. Reliability of observations for all subjects, based on the totals for C, x, and y, was 0.93. The writer's reliability with the second observer varied from 0.69 to 0.97 for individual subjects with a reliability of observation for all subjects of 0.92.

A Pearson product moment coefficient of correlation was computed across the ten subjects. Correlations of 0.99 were obtained for both inter- and intra-listener agreement.

Classification of Stuttering Dysfluencies

Audible dysfluencies were classified according to the system and criteria developed by Johnson (1961). To Johnson's eight categories (interjections, part-word repetitions, whole-word repetitions, phrase repetitions, revisions, incomplete phrases, broken words, and prolonged sounds) was added a ninth category, pause. A pause was defined as any time lapse between utterances which was considered longer than would be expected to occur during normally rhythmic speech and which contained no recognizable phonemic utterance. Intervals during which sounds of breathing, nasal emission of air, panting, tongue "clicks," and other nonphonemic sounds could be distinguished were categorized as pauses, as were intervals of complete silence. Johnson omitted pauses from his classification because of "the relatively unsystematic judgment involved in deciding whether a given pause is or is not part of the meaningful fluent production of speech" (Johnson, 1961). The use of film in this study provided a means of checking the accuracy of judging pauses as a part of stuttered speech.

Verbal Output

Johnson (1961) defines verbal output as the number of words spoken. He specified that in determining verbal output words repeated singly or in a phrase are counted only once, interjections of sounds or words not regarded as integral parts of the meaningful context are not counted, and for revisions, only the words in the final form are counted. These criteria were used in determining verbal output for the Job Task. In addition, it was specified that hyphenated words be counted as one word and that for abbreviated forms, such as M.I.T. and Ph.D., the pronunciation of each letter be counted as a separate word. For the reading passage, the number of words spoken was always taken as the number of written words in the passage.

Number of Words Stuttered

The number of words stuttered in self-formulated speech was determined for the Job Task as it had been for the reading task.

Cumulative Stuttering Time

Cumulative stuttering time was defined as the amount of the total speaking time which was consumed by dysfluencies. This measure was made for the Job Task only.

In determining cumulative stuttering time, all dysfluencies listed by Johnson, as well as pause time, were bracketed on a copy of the script. As the recording played through, the bracketed sections were timed, using a cumulative timing device. The recordings were replayed and the cumulative stuttering time scored as many times as was necessary in order to reach a criterion of three consecutive scores which agreed within ± 2 seconds. Two months later the cumulative stuttering time was rechecked for all 23 subjects. Timing on the recheck differed from 0 to 3.16 seconds with the original scores with a mean difference of 1.16 seconds for the group.

The variation in time appears to be somewhat related to the total speaking time for individual subjects on the Job Task. The range for total speaking time (Table C-4, Appendix C) was 73.4 to 230.2 seconds. The type of stuttering was, in the judgment of the writer, also an important factor; the more subtle dysfluencies being more difficult to time.

Reading and Speaking Rates

The ratio of verbal output to reading or speaking time was calculated to obtain the reading and speaking rates in words per minute. Total speaking time was obtained by timing audio tape recordings of the reading passage and self-formulated speech passage. It was required that two consecutive timings agree within ± 1 second. Retiming of the tapes of the self-formulated speech task two months later revealed an average difference of 0.47 second for the group from the measurements established earlier.

MEASUREMENT OF VISIBLE CHARACTERISTICS

Occurrence of Stuttering

Each sound film was viewed at normal speed as many times as necessary in order to determine confidently the frequency of occurrence of stuttering. Variations in severity and complexity from stutterer to stutterer required flexibility in procedure. In general, however, the procedure followed involved marking each word on which stuttering was noted during the viewing of the sound film at normal speed. The words stuttered were underlined on a script prepared from the audio tape recordings of the film sound track.

Separate lists were made of words noted as stuttered during the analysis of the audio tape recordings which were not confirmed by the audio-visual analysis, and of words noted as stuttered on the audio-visual analysis which had not been recorded as stuttered on the audio analysis.

In order to determine the reliability of observations, ten of the films were analyzed for occurrences of stuttering by a second observer. Inter-listener

reliability was determined, as for adaptation, by use of the formula $r = C/\sqrt{xy}$. The writer's reliability with the second observer was 0.83. A Pearson product moment coefficient of correlation was computed and resulted in an inter-listener correlation of 0.96.

Selection of Words for Frame-by-Frame Analysis

From each subject's list of stuttered words, a sample of ten words was selected for frame-by-frame analysis. In order to assure that selection was made from words stuttered at both the beginning and end of the self-formulated speech sample, each subject's list of words was divided into two halves and five words were selected randomly from each.

Selection of Visible Phenomena for Analysis

A visible phenomenon of stuttering was defined as any movement or suspension of movement of the oro-facial structures which occurred during a moment of stuttering and was not an integral part of the ongoing process of speech.

In selecting the visible phenomena to be analyzed, the sound films were first viewed at normal speed and a list of observable phenomena made for each subject. A listing was also made of all of the possible directional movements which could be made by the facial structures and of the positions which these structures could assume. These two lists were narrowed down to include those movements and positions of the eyelids, jaw, lips, head, tongue, forehead, eyebrows, chin, neck, and nostrils which observation of the pilot films at both normal and reduced speed indicated could be observed from a frontal view of the subject, would provide useful information about stuttered speech, and could be described objectively.

DEFINITION OF CATEGORIES USED TO DESCRIBE THE VISIBLE PHENOMENA OF STUTTERED SPEECH

Jaw and Lips

The articulation of speech involves the almost continuous activity of the jaw and lips, whereas stuttering is frequently described in terms of the suspension of the ongoing process of speech. Therefore, categories were included to describe the suspension of movement of the jaw and lips as well as their movement. Movement was recorded when a change in position was observed from one frame to another and was described by the terms "opening" and "closing." Suspension of movement was recorded when there was no apparent change in the position of the jaw or lips from one frame to the next. The term "stable" was used to describe suspended jaw movement and the terms "open" and "closed" were

used to describe suspended lip movement. Further definitions of the terms used in the visible analysis are as follows:

Jaw

In observing movements of the jaw, attention was focussed on either the lowest point of the midpoint of the chin and/or, when visible, the distance between the teeth.

Closing: upward movement of the mandible.
Opening: downward movement of the mandible.
Stable: no discernible movement of the mandible.
Deviating right (or left): movement of the mandible to the right (or left) of midline or of the subject's habitual mandibular posture.
Deviated right (or left): holding of the mandible to the right (or left) of midline.
Supra-open: excessive opening of the mandible as indicated by the appearance of lines from the corner of the lips to the chin.
Sudden: rapid opening or closing or deviating of the mandible as indicated by viewing the word at normal film speed. As the criteria for judging this category are more subjective than for other categories, judgments were made cautiously.

Lips

Closing: narrowing of the space between the lips.
Closed: any posture of the lips in which the two lips are placed in contact such that no space may be observed between them.
Open: any posture of the lips during which there is no observable movement and which does not qualify for the classification "closed."
Protrusion: forward movement and positioning of the lips.
Retrusion: inward movement and positioning of the lips.
Retracting: movement of the lips laterally.
Retracting right (or left): unilateral movement of the right (or left) corner of the lips.
Retracted: holding of the corner(s) of the lips laterally.
Returning: movement of the lips from the retracted position back to the midline position.
Tensed: exaggerated positioning or movement of the lips as evidenced by deepening of the lines radiating from the lips.

Eyelids

Eyelid activity was described both in terms of movement (opening and closing) of the lids and suspension of movement (closure and partial closure) of the lids. Movements of the eyelids which occurred during the time that the eye was covered by them ("closed" position) were not recorded unless they met

the criteria for the "supra-closed" category. Closing activity was described from the first visible evidence of the downward movement of the eyelid through the cessation of such activity or through the film frame in which the eyelid assumed the "closed" position. Opening of the lid was described from the first film frame in which a portion of the eye became visible through the last film frame in which continuous upward movement of the lid could be observed.

Opening: upward movement of the lid.
Closing: downward movement of the lid.
Closed: eyelid completely covers the eyeball.
Partially closed: eyelid lowered more than for the subject's habitual posture but not completely covering the eyeball.
Left only: movement or position recorded refers to the left lid only.
Right only: movement or position recorded refers to the right lid only.
Supra-closed: overclosure of the lid(s) as evidenced by deepening of lines surrounding the eye(s).

Head

Because some head movement is expected during speech and because the head is capable of movement in more than one direction at a time, head movements were recorded only when they were sustained for four or more film frames, were extreme in excursion, and/or qualified for the category "supra."

Rising: the top of the head moves back and away from the observer.
Lowering: the top of the head moves forward toward the observer.
Moving right (or left): the head is tilting or rotating toward the right (or left) of midline as evidenced by the emergence into view of the ear on the side of the head opposite to the direction of movement.
Supra: extreme raising or lowering of the head, or extreme deviation of the head to the left or right as evidenced by accompanying tension in the neck region, ability to partially view the roof of the mouth (head raised), top of the head (head lowered), or the chin pressing against the chest (head lowered).
Sudden: rapid, precipitous movement of the head in any direction as revealed by viewing the film at 24 frames per second. As the criteria for judging this category were more subjective than for other categories, judgments were made cautiously.

Eyebrows

Elevation: any frame in which the eyebrows are elevated above their habitual level regardless of whether or not they are moving.
Elevation right (or left): elevation of the right (or left) eyebrow only.

ERRATA

Re: Final Report, OEG-3-6-062382-1882
A Study of the Behavioral Components of Stuttered Speech.

Page 1
line 15: occurances should be occurrences
line 22: phenomena should be phenomenon
line 26: McQuistom should be McQuiston

Page 2
line 1: catestrophic should be catastrophic

Page 5
line 28: Tuthil should be Tuthill

Page 9
line 3: focussed should be focused

Forehead, Chin, and Neck

A phenomenon frequently associated with stuttering is tension. Presence of activity in the neck, chin, and forehead appeared to be most accurately described in terms of the presence of this characteristic. Tension was recorded for these areas from the first film frame in which it could be observed through the last film frame in which it could be observed, without regard to changes in degree of tension.

Forehead

Tensed: appearance of vertical or horizontal lines in the forehead.

Chin

Tensed: appearance of wrinkles on the surface of the chin.

Neck

Tensed: increase in the width of the neck accompanied by prominence of the musculature of the neck region.

Nostrils

Flared: noticeable increase in the size of the nares; this phenomenon was recorded from the first noticeable increase in size until the nares returned to habitual size.

Compressed: noticeable decrease in the size of the nares, recorded from the first evidence of decrease in size until the nares returned to habitual size.

Tongue

All visible directional movements of the tongue were described as well as the stabilization of the tongue in the elevated, protruded, or lateralized positions.

Raising: tongue tip moving upward toward the roof of the mouth or alveolar ridge.

Lowering: tongue moving in the direction of the floor of the mouth or lower lip.

Moving right (or left): deviating away from the habitual midline position toward the right (or left) corner of the mouth.

Moved right (or left): deviated toward the right (or left) corner of the mouth

Protruding: moving forward, toward the lips.

Protruded: moved forward touching or in the plane of the lips.
Retracting: moving away from the lips and toward the oral cavity.
Supra-protrusion: tongue tip protruded beyond the vermilion border of the lips.

Other Facial Areas

Movements of facial areas other than those listed for analysis, as, for example, the side of the face, apparently did not occur as isolated phenomena in this group of stutterers. When they occurred, they were associated with simultaneous movements of some other structure such as the lip or eye. Therefore, these movements were not described as separate categories.

Selection of Scores for Analysis

From the accumulation of raw data as described above, the following scores were obtained to represent visible activity during the moment of stuttering.

A. Scores representing suspension of movement

1. Simultaneous suspension of jaw and lip movement. The score used to represent suspension of articulatory activity was the proportion of the total number of frames in the moment consumed by essentially stable positioning of the jaw and lips. Only those frames in which there was simultaneous suspension of movement of these structures were used to determine this score.

2. Closure and partial closure of the eyelids. A second score of suspended movement was the proportion of the total number of frames in the moment which were consumed by closure or partial closure of the eyelids.

B. Scores representing tension

Tension was represented by the proportion of the total number of frames in the moment consumed by visible signs of tension in the forehead, chin, lips, and neck. A separate score was computed for each of these areas. In addition, the proportion of the total frames in the moment showing tension in one or more of the above areas was used to represent the total tension for each moment.

C. Scores representing distortion of movement

1. Supra-movement scores. The proportion of the total number of frames in the moment consumed by excessive range of movement was scored separately for the jaw, lips, head, and tongue.

2. Sudden movement scores. The proportion of the total number of frames in the moment consumed by sudden movements was scored separately for the jaw and head.

3. Unilateral deviation scores. Separate scores were given for deviations of the jaw, the lips, and the eyelids, and for deviations of these structures to the right and left.* The occurrence of one or more unilateral deviations in one of these three areas during a moment of stuttering was given a score of one. A total deviations right and total deviations left score was also determined. These scores consisted of a score of one for each moment of stuttering in which a right (or left) deviation occurred in one or more of the three structures. Thus, eight unilateral deviations scores were derived: jaw right, lips right, eyelids right, jaw left, lips left, eyelids left, total right, and total left.

D. Scores representing excessive movements of structures not directly involved in the articulation of speech

The scores representing this area were the percent of the total number of frames in the moment consumed by closing and opening of the eyelids, depressing and/or elevating the eyebrows, and flaring and/or compressing the nostrils. Separate scores were derived for each of these three structures.

E. Scores representing repetitive oscillatory movements

Repetitive oscillatory movement scores were determined separately for the jaw, lips, and eyelids. The score used was the number of oscillations per second. Where more than one series of oscillatory movements occurred for a structure during any one moment of stuttering, the highest rate of oscillation was used to represent the subject's score.

In order for jaw and lip movements to qualify as oscillatory, two or more agonist-antagonist movements had to occur in succession and each successive oscillation had to be completed within six frames after the completion of the preceding oscillation. By limiting the oscillations to those contained within successive six-frame units, oscillations slower than four per second were eliminated from consideration. According to DeJong (1958, p. 504) four oscillations per second represent the midpoint of the slow tremor movements.

Because eyelid oscillations for this group were frequently complex and arhythmical, it was required that two or more successive oscillations be

*Three types of unilateral deviations were scored: (1) the movement of the jaw or lips toward one side of midline or the other; (2) the failure of one side of the lips to move apart or together synchronously with the opposite side of the lips; (3) the failure of one eyelid to open or close synchronously with the other eyelid.

separated by no more than six film frames (one-quarter of a second).

F. Number of anatomical areas involved in the moment.

The number of anatomical areas other than the jaw and lips for which movement was recorded was scored for each moment of stuttering.

Because they could not be distinguished from normal articulatory movements, opening and closing movements of the jaw and lips; protrusion, retrusion, and retraction of the lips; raising, lowering, and right and left movements of the head; and raising, lowering, protrusion, and retraction of the tongue were not used as scores unless the criteria designated for unilateral deviations, supra, or sudden movement were met.

The number of different visible scores which could be obtained by a subject was 27. An example of the graph used for recording visible phenomena and of the scores derived from the graph are included in Appendix B.

Frame-by-Frame Analysis

Equipment

A Photo-Optical Data Analyzer, Model 224-A, manufactured by the L. W. Photo, Inc., company was used for the frame-by-frame analysis of the films. This projector is designed to operate in forward or reverse direction at speeds of 24, 16, 12, 8, 4, 2, or 1 frame per second. A control box holding a series of switches permits the operator to change rapidly from one speed or direction of operation to another. A frame counter which is attached to the projector keeps an accurate count of each film frame as it passes before the lens.

Image Projection

The image was projected onto a small screen placed 16 inches in front of the projector. The size of the image was 4 inches by 6 inches. Although this size appears to be small, it had the advantage of providing a sharper image than could be obtained with a larger size. The small screen was flexible and was fixed to the end of the table on which the projector was placed in such a way that it could be removed and the image projected on a surface further from the lens when an enlarged image was desired.

Location of Words to Be Analyzed

In order to determine between which frames of the film the words which had been selected for analysis were located, the writer relied upon speech reading. The first step was to mark a frame at the beginning of the film with a grease pencil. This frame was used as a reference frame for setting the counter dial. The silent print of the film was then run at 16 to 24 frames per second and the

speech of the subject "read" with the aid of the script made from the audio tape recordings of the sound track. The film was stopped at intervals and the frame number recorded on a copy of the script. Words to be analyzed in detail were carefully studied in order to determine the film frames within which they were contained.

Segmentation of Stuttering Moments

The majority of words analyzed were monosyllabic and analysis was made of the selected events which occurred from the last visible feature of the word preceding the stuttered word through the completion of the utterance of the stuttered word. (See Appendix A for procedure for making the frame-by-frame analysis.) When stuttering occurred on the first syllable of a polysyllabic word, analysis was made only through the completion of the utterance of the first syllable. When stuttering occurred on some syllable other than the first, analysis was made of the visible events which occurred from the termination of the syllable preceding the stuttered syllable through the completion of the utterance of the stuttered syllable. For polysyllabic words in which more than one moment of stuttering occurred, only the first stuttered syllable was analyzed. Thus, for every subject only ten moments of stuttering were analyzed, regardless of the number of moments of stuttering which occurred during his utterance of ten words.

Observing and Recording Data

Once the moment of stuttering to be analyzed was located, it was possible to describe the action of each film frame. The activity of each anatomical area (eyelids, jaw, lips, head, eyebrow, forehead, nostrils, chin, and neck) was viewed separately. Thus, the analysis of one moment required a minimum of nine viewings in order to record the activity of the nine areas. For the jaw and lips, every frame was described. For the other areas, only the frames during which action was present were described. The presence of activity in areas other than the jaw and lips was first confirmed by running through the film at speeds from four to 24 frames per second. Analysis was then made frame by frame of any activity observed at faster speeds. Details of the procedures used in the frame-by-frame analysis are given in Appendix A.

The positions and movements of each structure were recorded by the observer and were later transferred to graphic form. From the graphs were determined the number and proportion of frames during which selected activities were observed for each structure. Examples of the original data collection sheets, graphs, and data summary sheets are in Appendix B.

Reliability of Observations

Ten of the 230 moments analyzed were randomly selected for reanalysis in order to check the reliability of observations. Table 1 shows the results of the two frame-by-frame analyses of these ten words. In most cases, the writer appears quite consistent in tabulating the visible phenomena demonstrated.

Table 1. Comparison of data derived from two observations made two months apart of the same ten stuttering moments.

Moment number	No. of frames	Observation number	% Jaw-lip susp.	% Eyelid closure	% Excessive movement			% Tension					No. of oscillations per second			No. of unilateral deviations							
																Right				Left			
					Eye-lids	Eye-brow	Nos-tril	Fore-head	Chin	Lips	Neck	Total	Jaw	Lips	Eye-lids	Jaw	Lip	Eye	Total	Jaw	Lips	Eye	Total
1	201	1	54.72	0.49	12.43				43.28	43.00		43.28		6.00									
		2	50.74	0.99	13.43				48.25	46.26		48.25		8.00									
2	36	1	33.33		11.11											1			1	1			1
		2	33.33		22.22											1			1	1			1
3	46	1	15.21	4.34	34.78		32.60	10.86	8.69			10.86											
		2	13.04	17.39	36.95		41.30																
4	9	1	22.22		44.44																		
		2	11.11	11.11	55.55																		
5	102	1	43.13	6.86	14.70					1.92		1.92			2.66						1		1
		2	53.92	7.84	14.70										2.82						1		1
6	27	1	22.22		7.40																		
		2	18.51		7.40																		
7	53	1	75.47	5.66	15.09	13.20	35.84		13.20	18.86		18.86			4.36		1		1				
		2	79.24	3.77	15.09	13.20	28.30		9.43	13.20		13.20			4.80		1		1				
8	14	1	50.00													1	1		2				
		2	42.85													1	1		2				
9	17	1	29.41	5.88	58.82										4.36								
		2	35.28	5.88	64.70										4.00								
10	28	1	10.71	7.14	53.57				14.28			14.28			4.23								
		2	39.28	7.14	53.57				25.00			25.00			4.23								

Pearson product moment correlations were computed across ten moments of stuttering for the two variables for which a majority of the ten moments received scores: simultaneous suspension of jaw and lip activity and eyelid movement. A correlation of 0.89 was obtained for the former and 0.97 for the latter. The magnitude of these correlations is similar to the reliability obtained by trained listeners for audible phenomena of stuttering.

It should be noted that a variation of one frame for observations of the shorter stuttering moments results in a large difference in the percent of the moment consumed by a given phenomenon. Moment number four (Table 1) illustrates this point. Also, observations appear to be more consistent for some subjects than for others as, for example, in the case of moments three and seven. These two stuttering moments are approximately equal in length. However, observation of the visible phenomena of moment number seven appeared to be more consistent than for moment number three.

SUMMARY

The subjects for this study were 23 male stutterers (mean age, 17 years). Two samples of speech were obtained: an audio tape recording of five consecutive readings of a 204-word passage and a sound film of a self-formulated speech task. The films were made of the oro-facial region. Measurements were made of the audible and visible characteristics of stuttered speech as follows:

1. Audible Characteristics. The audio tape recordings of the reading passage and film sound track were analyzed for verbal output, reading and speaking rate in words per minute, and frequency of occurrence of nine types of dysfluency. Trend, Percentage, and Normal Deviate measures of adaptation and the Normal Deviate measure of consistency were obtained for the five readings of the 204-word passage. In addition, cumulative stuttering time was determined for the self-formulated speech task.

2. Visible Characteristics. The sound films of the self-formulated speech task were analyzed for frequency of occurrence of stuttered words. Ten stuttered words were then selected from each subject's performance on the self-formulated speech task. A frame-by-frame analysis was made of the film of these 230 words. Nine oro-facial areas were analyzed for the presence of visible phenomena which were not an integral part of the ongoing process of speech.

CHAPTER III

RESULTS AND FINDINGS

A combination of inspection and statistical procedures were used for analyzing the data derived from the measures of audible and visible characteristics of stuttered speech. The results of the analyses are presented according to their relevance to the questions for investigation presented in Chapter I.

QUESTION 1. WHAT ARE THE NATURE AND DISTRIBUTION OF OBSERVABLE VISIBLE AND AUDIBLE CHARACTERISTICS OF STUTTERED SPEECH?

Audible Characteristics

Adaptation and Consistency. Percentage, Normal Deviate, and Trend scores of adaptation (Tate and Cullinan, 1961) and the Normal Deviate score of consistency (Tate and Cullinan, 1962) were computed for 16 stutterers.* The results indicate that eight subjects showed adaptation scores at or above the .05 level of significance on the Normal Deviate measure and five subjects on the Trend measure. Seven subjects showed adaptation scores at or above 50 percent on the Percentage measure. The adaptation scores for each subject are shown in Table C-5 of Appendix C. These results were similar to those found in other recent studies (Prins and McQuiston, 1964; Newman, 1963) and are further evidence that significant adaptation is not a phenomenon of the speech of all stutterers.

Thirteen subjects showed consistency scores significant at or above the .01 level of significance.

Dysfluency Types. Tables 2 and 3 show the total number of stuttering dysfluencies which were classified for each subject and the proportions of this total which were designated as each of nine dysfluency types. Self-formulated speech is shown in Table 2 and the Reading Task in Table 3. Comparison of the two tables reveals a tendency for dysfluencies to fall into fewer categories on the Reading Task than on the Job Task. These findings are in keeping with those of Johnson (1961) in his study of 100 male stutterers. The average number of categories into which dysfluencies fell on the Job Task was 6.93 compared

*As explained in Chapter II, four subjects were unable to complete all five readings of the adaptation passage, and three subjects stuttered on less than 2 percent of the words. Their adaptation scores are not reported.

Table 2. Total number of dysfluencies and distribution of proportions of nine dysfluency types for the pre-therapy Job Task (N = 23).

	Total incidence	Inter-jections	Part-word repetitions	Word repetitions	Phrase repetitions	Revisions	Incomplete phrases	Broken words	Prolonga-tions	Pauses
Subject number										
1	43	.0232	(.4651)*	.0232				.0232	.1860	.2790
2	23	(.2173)	.1304	.1739		.1304	.0434		.1739	.1304
3	50	.1400	.2800	.0600	.0200	.0200			(.4600)	.0200
4	54	.2592	.1111	.0370	.0555	.0555	.0185	.0555	(.3333)	.0740
5	30	.0816	.1632	.1836	.0612	.0408		.0204	.1836	(.2653)
6	61	(.3278)	.1967	.1147		.0163	.0491	.0163	.1311	.1475
7	61	.0655	.1639			.0162			(.5901)	.1639
8	34	.0588	.0882	.0294		.0294	.0588	.0294	(.4117)	.2941
9	90	.1333	.0888	.0666	.0222	.0111		.0777	(.3333)	.2666
10	80	.1375	.0625	.0250			.0125		(.6125)	.1500
11	98	.3367	(.5102)	.0306				.0102	.0816	.0306
12	38	(.7631)	.1052	.0526	.0526	.0263				
13	34	.0588		.0882	.0294	.0588	.0882	.0294	.0882	(.5588)
14	49	.0408	.1632				.0408	(.4693)	.1836	.1020
15	102	(.5784)	.1666	.0882	.0686	.0490	.0294	.0098	.0098	
16	69	.1449	(.2793)	.1014	.0114		.0289	.0434	(.3478)	.0434
17	31	.1290	.1290				.0322		(.7096)	
18	34	(.6176)	.0588	.0294		.0294				.2647
19	53	.0188	.0566	.0377			.0188		.2830	.5849
20	63	(.3174)	.2698	.0952	.0158			.0793	.1428	.0793
21	120	.3483	.0750	.0916	.0083			.0083	(.4583)	
22	92	(.5978)	.1630	.1304		.0108	.0108	.0108	.0652	.0108
23	28	.0171	.2857						.1785	(.4285)
Average		.2692	.1826	.0678	.0164	.0186	.0156	.0365	.2438	.1491

*Circled proportions indicate predominant dysfluency type for each subject.

Table 3. Total number of dysfluencies and distribution of proportions of nine dysfluency types for the Reading Task (N = 21).

Subject number	Total incidence	Inter-jections	Part-word repetitions	Word repetitions	Phrase repetitions	Revisions	Incomplete phrases	Broken words	Prolonga-tions	Pauses
1	0									
2	11		.5454*	.3636						.0909
3	57		.2982					.0175	.6491	.0350
4	1								1.0000	
5	2			.5000					.5000	
6	12	.1666	.3333	.0833				.1666	.1666	.0833
7	236	.0338	.3601	.0127				.0042	.5466	.0423
8	15		.2000	.2000	.0666			.0666	.3333	
9	122		.2459	.0081				.0737	.3360	.3360
10	136	.0073	.2058	.0073				.0220	.5808	.1764
11	134	.2014	.4925	.0223				.0074	.0522	.2238
12	62	.4516	.1935	.1935	.1451				.0161	
13	9		.1111		.1111			.1111	.3333	.3333
14	104		.1153	.0384				.0769	.1730	.5961
15	40	.0750	.3000	.2750	.1500				.1750	.0250
16	70	.0142	.3142	.0714	.0285	.0142		.0428	.4571	.0571
18	15	.0666	.4000					.0666	.0666	.4000
19	65		.0923	.0307				.0513	.4615	.4000
21	198	.0151	.1919	.0101				.0151	.7525	.0151
22	148	.3581	.2635	.0135				.0067	.3445	.0135
23	36		.4722		.0277				.2222	.2777
Average		.0862	.2742	.0373	.0135	.0006	.0000	.0244	.4086	.1547

*Circled proportions indicate predominant dysfluency type for each subject.

with 4.47 on the Reading Task. All but three categories show a smaller proportion of dysfluencies on the Reading than the speaking task. Interjections, which account for the largest proportion of dysfluent types on the Job Task, rank as the fourth largest category on the Reading Task. For all subjects, the proportion of interjections is less for reading than for speaking. For two subjects, however, interjections are the predominant type of dysfluency demonstrated on both tasks.

For the Reading task, the category with the largest proportion of occurrences is prolonged sounds. This category was the second largest one on the self-formulated speech task. The proportion of part-word repetitions and pauses is also greater in reading than in self-formulated speech.

The range and mean for each category for the Job Task is shown in Table 4. Individual subjects differed considerably in the proportion of their dysfluencies which fell into each category. This can be seen readily by observing the circled scores in Tables 2 and 3, marking each subject's predominant dysfluency type. In this sense, the heterogeneity of the stuttering pattern was demonstrated. For 12 stutterers, however, 50 percent or more of their dysfluencies fell into only one of four categories on the Job Task: pauses, interjections, part-word repetitions, or prolongations. These subjects show internal consistency in that their stuttering pattern is characterized by a specific type of dysfluency.

Table 4. Range and mean for the proportion of the total dysfluency types accounted for by the nine categories of dysfluency on the pre-therapy Job Task.

Dysfluency category	Range	Mean
Interjections	.0232-.7631	.2692
Part-word repetitions	.0000-.5102	.1826
Word repetitions	.0000-.1836	.0678
Phrase repetitions	.0000-.0686	.0164
Revisions	.0000-.1304	.0186
Incomplete phrases	.0000-.0882	.0156
Broken words	.0000-.4693	.0365
Prolongations	.0000-.7096	.2438
Pauses	.0000-.5849	.1491

In order to make some comparisons with Johnson's (1961) data, the number of dysfluencies per 100 words was calculated for both tasks for each category and for the total number of dysfluencies. These figures show a lesser total number of dysfluencies for the Reading than for the Job Task. While Johnson's data shows fewer dysfluencies in every category for the Reading Task, however, the data from this group shows slightly more dysfluencies occurring in the part-word repetition and prolongation categories for the Reading Task than for the Job Task.

In general, Johnson's group and the group reported here appear to be similar in many respects. The range for all types of dysfluency on the Reading Task is similar for both groups with the exception that for Johnson's group interjections and prolongations show a larger and smaller range, respectively.

Verbal Output, Speaking Time, and Speaking Rate. Compared with the norms published by Johnson, the average subject in this study spoke half as many words on the Job Task but required proportionately more time to do so. The mean verbal output for Johnson's group was 280.4 words as compared to 140.4 words for this group. The mean speaking time was 182 seconds for Johnson's group and 130.8 seconds for this group.

Table C-1, Appendix C, shows the rate of speaking and reading for each subject in words per minute. The average number of words spoken per minute on the Job Task was 73.53 and on the Reading Task was 83.08. Although the subjects in this study show a range of scores for both reading and self-formulated speech which is distributed over the first nine deciles established by Johnson for 100 male stutterers, half of the Job Task scores and three-fourths of the Reading Task scores place in the first three deciles. Since the lower deciles indicate fewer words spoken per minute, it appears that the subjects in this study were on an average more dysfluent than those in Johnson's study.

Cumulative Stuttering Time. The proportion of time consumed by stuttering on the Job Task is presented in Table C-2, Appendix C. The range for the 23 subjects is from 27.52 percent to 87.81 percent of the total speaking time. The mean for the group is 60.26 percent. In general, a low speaking and reading rate is accompanied by a high cumulative stuttering time.

Percent of the Words Stuttered. The percentage of words stuttered by each subject on the Job Task and the first reading of the adaptation passage was computed for 23 and 21 subjects, respectively.* Table C-3, Appendix C, shows these figures along with the differences in percentages. With the exception of four subjects, there was a lower percentage of words stuttered on the Reading Task than on the Job Task. The mean percentage of words stuttered was 28.01

*All but two subjects were able to complete the first reading of the Reading Task. Two subjects were unable to participate in this task because of reading disability.

for the Job Task and 26.65 for the Reading Task.

The results reported above indicate that this group of stutterers shows a wide range of behavior on the audible dimensions of stuttering which were measured. Although the group appears heterogeneous in the distribution of these dimensions, patterns for comparison among subjects are suggested in the predominant type of dysfluency demonstrated, the significance of adaptation, and the tendency of some subjects to show a greater proportion of words stuttered on the Reading Task than on the Job Task.

Visible Phenomena

The length of the moments selected for frame-by-frame analysis varied from six frames (0.25 second) to 425 frames (17.7 seconds) with a mean of 49.6 frames (2.02 seconds). The average number of anatomical areas involved in a moment was 2.33.

The 27 scores which represented visible activity during the moments of stuttering are listed in Tables 5, 6, and 7 along with the number of moments in which each phenomenon was recorded, the mean occurrence, and the range for each phenomenon. As indicated in Chapter II, suspended movement, visible tension, supra-movement, sudden movement, and excessive movement were scored as the percentage of the frames in the moment consumed by each phenomenon. The presence of a unilateral deviation(s) during a moment of stuttering was scored as one, and oscillatory movements were scored as the highest number of oscillations per second which occurred during the moment of stuttering.

Of the variables examined, those which occurred most frequently in the speech of this group of stutterers were simultaneous suspension of jaw and lip activity and movement of the eyelids (see Table 5). Some degree of both phenomena was demonstrated by all subjects. In only nine of the 230 stuttering moments was lip and jaw suspension absent. The proportion of the total duration of a moment consumed by this phenomenon ranged from 0 to 93.38 percent with a mean of 43.15 percent. Eyelid movement was recorded for 189 stuttering moments and ranged from 0 to 77.77 percent with a mean of 19.40 percent of the total duration of the moment.

All but one subject showed some evidence of closure or partial closure of the eyelids. However, this phenomenon was present in only 125 moments. The range of occurrence was 0 to 76.47 percent and the mean occurrence was 9.05 percent.

The number of subjects showing tension in a given area varied from four subjects with visible neck tension to 18 subjects with visible tension of the lips. The means for neck and lip tension were 1.09 and 5.47 percent of the moment, respectively. Chin tension was recorded for 15 subjects and occurred in 56 moments with a mean occurrence of 7.88 percent of the moment of stuttering.

Table 5. Mean percentage of time of all stuttering moments observed consumed by certain visible phenomena; range for these phenomena; number of subjects; and number of stuttering moments for which these phenomena were observed.

Variable	Mean		No. of subjects	No. of moments
Number of frames in moment	49.6	6-425		
Suspension of jaw and lip	43.15	0-93.38	23	221
Eyelid closure	9.05	0-76.47	22	125
Eyelid movement	19.40	0-77.77	23	189
Eyebrow movement	2.91	0-90.32	10	24
Nostril movement	4.86	0-92.59	8	31
Forehead tension	6.42	0-90.32	11	29
Chin tension	7.88	0-86.27	15	56
Lip tension	5.47	0-70.95	18	50
Neck tension	1.09	0.56.60	4	9
Total tension	17.34	0-95.00	20	99
Supra-movement—jaw	9.39	0-85.98	4	7
Supra-movement—lips	0.88	0-17.85	2	2
Supra-movement—head			0	0
Supra-movement—tongue	1.52	0-36.58	2	2
Sudden movement—jaw	2.16	0-8.31	2	7
Sudden movement—head	12.19	0-55.49	5	8
Total number areas involved	2.33	0-5		

Table 6. Mean frequency of occurrence of unilateral deviations in all stuttering moments observed; range of unilateral deviations; number of subjects; and number of stuttering moments for which unilateral deviations were observed.

Variable	Mean	Range	No. of subjects	No. of moments
Jaw left	1.04	0-8	7	24
Lips left	1.30	0-6	11	30
Left eyelid	.21	0-2	3	5
Total left	2.30	0-8	15	53
Jaw right	.30	0-1	7	7
Lips right	.82	0-3	11	19
Right eyelid	.04	0-1	1	1
Total right	.09	0-4	13	22

Table 7. Mean number of oscillations per second for those moments for which oscillatory movements occurred; range of oscillatory movements per second; number of subjects; and number of stuttering moments during which oscillatory movements were observed.

Variable	Mean	Range	No. of subjects	No. of moments
Jaw oscillations/second	5.79	0- 7.50	7	11
Lip oscillations/second	7.23	0-12.00	16	50
Eyelid oscillations/second	3.18	0- 9.60	22	60

Eleven subjects demonstrated forehead tension with a mean of 6.42 percent of the duration of the moment. The ranges in percentage of moment time consumed by forehead, chin, lip, and neck tension, respectively, were 0-90.32 percent, 0-86.27 percent, 0-70.95 percent, and 0-56.60 percent.

Twenty subjects received a score for tension in at least one of the four anatomical areas. The average for the percentage of the moment consumed by tension without regard to the anatomical area in which it occurred (total tension score) was 17.34 percent. The range of scores for total tension was from 0 to 95 percent of the stuttering moment.

Unilateral deviations of the jaw, lips, and/or eyelids were recorded for 16 subjects during 75 moments of stuttering. Individual subjects had occurrences of unilateral deviations in from one to eight stuttering moments. The largest number of deviations occurred for jaw and lip deviations to the left. Only one deviation was recorded for the right eyelid and five for the left eyelid.

Repetitive oscillatory movements of the eyelids, while occurring in only 60 moments of stuttering, were demonstrated by 22 subjects. The average number of oscillations per second which occurred in these 60 moments was 3.18 0/s. The most rapid oscillatory movements of the eyelids were 9.60 0/s and the slowest were 1.33 0/s. Houssay (1955) reports the average occurrence of spontaneous blinking to be 20 0/minute (0.33 0/s). The maximum blink frequency was reported by Adler (1959) as 390/minute (6.5/second).

Repetitive oscillations of the lips occurred at rates from 4.36 to 12.00 0/s. Lip oscillations were recorded for 50 stuttering moments. The average for the 16 subjects for which they were recorded was 7.23 0/s. According to DeJong (1958, page 504) this rate is approximately that for medium tremors.

Only seven subjects showed oscillatory movements of the jaw and this phenomena was recorded in only 11 moments of stuttering. Repetitions occurred at rates up to 7.5 0/s with a mean of 5.79 0/s. Repetitive oscillatory movements were recorded only when they were clearly visible. Lip oscillations could sometimes be seen at normal film speed during stuttering moments in which they were not visible in frame-by-frame analysis. Therefore, lip oscillations probably occurred more frequently than is reflected in the results of this data.

Several phenomena occurred in fewer than ten subjects and/or 30 stuttering moments. These phenomena were movements of the eyebrows, forehead, and nostrils; supra-movements of the jaw, lips, head, and tongue; and sudden movements of the jaw and head.

The results of the frame-by-frame analysis of the visible phenomena of this group of stutterers shows that suspension of jaw and lip activity, eyelid movement, eyelid closure, eyelid oscillations, and tension are represented in the stuttering moments of almost all subjects. Jaw and lip suspension and eyelid

movements were recorded for the majority of stuttering moments and, therefore, might be considered the phenomena which best represent the group. Eye closure also appears to be more of a group than an individual phenomena in that it occurs in a majority of stutterers and in a majority of stuttering moments. All of the other phenomena studied appear to be more individual than group characteristics in that they are demonstrated by only a few subjects or in relatively few moments of stuttering.

QUESTION 2. ARE THERE SIGNIFICANT INTER-SUBJECT DIFFERENCES IN THE DISTRIBUTION OF VISIBLE PHENOMENA ACROSS MOMENTS OF STUTTERING?

Two statistical procedures were used to determine if subjects could be differentiated in the distribution of their scores on selected visible variables. Ten of the variables observed were selected for an analysis of variance by ranks (Kruskal and Wallis, 1952). The omitted variables were those for which there were too few scores and included the supra and sudden movements, neck tension, jaw oscillations, and forehead tension. Unilateral deviations were also omitted because the manner in which they were scored made it more appropriate to evaluate them through the use of the chi square test.

For the analysis of variance by ranks, a significant value of H indicates that subjects differ from one another in the distribution of their scores on a particular variable. The results are shown in Table 8. For five of the ten variables, values of H significant above the 0.001 level of confidence were attained. These variables were: total number of film frames in the moment, simultaneous suspension of jaw and lip activity, eyelid closure, eyelid movement, and number of anatomical areas involved in the moment. A sixth variable, total visible tension, had an obtained H value which exceeds the value required for the 0.01 level of confidence. For these six variables, the hypothesis that all population distributions were identical was not accepted. The hypothesis was accepted for four categories: chin tension, lip tension, repetitive oscillations of the lips, and repetitive oscillations of the eyelids. Two other phenomena, eyebrow and nostril movement, reached significance; however, inspection of the distribution of scores in these categories revealed a large number of ties for the zero rank, making the validity of the analysis questionable.

The chi square test (Dixon and Massey, 1957, p. 231) was used to evaluate the significance of differences in the frequency distributions of selected phenomena across moments of stuttering for different speakers.

Table 9 shows the results of the chi square test for eight categories of unilateral deviations. Chi square values significant at the 0.001 level of confidence were obtained for total deviations to the right and left, left deviations of the jaw, and left deviations of the lips. A chi square value significant at the 0.01 level of confidence was obtained for total deviations to the left. Chi square values obtained for deviations of the left eyelid, total right deviations, right deviations of the jaw, and right deviations of the

Table 8. Summary of analysis of variance by ranks of selected measures of visible phenomena occurring during stuttered speech.

Phenomena	H	P*
Number of frames in the moment	88.488	<0.001
Simultaneous suspension of jaw and lip activity	49.682	<0.001
% eyelid closure	79.661	<0.001
% eyelid movement	67.018	<0.001
% chin tension	29.946	
% lip tension	27.802	
% total tension	47.141	0.001<P<0.01
Lip oscillations	27.748	
Eyelid oscillations	27.539	
Number of anatomical areas involved	67.982	<0.001

*H values of 30.81, 33.92, 36.78, 40.29, and 48.27 (df = 22) are required for significance at the 0.10, 0.05, 0.025, 0.01, and 0.001 levels of confidence, respectively.

Table 9. Results of the chi square test of the occurrence of unilateral deviations of the lips, jaw, and eyelids during stuttered speech.

Category	Chi square	P*
Total right and left deviations	81.841	<0.001
Total left deviations	64.518	<0.01
Jaw deviations to the left	106.561	<0.001
Lip deviations to the left	49.794	<0.001
Deviations of the left eyelid	23.639	
Total right deviations	20.607	
Jaw deviations to the right	11.504	
Lip deviations to the right	18.210	

*Chi square values of 30.81, 33.92, 36.78, 42.80, and 48.77 (df = 22) are required for significance at the 0.10, 0.05, 0.025, 0.01, and 0.001 levels of confidence, respectively.

lips failed to reach the 0.10 level of confidence. Because deviations of the right eyelid occurred only once during the 230 moments of stuttering, this category was not submitted to the chi square test.

These results, as well as those for the audible data, point to the heterogeneity of stutterers and indicate that they differ significantly from each other in the distribution of many visible phenomena in their stuttered speech.

QUESTION 3. ARE THERE PATTERNS OF CONSISTENCY OF VISIBLE PHENOMENA WHICH CAN BE IDENTIFIED WITHIN AND BETWEEN A SUBJECT'S MOMENTS OF STUTTERING?

For the purposes of this study, consistency for an individual subject was arbitrarily defined as:

1. the occurrence of a combination of the same two, three, or four visible phenomena within 60 percent or more of his stuttering moments;

2. the occurrence of the same phenomenon as the first event in at least 60 percent of his stuttering moments;

3. the occurrence of the same phenomenon as the last event in at least 60 percent of his stuttering moments.

Occurrence of Combinations of Visible Stuttering Phenomena

For each moment of stuttering, a list was made of the visible phenomena which occurred. The visible phenomena were eyelid closure; eyebrow and nostril movement; tension of the forehead, chin, lips, and neck; repetitive oscillations of the jaw, lips, and eyelids; supra movements of the jaw, lips, head, and tongue; sudden movements of the jaw and head; and unilateral deviations of the jaw, lips, and eyelids. It was apparent from the data above that suspension of jaw and lip activity and eyelid movement occurred in 60 percent or more of the stuttering moments of all but two subjects. Because of the pervasiveness of these activities they were not considered in evaluating the consistency of visible combinations.

The proportion of each subject's ten moments of stuttering during which a combination of the same two, three, or four phenomena occurred together was determined. The results of this analysis revealed two subjects who showed the same two visible phenomena occurring together in 60 percent or more of their stuttering moments. For one of these subjects, the two phenomena were eyelid closure and repetitive oscillations of the eyelids. For the other subject the two phenomena were chin and lip tension. One additional subject showed a cluster of four phenomena which occurred together in 60 percent of his stuttering moments. These were eyelid closure, repetitive oscillations of the eyelids, eyebrow movement, and left deviations of the jaw. Other than these, no variables occurred in combinations of two or more in 60 percent of the stuttering moments of any subject.

Occurrence of First and Last Visible Phenomena

Inspection of the graphic display of each subject's ten moments of stuttering was made in order to determine if it were possible to identify a consistently occurring first or last visible phenomenon. For 15 subjects, it was not

possible to identify any one phenomenon or group of phenomena which occurred initially in 60 percent or more of their stuttering moments. Eight subjects approximated the 60 percent criterion as follows: for seven, half of their stuttering moments began with jaw and lip fixation or with some kind of eyelid phenomena. The one additional subject began 50 percent of his stuttering moments with repetitive lip oscillations.

The last visible characteristic of the stuttering moment appeared to be even less consistent than the first. For 18 subjects, no consistent last event could be identified. For five subjects, eyelid movements were the last visible feature observed in five moments of stuttering.

In terms of the definitions of consistency proposed, there is no clear evidence that the subjects in this study generally follow a consistent pattern: (1) in combinations of visible phenomena throughout the course of their stuttering moments; or (2) in initiating or terminating stuttering moments. Three subjects, however, were marked by the consistency of two and four phenomena combinations.

QUESTION 4. ARE SIGNIFICANT CORRELATIONS APPARENT AMONG THE VISIBLE AND AUDIBLE CHARACTERISTICS OF STUTTERING, AND DO FACTORS EMERGE WHICH WOULD SUGGEST A BASIS FOR DESCRIBING DIFFERENT DIMENSIONS OF STUTTERED SPEECH?

The results above indicate that stutterers may be differentiated on the basis of certain audible and visible phenomena of their stuttered speech. With this possibility at hand, it becomes meaningful to evaluate correlations among all of the phenomena observed to determine whether it is possible to identify different clusters of variables which may be useful in the description of the visible-audible characteristics of stuttering. Correlation coefficients were computed between audible and visible variables and a factor analysis of the correlation matrix was made.*

Factor Analytic Procedure**

The expression of the strength of association of variables within factors, in terms of factor loadings or relative weights for scores on each variable for each factor, provides a means of summarizing the results of the correlation coefficients among pairs of variables.

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*Because adaptation and consistency scores were not available for all subjects, the scores of only 19 subjects were used in the factor analysis.

**The data were analyzed by computer, using a principal component solution and an orthogonal rotation of the factor analysis.

Although every variable in the present study has some loading or weight on each of the ten factors specified for this analysis,* for purposes of discussion and interpretation of factors, each variable is assigned to the factor on which it has the highest loading. In this way, the variables are divided into groups, each of which may measure a particular dimension of stuttering behavior.

Since, when two variables have high positive loadings on the same factor it is indicative of a high positive correlation between these variables, individuals who score high on one variable tend to score high on the other as well. On the other hand, when two variables, one with a high positive and one with a high negative loading, are found on the same factor, they are negatively correlated and individuals scoring high on the positively loaded variable will tend to score low on the other variable.

Although variables are assigned only to the factor on which they show the highest loading, there are instances in which a variable shows loadings large enough to be meaningful on more than one factor. These instances are noted in the discussion below.

Results of the Correlations and Factor Analytic Procedure

Figure C-1 in Appendix C shows the significant coefficients resulting from the correlations of all pairs of audible and visible phenomena. The factor loadings are presented in Table 10.

The assignment of variables within factors, based on the highest loading, is shown in Table 11. Of the ten factors shown in Table 11, six consist primarily of variables which have very low loadings on other factors (factors 1, 2, 3, 4, 6, and 10). Of these six factors 1, 3, and 4 are dominated by audible variables and factors 2 and 10 by visible variables. In general, audible and visible phenomena appeared to load most heavily on different factors.

Factor 1 is dominated by audible variables and might be labeled a severity factor. Frequent occurrences of stuttering, prolonged stuttering moments, low number of words spoken per minute, and visible phenomena occurring in several different anatomical areas all may be used as measures of stuttering severity. Number of lip oscillations per second is positively related to this factor, suggesting that it, too, be considered an index of severity. A low proportion of revisions, word repetitions, and incomplete phrases during self-formulated speech and of word repetitions during reading also are related to this factor.

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*Eighty-three percent of the variance was accounted for by the ten factors.

Table 10. Rotated factor matrix for audible-visible phenomena.*

Variable	1	2	3	4	5	6	7	8	9	10
Pre-therapy variables										
1. Total frames in moment	71	07	-16	20	-50	20	-12	-00	15	04
2. Jaw-lip suspension	13	09	-42	56	-31	-18	-03	22	15	-14
3. Eye closure	-02	07	13	-09	04	-82	00	-04	25	-11
4. Eyelid movement	07	04	25	41	77	-01	06	-16	-24	03
5. Chin tension	26	01	02	-11	17	01	-03	-79	-15	03
6. Lip tension	15	17	-41	32	-20	-23	23	-61	-05	08
7. Total tension	17	02	11	01	12	-10	08	-91	06	08
8. Lip oscillations	57	-23	32	00	01	28	31	09	02	51
9. Eyelid oscillations	-16	-13	-10	23	02	79	04	24	-07	-23
10. Jaw left	-05	-42	-24	00	40	-22	-45	40	-05	-01
11. Lips left	09	08	-00	-06	07	07	09	10	00	-92
12. Eyelids left	36	07	23	-52	05	11	-29	-31	-19	14
13. Total left	-14	-14	-06	-23	-04	02	-22	09	-15	-79
14. Jaw right	-01	-86	-10	-00	10	08	-06	23	-14	-13
15. Lips right	05	-92	06	-13	26	14	17	-13	-07	06
16. Eyelids right	00	00	00	00	00	00	00	00	00	00
17. Total right	03	-95	01	-01	01	13	11	-03	-10	01
18. No. areas involved	43	-21	19	-15	02	-42	-03	-22	-34	-35
19. Words/min, pre-therapy Job	-90	-14	14	-10	14	-02	17	14	-15	-02
20. Words/min, reading	-75	-01	-07	14	36	-09	02	17	-22	04
21. % words stuttered, pre-therapy Job	90	00	-22	11	16	-00	-07	-13	09	-03
22. % words stuttered, reading	59	-09	-05	-08	70	-01	-01	-19	11	-09
23. Difference in % words stuttered pre-therapy Job, reading	-05	-15	15	-24	87	-02	05	-14	06	-09
24. % time stuttered pre-therapy Job	91	17	-07	00	01	-11	-13	02	17	08
25. Consistency	28	-30	-04	20	35	23	29	-33	27	-45
26. Adaptation, %	38	14	01	62	28	19	03	-28	03	17
27. Adaptation, trend	-22	09	-23	83	-10	-01	08	29	23	08
28. Adaptation, Normal Deviate	02	03	06	78	21	02	-19	-11	05	23
Dysfluency types, pre-therapy Job Task										
29. Interjections	01	00	83	04	31	-08	-15	04	06	15
30. Part-word repetitions	25	-16	16	09	-41	23	-21	-19	47	-14
31. Word repetitions	-60	17	03	-03	33	08	-57	08	-14	-07
32. Phrase repetitions	-33	05	26	36	-00	-60	-26	09	-17	27
33. Revisions	-74	29	00	04	-11	05	-14	03	-02	31
34. Incomplete phrases	-56	28	-14	-16	09	15	54	-03	-16	-06
35. Broken words	-14	-52	-18	-11	09	-14	40	-55	05	-01
36. Prolongations	28	19	-80	04	25	-13	00	08	28	00
37. Pauses	04	08	-31	-12	-47	16	26	27	-63	-13
Dysfluency types, Reading Task										
38. Interjections	15	17	81	-13	21	00	-09	-05	06	-11
39. Part-word repetitions	00	-10	31	-15	06	65	-13	-01	23	04
40. Word repetitions	-62	07	01	10	00	08	-59	09	-04	03
41. Phrase repetitions	-16	27	51	17	05	-04	16	12	-25	34
42. Revisions	-17	-07	03	-43	21	-07	-01	07	11	01
43. Incomplete phrases	00	00	00	00	00	00	00	00	00	00
44. Broken words	-35	-16	-02	-02	17	25	65	14	-09	-35
45. Prolongations	17	12	-51	04	26	-67	-07	08	02	02
46. Pauses	11	-43	-09	-09	-06	18	55	-25	-40	-13

*Decimal points are omitted for all entries in the body of the table.

Table 11. The assignment of audible and visible variables within factors.

Factor Number	Variable Number	Description	Loading
Factor 1	24	% time stuttered, Job Task	.91
	21	% words stuttered, Job Task	.90
	19	Words/minute, Job Task	-.90
	20	Words/minute, Reading Task	-.75
	18	No. areas involved in moment	.43
	1	Total frames in moment	.71
	8	Lip oscillations/second	.57
	33	Revisions, Job Task	-.74
	40	Word repetitions, Reading Task	-.62
	31	Word repetitions, Job Task	-.60
	34	Incomplete phrases, Job Task	-.56
Factor 2	14	Right jaw deviations	-.80
	15	Right lip deviations	-.92
	17	Total right deviations	-.95
Factor 3	41	Phrase repetitions, Reading Task	.51
	29	Interjections, Job Task	.83
	38	Interjections, Reading Task	.81
	36	Prolongations, Job Task	-.80
Factor 4	27	Adaptation, trend	.83
	28	Adaptation, normal deviate	.78
	26	Adaptation, percentage	.62
	2	Suspension of jaw and lip activity	.56
	12	Deviations of left eyelid	-.52
	42	Revisions, Reading Task	-.43
Factor 5	23	Differences in % words stuttered, Job Task-Reading Task	.87
	22	% words stuttered, Reading Task	.70
	4	Eyelid movement	.77
Factor 6	9	Eyelid oscillations/second	.79
	39	Part-word repetitions, Reading Task	.65
	3	Eyelid closure	-.82
	32	Phrase repetitions, Job Task	-.60
	45	Prolongations, Reading Task	-.67
Factor 7	44	Broken words, Reading Task	.65
	46	Pauses, Reading Task	.55
	10	Jaw deviations left	-.45
Factor 8	5	Chin tension	-.79
	6	Lip tension	-.61
	7	Total tension	-.91
	35	Broken words, Job Task	-.55
Factor 9	30	Part-word repetitions, Job Task	.47
	37	Pauses, Job Task	-.63
Factor 10	11	Left lip deviations	-.92
	13	Total left deviations	-.79
	25	Consistency	-.45

Two factors are dominated by unilateral deviations: factor 2 which is composed of right deviations of the jaw and lips and of total right deviations, and factor 10 which is composed of left deviations of the lips and total left deviations. One audible variable, the consistency phenomenon, is also assigned to factor 10 but shows meaningful loadings on several other factors as well. Factors 2 and 10 might be labeled right and left deviations, respectively. The occurrence of factors composed of lateralized phenomena is of interest in terms of laterality theory and stuttering, particularly since there were twice as many left as right deviations in this group of stutterers. It should be noted that some difficulty was encountered in the discrimination of these deviations on film. Occurrences of deviations were sometimes subtle and possibly less reliable than other types of phenomena to identify. There was also a difficulty in distinguishing deviations of a functional nature from those related to structural anomalies of the mandible. Although these limitations do not account for the occurrence of twice as many left as right sided deviations, there is a need to interpret the results with caution. Further investigation of these phenomena is warranted before conclusions can be drawn as to their usefulness. Meanwhile, they should not be ignored as a dimension of stuttering which may prove useful in discriminating between subjects.

The only instance in which any of the nine audibly detected dysfluency types shows both high loadings on one factor and relatively low loadings on all other factors is on factor 3. This might be labeled an interjection factor noting that the loading of prolongations is in the negative direction.

Factor 4 is dominated by the adaptation phenomenon. The adaptation variables, especially the Normal Deviate measure, have relatively low loadings on all other factors. The percentage score of adaptation shows a modest loading with factor 1 (severity factor) which may reflect the tendency for this measure to correlate with the frequency of stuttering on the initial reading of an adaptation passage (Tate and Cullinan, 1961).

It is of considerable interest that adaptation, a long studied phenomenon of the speech of stutterers, emerges as a separate dimension of stuttering which appears unrelated to the other audible-visible phenomena which were studied.

Factors 5 and 6 are assigned combinations of audible and visible variables which bear similarities: the auditory phenomena are primarily reading task variables and the visible phenomena are the three eyelid measures. In factor 5, positive relationships are evident among the difference in percentage of words stuttered between the Job and Reading Tasks, percentage of words stuttered on the Reading Task, and eyelid movements. In factor 6, eyelid oscillations are positively correlated with part-word repetitions on the Reading Task and negatively correlated with eyelid closure, phrase repetitions on the Job Task, and prolongations on the Reading Task. It would be difficult to find labels suitable for these factors; however, it is interesting to note the positive relationship between the variables of eye movement and stuttering difficulty while reading.

Two positively correlated Reading Task variables (broken words and pauses) are assigned to factor 7 and two negatively correlated Job Task variables (part-word repetitions and pauses are assigned to factor 9. Jaw deviations to the left is also assigned to factor 7 but has meaningful loadings on several other factors as well.

Factor 8 stands out as a tension factor, with chin, lip, and total tension assigned to it. Only one other variable, broken words on the Job Task, is assigned to this factor. Moreover, chin and total tension have very low loadings on all other factors. No other variables have appreciable loadings on this factor except left deviations of the jaw which shows equally high loadings on several other factors.

The emergence of several different factors from the variables measured establishes empirically the multidimensionality of stuttered speech. Moreover, several of the factors identify dimensions of stuttering which previously have been discussed in the literature but have not been derived in this fashion: over all stuttering severity, adaptation, tension, lateralization, repetitions and prolongations as negatively related phenomena, and differences in speaking performance between reading and self-formulated speech. On the other hand, some clinically described features did not emerge as separate dimensions: for example, oscillatory movements, which would suggest a "tremor" factor, and the separation of phenomena according to anatomical areas.

Relationships Other Than Those Shown by the Factor Analysis

The adaptation and consistency phenomena, tension, and repetitive oscillatory movements have long been of interest to students of stuttering behavior. Because of this interest, special attention was given to these phenomena over and above reporting the results of the factor analysis. This was done by examining the significant correlations reported in Figure C-1, Appendix C, and further examining the factor loadings. The correlations of audibly detected types of stuttering dysfluency and severity of stuttering were also more thoroughly examined.

Adaptation, Consistency, Tension, and Repetitive Oscillatory Movements. For adaptation scores, the correlation matrix reveals no significant relationships which are not reflected in the factor analysis. The adaptation phenomenon appears to have very little relationship to other variables or to factors other than the one to which it is assigned with the one exception previously noted. The correlation matrix does show a slight negative relationship between percentage adaptation scores and eyelid movement and between trend adaptation scores and deviations of the left eyelid, suggesting that adaptation may be associated in some way with visibility of the reading material. The tendency for reading tasks and eyelid phenomena to cluster together on factors 5 and 6 also suggests that there may be an association between stuttering during reading and eyelid phenomena. Adler (1959) states that there is a blackout during 10 percent of the

time that the eyes are active in blinking. As blinking increases, the percent of the time that there is a blackout of vision becomes greater. Subjects in this study showed eyelid movements consuming up to 77 percent of the stuttering moment. For a stuttering moment which lasted to 50 frames (2.08 seconds), a subject for whom eyelid movements consumed 75 percent would have had visual blackout during approximately 16 percent of the moment. Adler (1959) estimates the average blackout time for men to be about 10.8 percent. Adler's data, however, is not based on eyelid movements during reading.

The consistency phenomenon does not seem to be strongly related to any one factor. Although it is assigned to factor 10 on the basis of its highest loading, the loading on that factor is not much larger than for several others.

Unlike adaptation, the consistency phenomenon appears to be a pervasive characteristic of stuttered speech and not a characteristic upon which stutterers may readily be differentiated.

A positive correlation of .62 between chin tension and deviations of the left eyelid was the only relationship with tension not revealed by the factor loadings.

Other than the factor loadings already presented, lip oscillations had a negative correlation of -.47 with total left unilateral deviations. Although these two variables were not assigned to the same factor, lip oscillations had a high loading on the factor to which total left deviations was assigned (factor 10).

Relationship of the Nine Audibly Detected Dysfluency Types to Severity of Stuttering. The correlation matrix was also inspected to determine which of the audible dysfluency types were associated with stuttering severity, as indicated by a positive correlation with percentage of words and percentage of time stuttered and a negative correlation with words spoken per minute. Prolongations, which Young (1961) found to appear to be correlated with severity ratings of stuttering, also was the type of dysfluency correlated with a measure of severity in this study. Word repetitions, revisions, and incomplete phrases were most consistently negatively associated with stuttering severity. These variables were negatively loaded on factor 1, reflecting also this relationship with severity.

The results above which identify factors from the audible and visible measures of stuttering do not of themselves provide a basis for the classification of subjects. Rather they suggest dimensions on which stutterers may be described and suggest that by measuring the behavior of stutterers on a number of different dimensions, profiles of stuttering behavior may emerge which will be useful in identifying similarities and differences between individuals and groups of stutterers.

CHAPTER IV

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The purpose of this study was to determine the locus, relative frequency, and consistency of occurrence of the visible phenomena of stuttered speech; to investigate the relationships between the audible and visiole phenomena of stuttered speech and to determine whether these relationships suggest a way in which different patterns of stuttering may be classified.

Two samples of speech were obtained from 23 male stutterers (Mean age = 17.0 years) enrolled in an eight-week summer residential program. A 204-word passage was read five consecutive times by each subject and was recorded on audio tape. Sound motion pictures were made of the oro-facial area of each subject as he performed a self-formulated speech task (the Job task).

Audio tape recordings of the first reading of the 204-word passage and of the self-formulated speech task were analyzed for verbal output, number of words spoken per minute, frequency of occurrence of stuttered words, and frequency of occurrence of each of nine types of disfluency.

Normal Deviate, Trend, and Percentage measures of adaptation and the Normal Deviate measure of consistency were obtained for the five readings of the 204-word passage. Cumulative stuttering time, the amount of the total speaking time consumed by disfluencies, was obtained from recordings of the Job task.

A frame-by-frame analysis of selected visible phenomena of stuttered speech was made for ten words stuttered upon by each subject during the filming of the Job task. Scores determined for the visible phenomena of stuttered speech were as follows:

1. Total number of film frames in the stuttering moment and total number of anatomical areas involved in the moment;

2. Percent of the total stuttering moment consumed by simultaneous suspension of jaw and lip activity; eyelid closure; eyelid movement; eyebrow movement; nostril movement; tension of the forehead, chin, lips, and neck; and exaggerated movements of the jaw, lips, head and tongue;

3. Frequency of occurrence of unilateral deviations of the jaw, lips, and eyelids;

4. Number of repetitive oscillatory movements per second of the jaw, lips, and eyelids.

The data derived from the measures of the audible and visible characteristics of stuttered speech were analyzed by a combination of inspection and statistical procedures. Statistical procedures included analysis of variance by ranks and chi square tests of the visible phenomena and a factor analysis of forty-six audible and visible variables.

The major findings in reference to the questions for research posed in Chapter I were:

1. What are the nature and distribution of observable visible and audible characteristics of stuttered speech?

a. As a group, the subjects demonstrated heterogeneity in the occurrence of visible as well as audible characteristics of stuttered speech.

b. The majority of subjects tended to show some one type of audible disfluency which dominated his speech pattern during his performance on the Job Task.

c. Approximately half of the subjects showed significant adaptation scores.

d. Two visible phenomena, simultaneous suspension of jaw and lip activity and eyelid movement, were characteristic of all subjects' moments of stuttering.

e. Unilateral deviations to the left side were twice as frequent as unilateral deviations to the right.

f. Tension in one or more anatomical areas, eyelid closure, and repetitive oscillatory movements of the eyelids and lips, while demonstrated by most subjects during one or more stuttering moments, were characteristic of the stuttering moments of only a few subjects.

g. For this group of subjects, supra- and sudden movements of the lips, head, and tongue were observed infrequently and were not present in the majority of the stuttering moments of any subject. Forehead tension, eyebrow movement, and nostril movement were characteristic of the stuttering moments of only one or two subjects.

2. Are there significant inter-subject differences in the distribution of visible phenomena across moments of stuttering?

The stutterers in this study differed significantly from one another in the distribution of their scores on the following visible variables: number of film frames in the moment, simultaneous suspension of jaw and lip activity, eyelid closure, eyelid movement, total visible tension, number of anatomical areas involved in the moment, total unilateral deviations,

of the jaw, and left deviations of the lips.

3. Are there patterns of consistency of visible phenomena which can be identified within and between a subject's moments of stuttering?

Inspection of the data did not support the suggestion that stutterers show combinations of, or first or last visible phenomena which occur consistently during their stuttering moments.

4. Are significant correlations apparent among the visible and audible characteristics of stuttering, and do factors emerge which would suggest a basis for describing different dimensions of stuttered speech?

Correlations between pairs of audible and visible variables and factor analysis revealed that for these subjects:

a. The adaptation phenomenon was not strongly related to the other audible or visible phenomena measured.

b. There was a relationship between phenomena involving eyelid movement and the performance of subjects on the Reading Task.

c. Prolongations showed the most consistent association with stuttering severity; and word repetitions, revisions, and incomplete phrases appeared to be the dysfluency types least associated with stuttering severity.

d. Among the 46 variables studied several relatively independent audible-visible factors of stuttering were found emphasizing the need for a multidimentional approach to the description of stuttered speech.

e. A number of the factors identified dimensions of stuttering which previously have been discussed in the literature but never have been derived in this fashion: overall stuttering severity, adaptation, tension, lateralization, repetitions and prolongations as negatively related phenomena, and differences in speaking performance between reading and self-formulated speech. On the other hand, some clinically described features did not emerge as separate dimensions: for example, oscillatory movements, which would suggest a "tremor" factor, and separation of phenomena according to anatomical areas.

LIMITATIONS OF THE PRESENT STUDY AND SUGGESTIONS FOR FUTURE RESEARCH

Interest in this study was inspired by the recent recognition of the need to identify differences among stutterers. The specific challenge was sounded by St. Onge (1963) when he called attention to the importance of differentiating between relevant and irrelevant signs and symptoms in establishing criteria for

differential diagnosis.

In undertaking a study specifically of the visible symptoms of stuttered speech, it was not anticipated that the results of the research would lead to clear-cut definitions of sub-groups of stutterers. Rather, it was hoped that from the investigation some guidelines would emerge which could be used to describe and eventually classify stuttering behavior.

LIMITATIONS IMPOSED BY THE POPULATION AND FRAME-BY-FRAME ANALYSIS

A necessary first step toward the major objective of this study was to determine the visible characteristics which could be investigated and to develop techniques for obtaining measures of these characteristics from the filmed samples of stuttered speech. The behaviors and scores selected for analysis were, to a great extent, dictated by the population samples and the limitations imposed by the collection of speech samples on film. The subjects demonstrated a very wide range of speech behavior, providing what appeared to be a good sample of stuttered speech. A number of limitations, however, were imposed by the use of film. One limitation was that only phenomena which could be identified from a frontal, oro-facial view of the subject could be recorded. Although many of the phenomena of interest can be observed from this view, not all phenomena are equally discriminable. Moreover, many visible phenomena of stuttered speech may occur in areas other than those studied.

The complexity of movements for some oro-facial areas creates problems in observing and accurately recording phenomena. Head movements are particularly difficult to record because of the wide range of movement and combinations of movement permitted the head. Another drawback to film analysis is the difficulty in establishing objective criteria for distinguishing between certain "normal" and stuttering related types of movement. The categories sudden-movement and supra-movement proved least satisfactory for making objective judgments. Perhaps some means of recording these phenomena other than, or in addition to, filming would provide more reliable measurements. Head movements were also occasionally responsible for obscuring the view of the lips or eyes. Fortunately, this event seldom occurred. Some consideration was given to stabilizing the head but this idea was rejected in an attempt to keep the speaking situation as normal as possible. Frame-by-frame film analysis also has the obvious problem of being time consuming and fatiguing. Finally, it must be kept in mind that observations were made only of phenomena which are visible on film and that the absence of film visibility does not necessarily imply an absence of the phenomenon.

In spite of what appears to be a formidible list of limitations, it is felt that a trained and practiced observer can demonstrate sufficient reliability in making observations and that frame-by-frame analysis of films becomes a useful tool for studying carefully selected variables. Future studies might supplement film data with simultaneously recorded physiological measures.

The difficulty in using such measures with stutterers is that the paraphernalia usually required for making these measurements places unusual circumstances on the speaker which might distort the results.

CONSISTENCY OF STUTTERING BEHAVIOR

The notion that stuttering behaviors are consistent in occurrence and follow a pattern is of particular interest to proponents of learning theories of stuttering. The presumed temporal sequence is viewed by some as demonstrating a learned chain of events in which one response produces the stimulus for the next. Van Riper's (1954) observation that stutterers display distinctive and sequential stuttering patterns was not confirmed however, by the results of this study.

An explanation might be found in the relatively small number of stuttering moments observed for each subject. Combinations of behavior may have emerged from investigation of a larger speech sample. However, it does not appear likely that even with a larger sample patterns would be found of the consistent nature suggested by Van Riper. It is possible, too, that the detail recorded during the frame-by-frame analysis obscures the salient features of a pattern. Another possibility is that the occurrence of combinations of visible phenomena in stuttering is somewhat dependent upon the phonetic structure of the stuttered word. Just as a word beginning with a bilabial sound requires a different articulatory attack than one beginning with a vowel, it may also evoke a different set of stuttering responses. Future studies might examine the sequence of stuttering phenomena in speech responses with similar or identical phonetic structure.

APPLICATION OF THE RESULTS OF THIS STUDY TO THE CLASSIFICATION OF STUTTERING BEHAVIOR

The factor analysis of correlations among the audible and visible phenomena demonstrated by this group of subjects suggests some of the dimensions of stuttering upon which stutterers might be measured. Further research will be necessary in order to demonstrate whether or not these dimensions will be of assistance in identifying profiles of stuttering behavior useful in its description and classification. One approach might be to devise a single measure which would best represent the several variables within a factor. For this purpose, the results of the analysis of variance and chi square test of visible phenomena could be used since seven factors (1, 4, 5, 6, 7, 8, and 10) contained variables on which subjects differed significantly from one another. Profiles resulting from the performance of stutterers on these dimensions then could be compared. Similarities between profiles might suggest bases for classifying subjects and make it possible to identify more objectively stuttering types such as those suggested by Douglass and Quarrington (Douglass and

Quarrington, 1952; Quarrington and Douglass, 1960) and Emerick (1966). For example, according to Emerick's description, tonic and clonic stutterers should rate in the opposite direction on visible tension, pauses, prolongations, interjections, and repetitions, all variables with high loadings on factors 3, 8, and 9.

The dimensions suggested by this study are not, of course, the only set of dimensions which could be used to categorize stuttering. They represent only the best combination of variables which could be determined for this group of subjects under the circumstances of the experimental conditions and the limitations of the methods used to obtain the data. Refinements of techniques for identifying, measuring, and quantifying visible phenomena are needed as well as investigation of the validity of the categories.

APPENDIX A

PROCEDURES FOR MAKING OF FRAME-BY-FRAME ANALYSIS OF THE VISIBLE PHENOMENA OF STUTTERED SPEECH

The analysis of the facial activity of the stutterers observed in this study followed the steps outlined below. The variety in activity demonstrated by subjects, however, required greater flexibility in approach than is suggested by these steps. The writer, for example, has suggested specific projector speeds as convenient for observing certain phenomena. Another observer may find other speeds more revealing and better suited to his own perceptual skill.

GENERAL PRINCIPLES

1. One type of activity was observed at a time. Care was taken not to be distracted by unexpected events or activities related to the structure being observed. For example, it was sometimes difficult to focus on jaw activity to the exclusion of lip activity. Distraction was reduced by blocking out the distracting area with a piece of black construction paper.

2. Observation began 2 or 3 frames preceding the frame for which activity was to be recorded. This procedure allowed the film frames to "seat" themselves in the projector and allowed the observer to adjust to the image.

3. Observations were checked frequently, especially when the movements under observation were very small.

4. Each area was observed at more than one projector speed setting. One speed setting frequently revealed phenomena not apparent at a faster or slower setting.

5. All observations of the direction of movement of a structure took into consideration the subject's habitual posturing of the structure. For example, the subject who habitually held his jaw to one side during nonspeech and fluent speech activity was not recorded as showing unilateral deviations of the jaw. Several subjects showed frowning and squinting of the eyes throughout the filming of the Job Task. This characteristic was felt to be due to the intensity of the light source used in filming and was thus not recorded as forehead tension.

STEPS IN ANALYSIS

1. Preparation

A double-spaced, verbatum script of the Job Task was prepared from the audio tape recordings of the film sound track. The script included all audible characteristics of the stuttered speech. Prior to the collection of the data to be used in this study, 40 stuttered words were observed in order to devclop skill in observing and recording and to become familiar with the mechanics of the projector.

2. Locating the Words to be Analyzed

A. A grease pencil was used to mark one of the film frames preceding the initiation of speech by the subject This frame was used as a reference for setting the frame counter at zero. For the study presented here, the frame immediately following the marked frame was used as the zero frame.

B. Viewing proceeded forward from the zero frame at 12 to 16 frames per second until speech was initiated. The film was then run backward and forward at slower rates of speed until the frame in which speech activity was initiated was located. The number of this frame was marked in the script before the first word.

C. Using the script as a guide to identifying the words as the subject spoke them, viewing proceeded forward through the film. The projector was stopped at the end of every several phrases and the number of the film frame marking the end of the phrase was noted in the appropriate portion of the script. These numbers provided useful general reference points when searching for the words to be studied frame-by-frame, or "target" words.

D. In approaching target words, more frequent reference numbers were used. It was noted generally the frames between which the target word fell. These frames were then viewed repeatedly and at increasingly slower speeds until the best judgment of the frames containing the word was made and these numbers were recorded in the script. In the study reported here, these frames fell between the last visible evidence of the articulation of the word or syllable preceding the target word or syllable and the completion of the utterance of the target word or syllable.

3. Analysis of the Target Word

A. Beginning Position

The film was adjusted to several frames preceding the initial frame for the target word. This frame will be referred to as the "beginning

position."

B. Jaw

1. The projector was adjusted to run at one frame per second. Opening, closing, stabl:, and supra-movements of the jaw were observed and recorded for each film frame.

2. Returning to the beginning position, the jaw was observed at 12 to 24 frames per second to check for unilateral and sudden movements. The film frames during which these phenomena occurred were located exactly at slower speeds.

3. A third check through the film was made for repetitive oscillatory movements.

C. Lips

1. Returning to the beginning position, the projector was set to run at one frame per second and observation made of the opening, closing, open, closed, protrusion, and other bilateral movements of the lips. Movement and suspension of movement was recorded for each film frame.

2. The lips were then observed at 12 to 24 frames per second and checked for unilateral movements, supra-movements, and evidence of tension. The film frames during which these phenomena occurred were identified and recorded.

3. Repetitive movements were observed in a third viewing.

D. Eyelids

In viewing eyelid activity, the projector was run at 4 frames per second from the beginning position and a frame-by-frame accounting made of eyelid activity when it occurred.

E. Head

1. From the beginning position, the projector was fun forward at 4 frames per second to check through the sustained head movements.

2. A separate check at 24 frames per second was made to identify rapid and sudden movements of the head.

F. Chin, Neck, Forehead, Eyebrows, Nostrils, Tongue

1. For each area separately, the film was returned to the beginning position and a check was made for the presence of activity in the area.

2. When activity was observed, it was recorded according to the categories designated for each area.

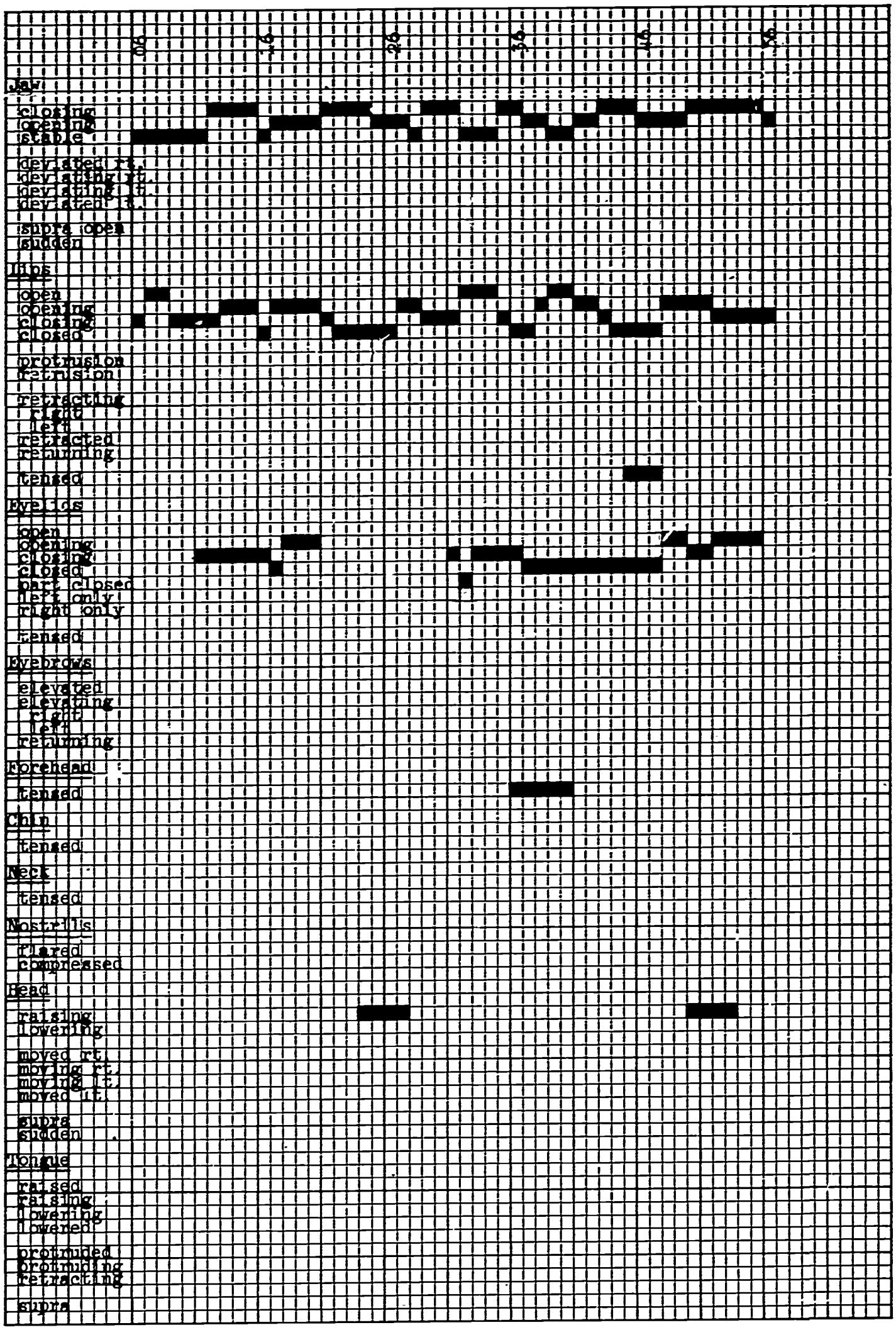
G. The final step was to review the face as a whole at 16 to 24 frames per second, noting additional phenomena which might be present.

APPENDIX B

Table B-1. Frame-by-frame record of the visible phenomena occurring during stuttering moment number 7 of subject number 12.

Word #7 — Subject number 12
Word "the"
Film frames 1006 to 1056

Frames	Phenomenon
Jaw	
1006-1011	stable
1012-1015	closing
1016	stable
1017-1020	opening
1021-1024	closing
1025-1027	opening
1028	stable
1029-1031	closing
1032-1034	stable
1035-1036	closing
1037-1038	opening
1039-1040	stable
1041-1042	opening
1043-1045	closing
1046-1049	opening
1050-1055	closing
1056	opening
Lips	
1006	closing
1007-1008	open
1009-1012	closing
1013-1015	opening
1016	closed
1017-1020	opening
1021	closing
1022-1026	closed
1027-1028	opening
1029-1031	closing
1032-1034	open
1035	closing
1036-1037	closed
1038	opening
1039-1040	open
1041-1042	opening
1043	closing
1044-1047	closed
1048-1051	opening
1052-1056	closing
1045-1047	tension
Eyes	
1011-1016	closing
1017	closed
1018-1020	opening
1031	closing
1032	partially closed
1033-1036	closing
1037-1047	closed
1048-1049	opening
1050-1051	closing
1052-1055	opening
Forehead	
1036-1040	tensed
Chin	no movement
Neck	no movement
Nostrils	no movement
Tongue	not visible



Each square represents one film frame.

Figure B-1. Graph of stuttering moment number 7 of subject number 12.

Table B-2. Scores derived from graph of subject 12, stuttering moment number 7 (Figure B-1).

Phenomena		Percent of the moment
Total number of frames in the moment	51 frames	
Simultaneous suspension of jaw and lip activity	8 frames	15.68
Eyelid closure	13 frames	25.49
Eyelid movement	22 frames	43.13
Forehead tension	5 frames	9.80
Lip tension	3 frames	5.88
Total tension	8 frames	15.68
Eyelid oscillations	1.92 per second	
Number of areas involved in the movement	3	

APPENDIX C

Table C-1. Speaking rate in words per minute for the Job Task (N = 23) and the Reading Task (N = 21).

Subject No.	Job Task	Reading	Subject No.	Job Task	Reading
1	30.00	154.20	13	123.60	159.60
2	127.80	133.20	14	96.60	82.80
3	31.20	56.40	15	98.40	114.00
4	85.80	126.60	16	124.80	91.80
5	111.60	163.20	17	77.40	
6	135.00	138.60	18	121.20	87.60
7	17.40	10.20	19	47.40	63.60
8	70.20	63.00	20	115.20	
9	24.60	16.80	21	37.20	34.20
10	37.80	42.60	22	45.00	36.60
11	30.00	31.80	23	18.00	58.80
12	85.20	79.20			

Table C-2. Cumulative stuttering time and percent of the total speaking time consumed by disfluencies on the Job Task (N = 23).

Subject No.	Cumulative Stuttering Time in Seconds	Percent Time Stuttered
1	101.20	68.84
2	24.50	25.81
3	83.80	68.40
4	57.30	59.81
5	49.33	49.42
6	42.00	27.52
7	191.96	87.81
8	60.90	75.09
9	161.76	70.26
10	134.33	80.58
11	163.76	79.57
12	50.60	62.85
13	31.06	42.31
14	40.03	46.60
15	80.60	48.29
16	53.26	43.94
17	47.66	52.66
18	34.53	45.31
19	77.10	66.58
20	49.23	44.39
21	151.30	82.63
22	134.80	77.87
23	92.30	79.56

Table C-3. Precentage of words stuttered on the Job Task (N = 23) and Reading Task (N = 21) and the difference between the Tasks in percentage of words stuttered.

Subject No.	Pre Therapy Job Task	Reading Task	Difference Between Pre Therapy Job and Reading Tasks
1	39.18		39.18
2	7.92	3.43	4.49
3	46.87	20.58	26.29
4	25.87	1.47	24.40
5	19.35	0.98	18.37
6	13.95	4.41	9.54
7	83.78	75.59	8.19
8	21.31	5.39	15.92
9	51.06	46.07	4.99
10	60.95	58.33	2.62
11	53.39	46.07	7.32
12	25.43	22.54	2.89
13	19.20	4.90	14.30
14	34.05	47.54	+13.49*
15	20.16	12.25	8.91
16	21.51	28.43	+ 6.92*
17	21.36		
18	13.63	6.37	7.26
19	41.30	27.45	13.85
20	22.06		
21	57.01	78.92	+21.91*
22	42.30	51.47	+ 9.17*
23	51.42	17.64	33.78

*A greater percentage of the words spoken on the Reading Task were stuttered.

Table C-4. Number of words spoken on the Job Task (N = 23), speaking time in seconds and number of words stuttered on the Job Task and the Reading Task (N = 21).

Subject No.	Number of Words Spoken	Speaking Time in Seconds		Number of Words Stuttered	
	Job Task	Job Task	Reading Task	Job Task	Reading Task
1	74	147.0	79.5	29	0
2	202	94.9	92.0	16	7
3	64	122.5	216.9	30	42
4	143	95.8	96.5	37	3
5	186	99.8	75.0	36	2
6	344	152.6	88.2	48	9
7	37	218.6	183.0	31	127
8	95	81.1	195.1	25	11
9	94	230.2	116.3	48	94
10	105	166.7	285.5	64	119
11	103	205.8	384.0	55	94
12	114	80.5	155.0	29	46
13	151	73.4	76.7	29	10
14	138	85.9	147.6	47	97
15	274	166.9	107.1	58	25
16	251	121.2	133.6	54	58
17	117	90.5		25	
18	154	76.2	139.5	21	13
19	92	115.8	193.0	38	55
20	213	110.9		47	
21	114	183.1	360.6	65	161
22	130	173.1	333.8	55	105
23	35	116.0	208.1	18	36

Table C-5. Percentage (A_p), normal deviate (A_z) and trend (A_t) scores of adaptation and normal deviate (C_z) scores of consistency of stuttering (N = 16).*

Subject No.	A_p	A_z	A_t	C_z
2	83	1.768**	.39	1.096
3	-35	-2.373	-.38	11.194**
6	75	1.443**	.30	.044
8	40	.866	.14	1.727**
10	10	1.200	.34	15.230**
11	9	1.080	.23	18.243**
12	52	3.208**	.26	4.246**
13	20	.250	.22	.435
14	31	4.270**	.33**	18.418**
15	- 8		-.07	4.126**
16	57	4.865**	.59**	6.371**
18	50	1.336	.19	3.564**
19	52	4.070**	.45**	6.756**
21	4	.500	.05	7.046**
22	22	8.544**	.32**	3.053**
23	78	5.568**	.53**	4.121**

*Scores for subjects who stuttered on fewer than 2 percent of the words are not reported above.

**Scores at or above the 0.05 level of significance.

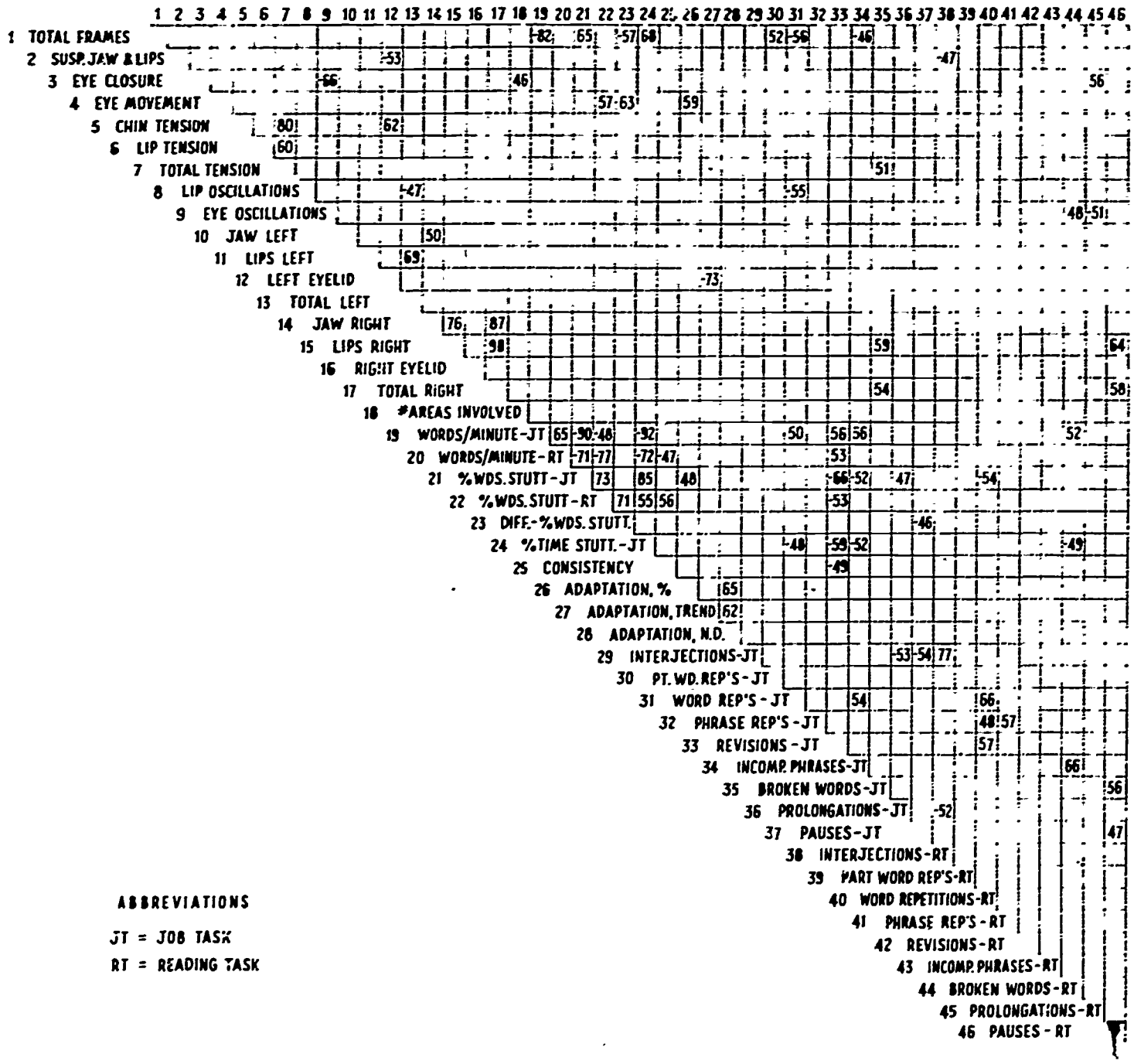


Figure C-1. Selected correlation coefficients among visible and audible phenonema of stuttered speech.*

* A correlation coefficient of 0.46 was found to be equivalent to the t ratio value required for the 0.05 level of confidence (Hays, 1963, page 529). This table shows only those correlations which were 0.46 or greater.

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BUREAU OF EDUCATION FOR THE HANDICAPPED
DIVISION OF RESEARCH

PROJECT NO: 6-2382 (FINAL REPORT)

TITLE: A Study of the Behavioral Components of Stuttered Speech

INVESTIGATOR(S): T. David Prins and Frances E. Lohr

INSTITUTION: The University of Michigan
Ann Arbor, Michigan

OE COORDINATOR: Max W. Mueller

RECOMMENDATION: Approval and submission to ERIC

SUMMARY OF REVIEWS

This report has been reviewed by the Division of Research Staff and appropriate field readers. Approval and submission to ERIC have been recommended.

The report testifies that the work done on the project was that work promised in the original proposal.

The investigators present a thorough and comprehensive report, well documented and carefully written. The findings of the study are reported in detail with clarity and are interpreted with caution. The measurements used were precise and the statistical analysis thorough.

The report is well written with careful and complete reporting of data.

In terms of educational significance, the report adds information to categorization and classification of stuttering behavior. It is possible that workers in programmed instruction, contingency management, and in functional analysis of behavior may find this data most helpful in the future.

The technical quality of the report is excellent.

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