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Subvocalization and Stuttering

LaVerne Brent Gohl

Abstract

SUBVOCALIZATION AND STUTTERING

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Twenty-six subjects, thirteen stutterers and thirteen fluent speakers, were matched by age, sex and educational background. None had any history of neurosurgery, neuropathology or debilitating injury to the head or neck.

Two GRASS silver chloride electrodes were attached to the chin and inferior surface of the lower lip of each subject. This recording site was chosen because, presumably, it would detect activity of the quadratus labii inferioris, a muscle involved in the articulation of labial phonemes, permitting a distinction between the labial and nonlabial ensembles and, therefore, speech and nonspeech oral activity. EMG recordings, measuring covert phonetic activity, were obtained with a GRASS Model 7 polygraph and recorded on a strip printer during a verbal-listening task. Each subject heard ten groups of five words each. Five of the ten word-groups were comprised of words with bilabial sounds (/p/, /b/, /m/). The other five groups had words without bilabial sounds. The subjects were instructed to attempt memorization of each word-group as it was presented, as they may be asked to write the words on paper shortly after each presentation.

The electromyography print-outs were divided into two

ten-second categories: First, presentation which coincided in real time with the subject's auditory reception of each word group; second, rehearsal which coincided in real time with the subject's attempt to retain the word group in auditory memory before being instructed to write down the words heard or wait for the next word-group presentation.

Statistical analyses of the electromyograms revealed no significant group differences between stutterers and fluent speakers; however, highly significant individual differences were found when experimental subjects were compared one-by-one with their controls. Fifty-four percent (seven pairs) of the experimental subjects were significantly more active subvocally during presentation and rehearsal of labial and nonlabial word groups than their control. In twenty-three percent (three pairs), the experimental subjects were significantly less active subvocally. The remaining twenty-three percent (three pairs) were not significantly different from each other in subvocal activity. The terms "hyperactive-subvocalizer," "hypoactive-subvocalizer" and "active-subvocalizer" were coined for use in labeling subjects who were relatively more active, less active or normally active subvocalizers.

It was concluded that seventy-seven percent of the stutterers in the present research study showed aberrant subvocal articulatory patterns. It was suggested that analysis of subvocalization patterns may be used as part of a

differential diagnostic test battery to aid in identification of a neurogenic component as part of an individual stutterer's communicative disability.

LOMA LINDA UNIVERSITY

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SUBVOCALIZATION AND STUTTERING

by

LaVerne Brent Gohl

A Thesis in Partial Fulfillment

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Master of Science in the Field of Speech Pathology

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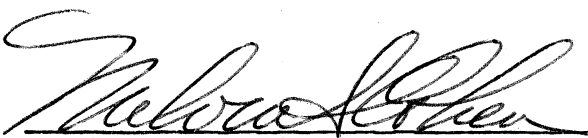
Each person whose signature appears below certifies that this thesis, in his/her opinion, is adequate, in scope and quality, as a thesis for the degree Master of Science.



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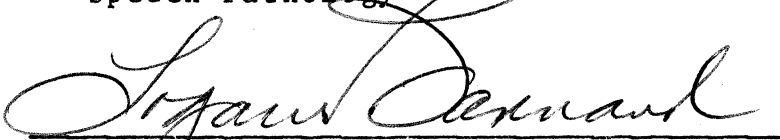

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CHAPTER I

OBJECTIVES

The National Advisory Neurological Diseases and Stroke Council (1969) estimated that 0.7 percent of this nation's 200,000,000 citizens are specifically handicapped by the communication disorder known as stuttering. The Council's investigation revealed that 1,400,000 Americans stutter.

Canter (1971) states that historically, theories about the etiology of stuttering have been classified as simply "organic" or "functional," with the latter category arising during the 1900's, along with psychoanalysis. The past quarter century of research in operant conditioning has added another theory, suggesting that stuttering might be a learned behavior.

Andrews and Harris (1964) suggested that several variables, having their bases in the central nervous system and the environment, combine to produce stuttering. In spite of all speculation, no one knows the specific cause or causes of stuttering. Further research is needed to more clearly describe the differences between stutterers and fluent speakers.

STATEMENT OF THE PROBLEM

The present study was designed to answer the question: Do stutterers subvocalize differently than fluent speakers during a verbal-listening task?

THE NULL HYPOTHESIS

It was hypothesized that electromyographic recordings of the quadratus labii inferioris would reveal no significant differences between the electrical activity patterns produced by stutterers and fluent speakers during auditory reception, subvocal rehearsal, and graphic reporting of groups of words, some containing no bilabial speech sounds and others containing high percentages of /p/, /b/ and /m/ speech sounds.

IMPORTANCE OF THE STUDY

Many authors have suggested that there may be disruption along the afferent language pathways of those who stutter. The theory is supported by research data showing that stutterers perform inferiorly on such tasks as dichotic listening (Perrin, 1969; Curry and Gregory, 1969), tachistoscopic recognition (Cohen, 1971), and auditory-visual integration (Cohen, 1973).

The present study was designed to determine whether there are afferent auditory-verbal processing differences between persons who stutter and those who are fluent speakers. If such differences do exist, it might suggest that stutterers not only produce overt speech movements inefficiently, but their spontaneous covert articulatory activity during speech reception may also be different from that of fluent speakers.

Such a finding might suggest the presence of what could

be termed "receptive stuttering." Considering that the expressive-speech disorder of stuttering is known to disrupt the normal communication process when the stutterer is speaking, a phenomenon of "receptive stuttering" might relate to reading difficulties or learning problems, to the extent that these receptive processes are dependent upon efficient auditory-verbal processing.

DEFINITION OF TERMS

Auditory-Subvocal Processing - Covert approximation of articulatory innervation patterns, such as those used in the overt production of words, phrases and sentences without vocalizing or consciously moving the articulators.

Dysfluent Subvocal Speech - Blocks, repetitions or other dysrhythmic characteristics of stuttering which are observed (using electromyography) during subvocal speech production.

Electromyography - The preparation and study of graphic records (electromyograms) of the changes in electrical potential during the contractions of a muscle.

Stuttering - Temporal disruption of the simultaneous and successive programming of muscular movements required to produce one of a word's integrated sounds, or to emit one of its syllables appropriately, or to accomplish the precise linking of sounds and syllables that constitutes its motor pattern (Van Riper, 1971).

Subvocal Speech - The unseen movements of articu-

latory muscles which occur when a person is covertly articulating during auditory and visual reception, interpretation and retrieval of information.

CHAPTER II

LITERATURE REVIEW

NEUROTIC THEORIES OF STUTTERING

Within the field of psychiatry, there are many explanations for stuttering. The theories include that of Sheehan (1958), in which he carefully pointed out that within the psyche of the person who is abnormally dysfluent, there exists an approach-avoidance conflict. The individual desires to express himself verbally and approaches the moment in time when the actual motor movements are to occur; but he avoids free expression because of some conflict within himself, which is inhibitory in nature. The resulting speech is stuttered.

Psychoanalytic theories, like those of Glauber (1958), speculate that stuttering might be ascribed to a pregenital conversion neurosis. Travis (1971) detailed this neurosis by commenting that "stuttering is a special case of the universal conflict between closeness and distance, involvement and autonomy, intimacy and autism."

Many descriptions of the unobservable characteristics of stuttering have been attempted. Some researchers (Cobb, 1943; Barbara, 1957) have described the phenomenon as an expression of anxiety. Within the network of stuttering-related anxiety, Van Riper (1971) stated that expectancy to stutter correlated highly with the occurrence of the

stuttering block. Knott, Johnson and Webster (1937) found that expectation of stuttering resulted in their subjects producing a higher frequency of dysfluencies than at times when there were no expectations of stuttering. Johnson (1948) summarized these descriptions by identifying stuttering as an "anticipatory, hypertonic, apprehensive avoidance reaction."

Perkins (1971) reported on a psychophysiological study conducted by Gray in 1968, in which it was found, by using electroskin conductance and evaporative water loss as physiological measures of anxiety, that stuttering and anxiety apparently are not directly related.

ORGANIC THEORIES OF STUTTERING

Organically-oriented studies have attempted to determine whether significant differences exist in the physiological or anatomical systems of normal speakers and stutterers. For more than twenty years, electroencephalographic research has brought interest and controversy to the investigation of the various organic theories. During this time, the results of using the electroencephalogram (EEG) as a tool for investigation have been varied. While research findings by Douglass (1943), Freestone (1942), and Knott and Tjossem (1943) indicated that brain-wave patterns were not the same for stutterers and fluent speakers, Scarbrough (1943), Busse and Clark (1957), and Fox (1966) found no evidence of statistically significant differences indicative of pathological activity in their stuttering subjects.

Bohme (1968) explains this apparent dichotomy by suggesting that stuttering is a subcortical syndrome. If this were true, then electroencephalography would not be a useful instrument for providing evidence of a somatic origin for stuttering.

Several researchers have artifically induced stuttering by electrical stimulation of the brain. Sem-Jacobsen (1968) cites examples of six subjects who stuttered in response to electrical stimulation of an area near the thalamus. Ojemann, Fedio and VanBuren (1968) induced an unanesthetized subject to stutter by electrical stimulation of the pulvinar, an area near the posterior-lateral border of the thalamus.

The central nervous system is thought to play an important role in the production of stuttered speech. Sheehan and Vaos (1954) measured muscular tension just prior to termination of blocking and found it to be greatest at the point in time just before release. Travis (1931) emphatically stated that in a person who stutters, there is neuromuscular derangement, secondary to cortical lead control.

The suggestion that speech areas of the cortex might suffer from delayed myelinization was offered by Karlin (1947). He developed this idea by relating the high prevalence of stuttering among children to the fact that critical myelinization of neuronal pathways occurs simultaneously with the peak periods of normal dysfluency. Disruption in the normal development might be a factor related to the

problem of stuttering.

LEARNED BEHAVIOR THEORIES

Penfield and Roberts (1959) pointed out that an ideational mechanism, which makes available the acquired elements of speech, and a motor articulation mechanism that is inborn and may be utilized by the voluntary motor system, function for learning and producing speech. Their theory of speech is more than just a description of the mechanisms. It implies that voluntary control is possible.

The question has been asked, "If stuttering were not learned, then how is it possible for a stutterer to 'unlearn' dysfluencies and to become a fluent speaker?" Brutten and Shoemaker (1967) hypothesized that dysfluency is conditioned. Emotional responses (classically conditioned) are thought to interfere with normal speech. Stuttering responses (instrumentally conditioned) are, as a result, said to be learned. This is commonly referred to as the two-factor learning theory.

INTEGRATED THEORIES

Several investigators have tried to bring harmony out of the chaos created by the many theories, definitions and treatment programs existing within the literature about stuttering. In one study conducted by Neaves (1970), four factors were compared among stutterers: (1) Motor Impairment; (2) Lateral Dominance; (3) Intelligence; and (4) Personality Adjustment. Results of the Neaves investigation

supported a multifaceted theory of the disorder. Poor neuromuscular coordination appeared to be the basic causative factor. In addition, the history of speech development in the stutterers and their close relatives, the nature of the onset of the stuttering, intelligence, and some dimensions of personality were all found to be significantly correlated to stuttering in these nonfluent subjects.

Riley and Riley (1974) describe three areas for examination when considering a diagnostic model of stuttering. They include a motor component, a language component, and several complicating factors. Their list of fifty-one sub-areas clearly indicates the complexity of attempting to reduce the etiology of stuttering to a single factor.

DEFINITION BY LISTENERS

Several studies have been conducted to analyze the behaviors and characteristics which naive listeners might judge to be stuttering. Perkins (1971) pointed out that dysfluencies which result from uncontrolled articulatory movements are considered by listeners to be abnormal, while dysfluent articulatory movements appearing to the observer to be controlled are judged to be normal. Luper and Mulder (1964) stated that dysfluencies in distinctive phonetic characteristics of speech, such as sounds and syllables, are most likely to be judged as stuttering; whereas, disrupted words, phrases and sentences are likely to be considered normal.

TREATMENT BY RHYTHM AND RATE CONTROL

Goldiamond (1965) felt that by slowing the rate of speech, stuttering could be virtually eliminated. Many studies have shown that reduction of stuttering is achieved by providing the stutterer with a slow, rhythmic pattern to follow. Among such reports appearing in the literature are articles by Beech (1967), Beech and Fransella (1969), and Meyer and Comley (1969).

Curlee and Perkins (1969) experimented with delayed auditory feedback (DAF) and found it to be an effective adjunct for reducing the rate of speech and increasing the percentage of fluent speech. Many researchers (Trotter and Lesch, 1967; Curlee and Perkins, 1969; Cherry and Sayers, 1956) have obtained favorable results using auditory masking noise for the purpose of rate control.

ELECTROMYOGRAPHY (EMG)

Many of the body's muscles, including those of the speech articulators, can be innervated without their movements being visible to the unaided human eye. Although the muscle's action is not overtly detectable, electrical activity is present and measurable. During its contraction period, the active portion of a muscle fiber becomes electrically negative with respect to adjacent tissue or inactive muscle. The electrical potentials generated by an active muscle are known as muscle-action potentials. These action potentials, which are similar in nature to those developed by nerves, may be detected by means of electrodes and, with

suitable amplification, can be displayed on an appropriate recording device. The technique of recording muscle-action potentials, known as electromyography (EMG), has recently become an important research tool (Zemlin, 1968).

SUBVOCALIZATION

An extensive review of the literature (Locke, 1970) concerning the occurrence of subvocalization during learning did not cite any studies relating subvocalization to overt speech, even though the same articulators are used for speech production and subvocalization. Locke and Fehr (1970) hypothesized that subvocalization might be a form of articulation, and their experimentation tends to support this concept.

Covert oral activity was measured by Locke (1971) in an original study using EMG recordings obtained from changes in subjects' action potentials in the region of the chin and lower lip during reception of visually-presented words. The EMG recordings clearly indicated a significant increase in subjects' covert muscular activity in the area of the quadratus labii inferioris during reception of those visually-presented words which were heavily loaded with bilabial speech sounds. There was significantly less activity in that specific area during reception of visually-presented words which did not contain any bilabial sounds. A study conducted by Locke and Fehr (1970) provided additional support for this subvocalization theory.

The pursuit for objective data regarding subvocalization and speech was continued by Locke and Fehr (1972) in a study designed to determine the effect of intermodality crossing of information. They found that subvocalization occurred more frequently when subjects were instructed to "say what they had seen" or to "write what they had heard" than under other circumstances, such as writing what was seen or saying what was heard. The authors theorized that translation of the stimuli into a different mode and code from stimulus to response was the variable which caused this phenomenon.

Apparently, to date, no attempts have been made to investigate the possibility that persons whose speech is abnormal, such as stutterers, might demonstrate abnormal subvocalization patterns. There seem to be sufficient theoretical bases for investigating the possibility that stuttering may be a receptive, as well as an expressive, communication disorder. The experimental data may help to determine whether stutterers tend to possess some type of specific neurological dysfunction which somehow prevents or interferes with their ability to function efficiently in speech production, auditory perception, and intersensory integration (Cohen, 1973). If the occurrence of stuttering in overt speech is due primarily to anxiety, frustration, neurosis or other psychological dysfunctions, there should be no reason for its characteristics to be seen in a covert

process, such as the subvocalization which accompanies auditory reception.

CHAPTER III

METHODOLOGY

SUBJECTS

Twenty-nine persons served as subjects for the present study. None of the subjects had any history of neurosurgery, neuropathology or debilitating injury to the head or neck. Each subject's chronological age was commensurate with his or her educational level. All subjects had either recently received audiometric evaluations or were not in doubt as to the normalcy of their auditory acuity. One subject had recently undergone corrective surgery on his right tympanic membrane and was experiencing a mild, unilateral hearing loss, without tinnitis or sound distortion. According to a recent audiogram, his hearing acuity in the left ear was within normal limits.

Each experimental subject was matched for age and sex with a control subject who reported having no history of non-fluent speech (APPENDIX I). In twelve pairs of subjects, the difference in age between each experimental subject and his control was less than twenty-four months. One pair of subjects had a thirty-nine month span between their ages. Three additional subjects (two experimental and one control) were also evaluated but, because their counterparts were unavailable for participation in the study, their scores were not included in the data analysis.

Each subject's conversational speech was evaluated

by the examiner during an interview which immediately preceded the testing. The stutterers were divided into two groups: "Bilabially dysfluent" or "generally dysfluent."

CONSTRUCTION OF TEST STIMULI

Fifty common monosyllabic words were selected for use as auditory test stimuli. Twenty-five of these contained one or more of the bilabial phonemes /m/, /p/ or /b/. The remaining twenty-five words contained no bilabial phonemes and were least likely to evoke any lip movements. Each of the two twenty-five word-groups was randomly divided into smaller groups of five words each. The resulting ten lists, each containing five words, were randomly ordered and resulted in the pattern presented in Table 1.

Table 1. Word List

	WORDS					WRITE	LABIAL
1.	MILD	MOM	POST	BUG	PICK	YES	YES
2.	MINE	BILL	PASS	PAST	POT	NO	YES
3.	LANE	CUT	KNEE	CAN	COULD	YES	NO
4.	MARK	MAKE	BOY	MOST	PRESS	NO	YES
5.	LINE	CALL	EGG	HUNG	HUSH	NO	NO
6.	BALL	BLUE	BIG	ME	BRUSH	YES	YES
7.	MAN	MORE	MIX	MISS	BUY	NO	YES
8.	LACK	NIECE	ALL	THING	GONE	YES	NO
9.	EAT	ON	IN	HEAD	LAWN	YES	NO
10.	TEA	LED	DING	TAN	GUN	NO	NO

The instructions to the subjects and the lists of test words were prerecorded on audio tape. Presentation of five of the ten lists (Table 1) was followed with an

instruction for the subject to write the group of words he had just heard. This instruction came twelve seconds after presentation of the last word in the group. Although the graphic task was not graded for correctness, it was included to reinforce the subjects' post-presentation subvocal rehearsal of the stimuli during intersensory translation.

TESTING PROCEDURE

Each subject was seated in a reclining chair, facing away from a one-way mirror which separated the testing room from the control room. Auditory stimuli originating from a Sony Audiorecorder (Model TC 106A) were transmitted through a cable to Damark Stereo Headphones (Model H S-102).

Presentation of test stimuli was preceded by the following recorded instructions:

> "This test is for the purpose of finding out more about the physiology of learning. You are going to hear a tone like this...TONE (1-KHz/1 sec)... followed by a group of five words. Listen carefully and try to remember the words in order. You will be asked to write some of them from memory. If a series of three tones follows the five-word group sounding like this...THREE TONES (3-KHz/½ sec) ...you are to write the group of five words which you have just heard. Then, relax and wait for the next tone and the next group of five words. Here are examples of what you will do after you hear the five-word group: TONE (1-KHz/1 sec)...RING...RANG ...RUNG...ON...IT...(silence/20 sec). If a long period of silence follows, just relax and wait for the next word group. You do not need to write. Here is another example of what you will do: TONE (1-KHz/1 sec)...RING...RANG...RUNG...ON...IT... (silence/2 sec)...THREE TONES (3-KHz/½ sec). You have thirty seconds in which to write the group of five words, in order, which you have just heard. Begin writing (silence/30 sec). The test will begin in thirty seconds." (Note: At this point, the

examiner entered the testing room and asked the subject if he/she understood the directions and was ready to proceed. Each subject indicated that the instructions had been clear.)

Instrumentation and procedures followed during the present study were identical to those followed by Locke and Fehr (1972), and the first subjects were evaluated in Dr. Fehr's presence.

ELECTROMYOGRAPHIC RECORDING

Two GRASS E5S Silver Cup-Shaped electrodes were attached to each subject, using adhesive strips and electrode cream. One electrode was positioned on the chin and the other on the inferior surface of the lower lip, to detect activity of the quadratus labii inferioris, a muscle involved in the articulation of labial phonemes. A ground was connected to the left ear lobe by means of a GRASS E34S Silver Ear Electrode Clip Assembly.

Changes in electrical potential passed through a GRASS Polygraph Direct Current Driver Amplifier, Model 7DAE (Serial 276 TOJ), which was adjusted as follows:

Polarity	Use
½ Amp High Frequency	35 Hz
Standby	On
Driver Sensitivity	3
Baseline Position	0.5
60 Hz Filter	On

This was coupled with the GRASS Solid-State Alternating Current Pre-Amplifier, Model 7P3B (Serial 242S8), which was set as follows:

Calibrator	50 μv
Sensitivity	High, 7
Function	Int., AC Calibration

Time Constant	.08 seconds
½ Amp Low Frequency	1 Hz

Electrical changes were transmitted to a strip-chart recorder and recorded on GRASS Polygraph paper with 2 mm/1 second grid at a paper speed of 6 mm/1 second. The position of each word group was hand marked on the print-out and numbered consecutively from one to ten. A 20-second electromyography tracing was produced for each word group presented to the subject.

CHAPTER IV

RESULTS

ANALYSES OF ELECTROMYOGRAMS

A Hewlett-Packard 9820A calculator was used to determine the total linear distance of each 20-second tracing. This analysis provided a score (in centimeters) for each word-group, yielding ten scores for each subject (Table 2).

Table 2. Linear Distance in Centimeters for Ten-Word Groups

SUBJECT NUMBER									
1-E	1-C	2-E	2-C	3-E	3-C	4-E	4-C	5-E	5-C
27.2*	12.8	22.6	34.6	23.3	12.1	16.3	14.7	12.5	13.1
25.0	13.9	32.8	33.5	21.4	14.1	13.3	12.5	15.3	11.9
20.6	14.1	16.4	25.9	25.6	13.2	17.5	20.2	13.9	12.2
29.0	12.9	20.4	25.6	37.5	17.1	26.2	15.0	12.3	12.1
36.5	13.1	17.7	54.9	26.6	11.9	13.7	20.4	12.3	12.2
32.0	12.9	12.8	34.2	33.2	20.0	25.5	12.6	13.0	11.9
19.9	12.1	12.5	31.5	26.6	18.5	13.3	12.3	12.7	12.0
14.6	13.3	21.3	26.4	41.7	11.9	14.6	12.2	12.9	12.0
17.6	12.0	55.5	37.3	13.1	13.1	14.4	11.9	13.7	12.3
21.2	13.4	15.4	45.0	15.9	15.8	13.6	12.5	13.1	15.5
6-E	6-C	7-E	7-C	8-E	8-C	9-E	9-C	10-E	10-C
12.0	28.3	42.6	13.2	17.8	12.8	12.1	12.2	12.7	12.8
12.3	51.0	31.9	13.5	12.7	13.0	18.2	20.0	52.6	13.6
20.7	49.8	22.1	14.4	14.1	14.5	14.7	13.5	17.7	31.2
13.8	18.5	29.9	12.4	16.7	12.4	15.2	22.0	31.6	16.2
12.9	23.1	29.0	12.2	12.0	11.9	14.3	12.3	63.9	20.4
11.9	26.5	32.0	21.7	12.2	12.2	28.0	12.7	16.3	13.7
12.7	17.8	14.1	12.5	18.0	12.0	23.2	12.0	15.2	15.6
14.3	13.8	25.9	15.5	12.6	11.9	13.0	12.4	12.6	35.0
15.0	14.6	12.5	14.8	11.9	13.5	14.3	22.8	25.1	19.6
12.4	18.9	21.5	14.2	21.7	11.9	14.9	17.2	30.6	27.9

* Values in table in centimeters

11-E	11-C	12-E	12-C	13-E	13-C
12.3	13.8	11.9	25.3	16.6	12.1
24.1	20.3	13.4	17.1	13.7	11.8
45.3	17.1	13.4	11.9	26.6	12.0
12.3	18.0	12.4	12.8	15.2	12.1
42.4	19.9	12.8	12.1	33.0	28.3
24.2	26.5	13.9	12.0	19.2	11.9
30.2	12.2	12.2	11.9	15.1	11.9
14.9	18.3	12.5	13.3	45.3	11.8
31.3	12.0	12.4	19.9	25.9	11.9
57.0	15.2	12.3	19.6	26.2	12.1

* Values in table in centimeters

A template, constructed from clear plastic, was used to measure the greatest pen deflection (millimeters) from the baseline for each of the twenty one-second time intervals recorded by the electromyograph during the presentation and rehearsal periods for each five-word group. The ten seconds during which the five-word group was presented is shown on Table 3 as Presentation. The ten seconds during which the five-word group was rehearsed subvocally, prior to the subject's being told whether or not the word group was to be written, is shown on Table 3 as Rehearsal.

Table 3. Pen Deflection in Millimeters for Each Second During Presentation and Rehearsal of Word Groups (* Time in seconds)

Subject 1-E

	Word Group - Presentation									
*	I	II	III	IV	V	VI	VII	VIII	IX	X
1	94	98	97	98	98	98	68	61	62	52
2	87	98	98	98	98	84	76	56	60	78
3	96	98	98	98	98	75	80	54	62	70
4	86	92	97	98	92	71	75	54	64	70
5	80	91	97	98	98	64	75	49	66	59
6	86	98	98	98	98	97	74	47	58	79
7	81	98	98	80	98	79	76	56	64	68
8	83	86	97	98	74	70	74	51	56	72
9	82	91	97	98	98	74	83	50	59	65
10	72	90	97	98	98	65	74	55	70	69
	Rehearsal									
11	75	96	97	98	97	73	79	49	64	77
12	76	84	97	98	82	70	76	50	58	70
13	82	78	97	98	94	85	73	50	58	55
14	68	84	97	98	84	96	58	50	64	64
15	98	98	90	96	98	98	62	48	52	60
16	73	94	97	98	92	74	83	52	62	81
17	88	83	97	98	87	64	72	50	56	69
18	75	79	97	98	98	90	64	54	53	74
19	98	76	97	98	98	82	66	51	68	60
20	97	98	97	76	98	98	64	47	61	58

Subject 1-C

	Word Group - Presentation									
*	I	II	III	IV	V	VI	VII	VIII	IX	X
1	24	25	22	24	24	25	22	22	22	24
2	44	26	26	26	37	26	26	26	36	36
3	27	24	21	35	26	21	22	38	26	24
4	32	22	22	24	24	23	23	23	24	24
5	23	20	20	22	22	20	20	20	21	38
6	20	22	20	22	30	19	20	20	24	26
7	20	18	20	22	24	19	20	19	24	22
8	22	24	26	31	26	22	24	25	30	24
9	22	20	19	20	22	22	19	19	21	20
10	22	24	26	29	24	24	24	28	25	24

Rehearsal

11	24	24	25	28	39	24	24	30	26	36
12	33	28	26	32	33	22	30	27	33	29
13	30	23	22	22	28	22	22	22	31	26
14	24	25	25	24	24	23	32	25	23	25
15	34	22	24	23	24	24	24	22	23	23
16	32	29	20	20	20	31	20	21	24	20
17	22	20	24	22	22	22	20	22	22	21
18	22	28	35	34	34	24	36	38	32	28
19	20	20	20	26	20	20	20	21	22	20
20	22	29	40	25	22	24	37	45	24	21

Subject 2-E

Word Group - Presentation

*	I	II	III	IV	V	VI	VII	VIII	IX	X
1	79	32	22	23	21	28	24	23	20	22
2	23	50	25	98	60	24	43	52	92	90
3	20	20	22	20	22	21	22	20	20	26
4	98	30	26	26	26	83	27	26	26	25
5	32	31	60	32	20	29	24	49	24	22
6	30	20	19	18	18	23	20	18	18	18
7	20	19	20	19	30	20	18	18	19	20
8	25	19	21	25	21	23	20	39	20	21
9	20	33	50	98	35	32	98	22	98	32
10	30	46	29	21	21	28	54	22	22	21

Rehearsal

11	21	82	27	22	28	23	92	22	21	28
12	33	22	23	20	28	31	22	21	26	20
13	38	25	46	21	20	36	21	52	22	20
14	23	32	34	22	21	24	27	27	22	24
15	20	21	22	21	19	21	27	21	21	18
16	19	26	20	19	19	26	27	20	20	22
17	19	20	20	25	22	20	21	20	24	20
18	24	98	22	21	20	22	81	26	20	21
19	74	30	98	44	39	42	98	98	38	98
20	20	20	19	20	19	20	20	20	20	20

Subject 2-C

Word Group - Presentation

*	I	II	III	IV	V	VI	VII	VIII	IX	X
1	97	98	98	74	50	62	98	98	45	51
2	44	45	97	50	47	52	97	97	40	98
3	98	90	45	49	38	98	42	42	47	39
4	58	36	35	36	74	38	34	36	70	42
5	45	98	88	36	97	58	98	72	36	98
6	50	41	53	98	95	42	38	60	98	60
7	72	98	95	33	34	64	98	37	37	33
8	70	42	31	36	42	56	34	31	30	48
9	54	30	31	30	54	31	31	30	30	82
10	29	76	30	27	25	29	25	28	27	96

Rehearsal

11	51	47	45	38	34	50	47	43	34	97
12	98	54	38	36	35	52	42	36	41	34
13	56	41	36	36	40	53	37	36	44	97
14	38	37	98	52	34	35	40	98	35	36
15	89	98	98	44	50	98	98	83	40	98
16	35	34	75	34	66	36	36	65	34	63
17	31	98	42	32	32	39	60	32	31	30
18	33	30	45	30	98	30	31	40	31	98
19	72	98	54	30	98	33	98	41	30	98
20	98	98	43	27	98	98	98	36	28	98

Subject 3-E

Word Group - Presentation

*	I	II	III	IV	V	VI	VII	VIII	IX	X
1	48	56	57	58	98	50	54	60	60	98
2	98	72	98	98	62	97	97	98	98	97
3	50	53	88	98	98	54	61	88	75	97
4	86	86	98	97	98	81	73	98	98	78
5	97	83	70	91	97	97	80	71	96	63
6	70	97	97	96	62	97	70	97	96	64
7	65	64	97	97	91	65	65	97	97	74
8	97	97	43	97	65	97	63	97	97	97
9	69	66	72	65	65	67	77	68	66	64
10	64	90	59	59	60	97	60	59	59	59

Rehearsal

11	97	67	94	70	69	64	97	97	64	67
12	72	58	57	56	55	58	60	56	55	55
13	56	54	53	60	80	56	54	53	81	64
14	88	57	98	82	75	65	58	84	78	75
15	59	57	56	59	56	73	56	59	59	57
16	64	65	57	66	98	70	62	59	65	76
17	69	66	75	70	70	63	97	62	68	61
18	59	97	50	50	50	96	97	50	50	97
19	66	66	64	64	62	68	64	64	63	66
20	66	70	59	58	58	71	59	59	59	64

Subject 3-C

Word Group - Presentation

*	I	II	III	IV	V	VI	VII	VIII	IX	X
1	50	48	48	48	50	48	47	47	49	49
2	62	53	52	52	54	53	52	50	49	68
3	48	54	52	46	43	60	50	47	44	43
4	45	44	46	46	43	45	44	44	44	43
5	40	41	40	41	42	41	42	41	40	41
6	97	63	50	52	43	98	59	42	48	88
7	40	42	40	82	43	40	40	40	80	42
8	36	36	36	36	36	37	36	36	35	36
9	43	44	54	50	48	45	43	44	48	45
10	37	38	38	38	52	38	38	37	84	48

Rehearsal

11	48	47	47	46	46	49	46	46	45	51
12	53	50	46	46	46	50	47	45	47	50
13	43	47	45	45	46	46	46	44	44	44
14	43	44	80	51	44	44	78	54	44	44
15	40	40	41	41	43	40	41	42	41	42
16	60	44	42	41	41	55	41	41	40	40
17	40	50	40	72	39	40	42	40	60	39
18	36	37	36	38	37	36	38	37	36	40
19	48	50	42	39	39	52	45	40	40	42
20	43	39	40	40	37	40	38	39	38	38

Subject 4-E

Word Group - Presentation

*	I	II	III	IV	V	VI	VII	VIII	IX	X
1	18	21	21	19	18	19	28	20	20	30
2	21	19	21	20	19	19	19	19	25	20
3	20	39	26	20	39	40	43	19	18	21
4	20	23	27	18	19	21	28	20	22	18
5	20	33	21	19	18	18	20	21	18	17
6	20	28	18	19	16	28	17	17	20	16
7	17	16	17	20	18	17	17	19	27	18
8	51	25	21	23	29	47	22	22	21	20
9	24	26	22	19	32	22	27	21	31	21
10	23	19	19	17	17	18	22	19	17	17

Rehearsal

11	42	19	18	17	19	20	18	17	25	16
12	19	20	21	23	18	25	19	25	19	17
13	21	25	22	24	23	25	20	20	25	21
14	20	20	24	23	27	20	20	23	24	21
15	19	16	16	17	19	17	16	22	18	18
16	16	17	17	16	16	18	18	16	27	17
17	17	17	19	16	28	17	17	16	18	24
18	21	22	20	20	20	22	20	20	20	20
19	22	30	18	18	18	20	22	18	19	18
20	18	16	28	23	26	18	17	23	20	21

Subject 4-C

Word Group - Presentation

*	I	II	III	IV	V	VI	VII	VIII	IX	X
1	19	19	18	25	34	17	20	18	32	20
2	18	17	17	17	17	18	17	16	18	16
3	17	18	19	17	18	18	20	17	18	20
4	20	16	17	16	17	18	26	16	16	16
5	18	17	18	18	20	17	18	18	20	19
6	18	16	15	16	16	16	16	16	16	16
7	25	20	25	20	20	22	24	20	20	20
8	19	20	20	23	20	18	20	21	20	22
9	20	20	18	17	17	19	18	17	17	18
10	17	24	18	16	16	18	18	18	16	16

Rehearsal

11	18	18	36	29	23	20	27	27	26	24
12	17	20	21	17	98	22	22	20	98	20
13	18	98	20	23	20	98	31	22	20	19
14	16	17	18	18	50	17	17	28	18	23
15	18	19	20	98	19	19	19	92	26	17
16	15	16	20	31	17	16	16	20	19	17
17	20	18	18	18	17	19	18	18	17	18
18	20	20	22	22	20	19	20	17	20	21
19	18	18	17	17	19	17	18	17	17	20
20	16	16	17	16	16	17	17	20	16	18

Subject 5-E

Word Group - Presentation

*	I	II	III	IV	V	VI	VII	VIII	IX	X
1	23	26	26	25	26	28	22	25	22	23
2	36	24	24	25	24	32	24	23	25	24
3	34	30	41	30	33	30	32	39	31	34
4	24	25	22	21	24	25	23	22	22	30
5	28	23	24	24	24	27	24	24	25	25
6	26	22	22	22	22	22	23	22	23	22
7	24	26	22	24	26	30	22	23	26	23
8	22	22	22	22	30	22	22	21	30	29
9	30	32	30	36	32	26	36	28	32	24
10	30	27	25	26	32	28	28	27	28	28

Rehearsal

11	25	24	22	25	22	23	23	24	26	22
12	22	24	32	34	36	24	24	43	40	34
13	32	31	31	34	32	31	32	30	39	30
14	24	23	24	21	22	23	22	24	23	24
15	25	24	25	24	24	24	24	25	24	24
16	22	22	25	22	24	21	23	24	24	32
17	22	26	22	23	23	22	26	23	22	22
18	22	23	22	23	23	22	23	22	22	23
19	29	26	27	27	26	25	28	28	26	26
20	28	32	26	23	26	26	35	25	26	25

Subject 5-C

Word Group - Presentation

*	I	II	III	IV	V	VI	VII	VIII	IX	X
1	29	20	21	19	20	19	19	21	20	21
2	12	13	14	14	14	12	13	14	14	14
3	16	16	17	15	16	16	22	15	15	16
4	17	18	15	16	17	17	19	15	17	18
5	18	16	16	16	17	15	18	20	16	16
6	16	15	14	16	16	16	14	16	16	16
7	22	23	27	22	22	24	26	22	24	24
8	22	22	20	20	20	22	21	20	20	21
9	14	13	14	22	17	12	14	17	22	15
10	52	17	13	21	16	18	13	16	16	15

Rehearsal

11	31	21	21	21	20	25	21	20	20	21
12	14	14	14	15	14	14	15	16	14	18
13	15	15	16	16	16	15	16	15	16	16
14	18	16	17	16	17	21	17	16	16	16
15	14	15	15	15	15	14	14	14	15	16
16	16	16	15	16	16	16	17	16	16	16
17	24	24	23	24	24	24	24	24	23	25
18	22	23	24	25	24	22	24	24	24	19
19	15	13	13	13	13	13	13	13	13	13
20	15	15	15	15	15	15	16	16	16	15

Subject 6-E

Word Group - Presentation

*	I	II	III	IV	V	VI	VII	VIII	IX	X
1	20	20	22	21	24	19	20	23	20	19
2	22	26	23	20	20	30	24	22	20	22
3	97	44	26	25	24	96	26	29	30	26
4	24	24	22	19	20	42	23	20	20	20
5	20	21	22	22	23	20	35	22	26	29
6	19	20	19	20	19	19	20	20	19	20
7	29	22	24	20	23	22	23	21	22	22
8	28	25	20	26	21	22	26	21	22	19
9	21	35	25	20	22	36	25	25	26	22
10	25	19	25	20	22	20	21	21	20	20

Rehearsal

11	21	20	20	20	20	20	21	19	20	20
12	21	22	22	20	20	20	21	20	20	21
13	25	22	28	23	20	24	20	22	20	19
14	27	26	22	19	20	26	26	20	19	19
15	26	23	20	20	19	23	20	21	20	22
16	20	20	18	18	18	20	18	18	18	19
17	22	22	20	19	19	20	20	20	20	20
18	31	21	25	19	19	24	29	30	20	26
19	27	24	28	22	22	23	26	21	27	41
20	26	21	20	21	20	26	20	21	20	20

Subject 6-C

Word Group - Presentation

*	I	II	III	IV	V	VI	VII	VIII	IX	X
1	27	42	41	36	34	24	37	28	39	31
2	52	56	85	89	58	75	40	98	43	50
3	98	92	98	44	27	98	98	98	46	34
4	58	24	20	18	17	75	22	19	17	17
5	32	21	20	20	22	22	19	19	22	22
6	46	58	22	27	98	48	32	22	23	68
7	47	26	32	23	27	28	24	24	22	41
8	24	22	22	21	21	22	23	21	22	22
9	29	23	24	22	24	22	24	24	24	37
10	45	31	23	22	22	31	32	22	22	22

Rehearsal

11	24	98	38	24	30	77	45	26	26	54
12	74	48	34	89	42	54	46	37	40	64
13	90	78	30	42	23	69	62	26	43	36
14	21	44	18	24	19	40	22	25	24	20
15	50	33	33	61	23	71	24	61	40	20
16	35	22	20	20	23	20	23	22	20	22
17	42	29	26	32	30	27	33	26	32	30
18	22	23	32	22	29	24	23	40	32	24
19	40	24	22	22	27	30	24	22	28	21
20	21	26	22	44	48	24	25	42	48	46

Subject 7-E

Word Group - Presentation

*	I	II	III	IV	V	VI	VII	VIII	IX	X
1	98	98	98	98	98	82	98	64	62	82
2	98	98	98	98	98	82	98	98	98	98
3	97	97	97	97	97	97	97	97	97	92
4	97	97	70	54	58	97	97	66	68	52
5	96	97	84	84	52	97	97	81	84	70
6	80	96	88	96	91	95	75	88	82	96
7	21	18	46	20	27	18	19	33	19	26
8	34	46	21	50	21	47	31	53	34	20
9	25	31	20	20	20	38	21	20	20	20
10	20	22	21	21	22	25	21	22	21	22

Rehearsal

11	50	40	36	32	98	39	40	30	98	98
12	92	80	75	65	67	78	83	70	75	68
13	88	78	70	72	97	78	75	73	97	97
14	57	47	42	26	23	50	43	26	22	16
15	60	82	60	42	42	82	70	42	48	46
16	97	97	97	96	89	97	97	97	92	91
17	18	20	19	20	20	20	20	20	19	20
18	20	20	98	98	38	20	20	98	98	38
19	20	20	20	20	20	21	20	20	21	20
20	20	22	97	28	21	21	70	97	24	21

Subject 7-C

Word Group - Presentation

*	I	II	III	IV	V	VI	VII	VIII	IX	X
1	20	24	18	18	19	26	20	19	18	18
2	20	19	18	18	19	20	20	18	19	18
3	20	34	20	20	18	20	20	22	22	30
4	22	25	14	21	23	22	28	20	21	25
5	27	23	24	22	22	29	24	22	22	22
6	98	52	30	23	21	50	58	24	24	25
7	22	22	24	22	21	22	22	22	23	21
8	58	24	22	24	22	42	22	22	23	21
9	22	21	22	21	22	22	22	21	22	22
10	54	26	27	24	25	27	24	24	26	24

Rehearsal

11	32	18	20	20	18	28	18	21	19	20
12	19	18	22	25	22	22	19	36	19	24
13	20	18	18	18	33	18	18	18	18	30
14	21	22	25	21	23	22	22	24	22	23
15	21	27	22	22	24	23	24	22	22	23
16	42	22	23	21	22	30	22	21	22	22
17	21	23	21	30	21	22	22	21	22	22
18	23	21	22	22	40	22	22	22	22	22
19	24	60	22	22	21	42	24	22	22	22
20	22	28	24	26	24	23	26	24	25	30

Subject 8-E

Word Group - Presentation

*	I	II	III	IV	V	VI	VII	VIII	IX	X
1	35	38	41	44	41	34	46	44	51	46
2	28	30	29	26	28	26	28	26	27	28
3	26	27	26	32	27	25	24	27	41	33
4	33	26	29	38	33	25	24	36	42	44
5	22	22	22	21	24	21	22	22	26	23
6	20	20	19	26	22	20	19	27	22	22
7	20	20	27	35	47	20	20	30	48	47
8	23	22	24	23	22	22	22	22	23	21
9	25	23	24	23	24	23	23	24	24	24
10	50	97	21	18	28	97	20	20	21	44

Rehearsal

11	46	44	46	48	50	41	43	51	50	52
12	26	32	28	29	30	30	26	28	28	27
13	36	38	34	34	31	41	45	34	30	30
14	32	38	37	39	35	33	41	35	40	33
15	23	24	23	23	24	23	23	24	21	23
16	22	22	21	21	21	22	22	21	20	21
17	40	40	31	24	25	40	34	28	24	25
18	25	24	22	22	22	25	28	24	22	25
19	24	24	24	26	24	23	23	24	25	24
20	41	32	30	30	30	38	27	27	32	27

Subject 8-C

	Word Group - Presentation									
*	I	II	III	IV	V	VI	VII	VIII	IX	X
1	27	26	27	26	32	25	25	28	28	34
2	32	32	38	34	28	32	31	38	28	28
3	30	22	28	39	23	24	22	35	25	23
4	18	22	20	20	20	21	20	20	24	20
5	20	22	20	19	19	20	20	19	20	20
6	22	26	20	20	20	20	21	20	20	20
7	19	20	20	20	22	20	20	20	23	22
8	20	20	21	20	21	20	20	21	20	20
9	20	23	27	22	25	20	26	20	25	24
10	18	18	17	18	17	19	17	18	17	17
	Rehearsal									
11	37	37	34	32	31	37	34	33	32	34
12	28	28	28	28	30	30	28	30	30	30
13	24	26	24	24	22	24	24	39	22	22
14	20	20	20	20	20	20	20	20	20	20
15	18	20	20	19	20	20	19	19	20	19
16	20	20	20	20	20	22	20	20	20	19
17	21	20	20	20	21	23	20	20	22	22
18	20	22	21	20	20	23	21	20	20	22
19	25	27	22	24	23	29	20	24	24	20
20	18	18	19	19	18	18	20	20	18	18

Subject 9-E

	Word Group - Presentation									
*	I	II	III	IV	V	VI	VII	VIII	IX	X
1	35	30	33	30	30	30	33	34	30	31
2	33	37	36	34	59	33	42	33	70	39
3	35	36	34	42	35	34	34	52	37	52
4	35	36	35	34	54	36	34	36	34	54
5	44	38	38	44	46	38	38	41	51	40
6	40	38	40	97	14	38	39	38	95	98
7	97	86	65	34	36	93	79	38	36	42
8	43	39	34	39	40	38	38	36	38	41
9	46	42	44	41	42	43	57	46	38	44
10	39	43	42	40	52	50	40	41	48	46

Rehearsal

11	30	31	31	31	30	32	31	31	31	31
12	33	50	48	38	36	34	44	39	37	33
13	45	34	36	42	38	34	34	46	35	37
14	37	38	40	48	36	44	41	46	43	35
15	40	39	39	39	38	38	38	43	43	38
16	34	38	38	40	36	58	39	40	37	38
17	38	54	61	40	41	52	41	59	40	58
18	38	38	45	41	40	38	42	42	42	36
19	43	44	47	44	50	46	42	44	53	41
20	44	37	42	50	38	41	40	50	43	41

Subject 9-C

Word Group - Presentation

*	I	II	III	IV	V	VI	VII	VIII	IX	X
1	42	42	40	41	40	41	42	40	40	40
2	70	44	98	46	40	46	82	58	43	39
3	38	39	38	40	40	38	42	42	40	40
4	39	43	98	40	40	48	47	83	40	40
5	42	43	40	41	40	44	40	40	43	40
6	40	40	39	42	42	39	40	40	40	41
7	40	40	39	40	42	40	40	40	42	40
8	42	40	41	40	45	40	41	41	40	43
9	42	40	45	42	42	40	40	46	42	40
10	40	44	43	40	42	41	44	42	40	42

Rehearsal

11	41	40	42	40	40	46	43	40	41	41
12	40	40	40	40	41	40	40	45	39	40
13	51	54	47	41	50	50	53	47	39	50
14	40	42	98	52	46	40	98	90	42	41
15	44	41	39	41	42	46	42	39	42	46
16	42	42	42	42	45	41	42	41	50	38
17	40	40	40	40	40	41	40	40	41	38
18	41	40	41	40	40	41	42	42	40	40
19	45	40	50	98	98	54	40	70	98	78
20	39	42	41	40	41	42	42	40	40	97

Subject 10-E

Word Group - Presentation

*	I	II	III	IV	V	VI	VII	VIII	IX	X
1	34	32	34	28	29	33	36	30	30	31
2	32	36	97	34	36	32	97	35	35	94
3	32	32	32	29	95	36	40	30	36	36
4	26	62	98	98	36	26	63	98	44	32
5	28	8	15	98	98	9	11	98	98	98
6	30	36	32	42	39	31	33	38	47	33
7	28	34	32	34	57	28	32	35	40	35
8	30	26	28	26	28	26	26	25	29	29
9	28	48	33	34	28	30	30	36	27	30
10	97	80	58	98	64	74	68	98	68	65

Rehearsal

11	25	26	28	28	28	28	26	28	27	30
12	98	18	98	88	16	98	98	98	20	98
13	33	29	37	35	37	32	29	30	37	35
14	29	22	28	38	38	20	26	35	58	27
15	98	98	98	10	84	98	98	85	8	82
16	32	44	48	40	52	34	54	44	68	38
17	37	38	40	33	34	40	39	32	34	32
18	26	30	33	30	34	26	33	36	31	38
19	32	53	98	98	84	35	46	98	98	84
20	62	53	54	67	98	56	58	55	98	91

Subject 10-C

Word Group - Presentation

*	I	II	III	IV	V	VI	VII	VIII	IX	X
1	24	24	21	22	21	25	20	20	26	23
2	23	23	21	25	20	22	27	24	20	40
3	44	46	28	44	26	98	22	32	26	26
4	33	18	19	19	20	20	20	19	22	22
5	28	22	32	29	19	46	20	30	20	38
6	26	22	21	20	20	30	22	22	21	20
7	26	50	21	21	20	25	35	22	20	27
8	98	21	18	20	80	29	18	21	35	98
9	22	20	18	24	19	19	18	26	18	26
10	98	20	20	26	21	39	19	18	19	38

Rehearsal

11	24	23	24	26	20	23	25	25	23	28
12	24	22	24	26	20	22	20	22	22	24
13	23	28	98	98	48	23	37	98	40	24
14	29	22	47	32	40	27	48	28	31	22
15	35	46	24	20	19	19	51	23	19	24
16	21	33	29	22	23	21	21	30	22	20
17	20	22	22	21	24	22	22	21	24	34
18	53	51	98	44	25	32	47	98	34	24
19	33	98	21	19	21	98	65	21	17	26
20	29	98	17	25	22	98	30	31	16	35

Subject 11-E

Word Group - Presentation

*	I	II	III	IV	V	VI	VII	VIII	IX	X
1	22	17	20	16	17	17	15	17	17	22
2	34	98	34	22	30	98	33	18	27	41
3	35	50	98	26	98	44	98	98	45	89
4	21	17	16	18	15	21	16	15	15	16
5	98	98	93	97	28	98	97	43	25	25
6	34	98	61	41	25	94	98	25	45	37
7	31	98	32	41	36	98	98	43	37	37
8	31	32	14	17	16	18	18	18	16	15
9	28	16	18	19	18	22	18	17	20	19
10	95	97	49	24	16	98	71	21	19	22

Rehearsal

11	21	17	16	18	17	17	16	16	19	16
12	55	30	18	22	17	36	30	24	15	19
13	24	16	98	25	15	22	97	89	18	22
14	16	16	14	17	16	14	16	20	16	88
15	20	18	16	16	31	19	16	17	18	24
16	19	16	15	18	15	16	15	20	15	15
17	39	33	39	26	38	24	24	32	20	98
18	16	15	14	15	33	16	15	16	15	26
19	75	98	20	70	40	67	41	18	60	17
20	97	98	16	98	82	98	40	97	98	98

Subject 11-C

Word Group - Presentation

*	I	II	III	IV	V	VI	VII	VIII	IX	X
1	27	29	28	30	34	27	28	30	31	28
2	30	82	62	50	46	29	75	48	42	32
3	52	59	31	40	34	65	30	35	43	28
4	97	48	28	32	28	97	31	27	29	28
5	54	64	47	39	33	62	44	46	43	57
6	32	31	32	98	28	30	30	55	67	28
7	29	31	31	30	30	30	31	30	29	31
8	34	30	34	33	32	30	32	33	34	31
9	25	27	26	25	26	26	27	24	26	31
10	30	27	28	30	29	30	30	29	30	20

Rehearsal

11	27	28	48	27	30	27	53	29	28	27
12	32	27	33	34	28	28	28	33	34	26
13	30	30	47	28	30	30	28	28	28	32
14	27	28	28	31	28	28	28	27	30	29
15	47	30	40	34	33	37	46	30	32	34
16	30	46	32	62	65	29	48	33	70	65
17	30	32	31	30	30	32	32	31	33	30
18	32	33	32	81	46	34	34	95	32	36
19	26	25	29	24	26	26	26	26	26	30
20	29	30	28	28	50	28	30	29	29	70

Subject 12-E

Word Group - Presentation

*	I	II	III	IV	V	VI	VII	VIII	IX	X
1	30	26	24	24	24	24	24	22	24	24
2	27	32	39	29	30	29	39	28	30	35
3	36	49	45	40	43	46	46	41	40	39
4	40	40	36	34	34	38	38	37	34	35
5	42	41	42	43	42	42	40	40	40	39
6	34	34	34	36	36	38	34	38	36	52
7	29	29	30	31	30	30	30	28	30	29
8	30	29	30	28	29	30	29	30	30	28
9	32	32	32	35	32	34	32	35	32	33
10	37	35	35	35	32	36	36	36	36	34

Rehearsal

11	24	22	21	22	24	23	24	22	22	25
12	34	33	35	30	30	34	38	34	30	36
13	40	41	38	37	39	41	39	38	40	40
14	36	34	38	34	36	36	36	36	36	35
15	39	38	40	42	42	41	39	43	41	44
16	45	41	41	42	40	40	43	40	41	44
17	31	32	30	30	28	28	30	28	32	29
18	28	34	28	26	26	28	28	29	26	29
19	32	31	31	32	32	31	32	30	30	33
20	36	36	34	33	33	34	36	34	34	37

Subject 12-C

Word Group - Presentation

*	I	II	III	IV	V	VI	VII	VIII	IX	X
1	96	58	82	62	64	84	73	62	60	84
2	96	64	57	53	52	96	57	54	54	50
3	50	51	50	51	50	50	51	50	50	50
4	54	50	53	52	49	52	56	50	50	51
5	54	52	52	52	50	52	52	52	52	50
6	52	51	50	52	52	54	51	52	52	51
7	52	51	50	50	52	52	51	51	50	50
8	49	49	47	50	66	51	50	50	48	52
9	84	53	50	50	50	54	52	50	52	50
10	49	98	98	56	50	49	98	85	54	47

Rehearsal

11	84	88	60	54	54	84	69	56	53	54
12	50	50	53	61	51	50	52	68	50	51
13	50	50	50	50	49	50	50	50	50	50
14	52	56	50	49	50	57	51	50	49	50
15	50	50	52	54	53	52	50	56	52	56
16	51	51	51	50	52	51	50	50	51	52
17	50	50	51	50	50	50	52	50	50	50
18	49	49	47	55	50	50	48	47	50	50
19	56	88	68	59	98	67	85	62	68	66
20	47	48	46	46	46	48	47	46	46	46

Subject 13-E

Word Group - Presentation

*	I	II	III	IV	V	VI	VII	VIII	IX	X
1	16	25	30	38	29	23	21	21	28	29
2	18	22	39	29	22	19	30	36	21	24
3	18	55	54	42	28	21	37	56	26	25
4	34	27	31	28	26	24	21	25	30	37
5	20	60	25	32	34	58	56	23	54	21
6	34	50	22	24	29	64	43	25	24	29
7	21	22	30	42	32	30	29	34	32	24
8	48	23	25	65	64	81	34	38	44	67
9	38	25	31	20	36	22	26	29	30	69
10	17	21	53	54	27	22	74	37	31	35

Rehearsal

11	34	30	26	22	24	32	25	22	23	30
12	24	20	19	19	20	23	19	20	20	19
13	34	32	55	25	24	60	30	52	23	23
14	28	29	27	21	23	27	30	23	22	24
15	59	24	22	25	22	48	22	58	22	66
16	30	28	27	30	32	27	33	29	29	28
17	22	29	24	24	26	30	23	28	25	23
18	65	66	56	67	54	38	50	45	48	31
19	30	69	28	74	24	48	28	48	24	61
20	50	34	27	36	22	23	50	24	53	23

Subject 13-C

Word Group - Presentation

*	I	II	III	IV	V	VI	VII	VIII	IX	X
1	22	22	22	23	22	21	22	22	23	22
2	22	23	22	22	22	22	24	22	22	22
3	23	22	24	26	23	23	22	23	22	22
4	22	22	22	26	25	22	23	24	22	23
5	29	24	24	45	98	29	27	98	98	13
6	22	22	22	22	22	22	22	23	22	22
7	22	22	22	22	22	23	24	22	22	22
8	22	22	22	22	22	22	22	22	22	22
9	22	24	23	23	22	22	24	23	22	23
10	22	24	26	22	22	24	26	23	23	22

	Rehearsal									
11	22	22	22	21	24	23	22	24	22	22
12	22	25	24	23	22	22	24	22	23	22
13	22	22	22	22	22	22	24	22	22	22
14	22	23	22	22	22	24	22	22	24	22
15	10	32	22	23	22	40	27	22	23	22
16	22	22	22	22	22	22	22	22	22	24
17	22	22	22	22	22	22	22	22	22	22
18	22	22	23	22	24	22	22	23	22	23
19	24	23	22	22	23	22	22	23	24	23
20	23	24	23	23	23	24	24	22	23	23

STATISTICAL ANALYSES BY GROUPS

The data in Table 3 were analyzed by the "Three-Factor Mixed Design: Repeated Measures on Two Factors" (Bruning and Kintz, 1968), in order to determine whether quantitative differences in average electrical potential change existed between the experimental and control subjects (Table 5) and between generally dysfluent and bilabially dysfluent experimental subjects (Table 6). Differences between groups were so slight that no case is made for their being distinctly different in terms of average electrical potential activity.

Table 4. Experimental-vs-Control Subjects

Comparison	SS	df	ms	f	p
Total	29,013	115			
Between Subjects	26,764	25			
Between Groups	1,188	1	1188	1.11	-
Within Subjects	2,249	90			
L-by-NL	4	1	4	0.73	-
P-by-R	100	1	100	5.41	0.05
G-by-LNL	4	1	4	0.73	-
G-by-PR	72	1	72	3.9	-
LNL-by-PR	104	1	104	2.8	-
G-by-LNL-by-PR	0	1	0	0	

G=Groups L=Labial NL=Nonlabial P=Presentation R=Rehearsal

Table 5. Generally Dysfluent-vs-Bilabially Dysfluent

Comparison	SS	df	ms	f	p
Total	18,831	59			
Between Subjects	17,226	14			
Between Groups	329	1	329	0.253	-
Within Subjects	1,605	45	35.7		
L-by-NL	7	1	7	0.12	-
P-by-R	171	1	171	6.65	0.05
G-by-LNL	6	1	6	0.23	-
G-by-PR	86	1	86	1.53	-
LNL-by-PR	45	1	45	6.60	0.05
G-by-LNL-by-PR	47	1	47	6.90	0.05

G=Groups L=Labial NL=Nonlabial P=Presentation R=Rehearsal

Computerized paired t-tests (Tuckman, 1972) were performed upon the linear (Table 2) and excursion (Table 3) measurement data to examine the possibility of significant differences occurring in various combinations of (a) experimental-vs-control subjects, (b) presentation-vs-rehearsal periods, and labial-vs-nonlabial word groups. No significant differences were found at the 0.05 level of confidence for any of these group comparisons.

STATISTICAL ANALYSES OF INDIVIDUALS

A computerized Mann-Whitney U-Test (Siegel, 1956, and Tuckman, 1972) was used to determine whether statistically significant individual differences would be found between the thirteen matched pairs of subjects. Analysis of the linear measurements from Table 2 indicates that six of the experimental subjects demonstrated significantly more subvocal articulatory activity than their matched controls;

only two control subjects were found to demonstrate significantly more activity than their experimental counterparts; and there was no significant difference found among the remaining five pairs of the subjects (Table 6).

Table 6. Comparison of Linear Distance (Centimeters)

Pair	Experimental	Control	U	Significance
1	155.0	55.0	0	.001*
2	69.0	141.0	14.0	.01 +
3	145.5	64.5	9.5	.001*
4	127.0	83.0	28.0	
5	137.5	72.5	17.5	.01 *
6	63.5	146.5	8.5	.001+
7	141.5	68.5	13.5	.01 *
8	125.5	84.5	29.5	
9	118.0	92.0	37.0	
10	112.0	98.0	43.0	
11	130.0	80.0	25.0	.05 *
12	98.5	111.5	43.5	
13	147.0	63.0	8.0	.001*

*=Greater activity in the experimental subject
+=Greater activity in the control subject

Computerized t-test analyses of excursion measurements from Table 3 resulted in the following Tables 7-15. Table 7 presents the results of subvocalization activity during the presentation period for the ten groups of words. Eight experimental subjects demonstrate significantly more activity than their matched controls. Three of the controls show greater activity than their matched experimental counterparts, and two of the thirteen pairs demonstrated no significant difference.

Table 7. Sum of Presentation Period for Bilabial and Non-labial Word Groups

Pair	Experimental	Control	U	Significance
1	155.0	55.0	0	.001*
2	63.0	147.0	8	.001+
3	154.0	56.0	1	.001*
4	137.5	72.5	17.5	.01 *
5	154.0	56.0	1	.001*
6	75.0	135.0	20	.025+
7	139.0	70.5	15.5	.01 *
8	136.0	74.0	19	.01 *
9	102.5	107.5	47.5	
10	141.0	69.0	14	.01 *
11	112.0	98.0	43	
12	55.0	155.0	0	.001+
13	146.0	64.0	9	.001*

*=Greater significance for experimental subject
+=Greater significance for control subject

Table 8 presents the results of subvocalization activity during the rehearsal period of the ten groups of words. Seven experimental subjects demonstrate significantly more activity than their matched controls. Four of the controls show greater activity than their matched experimental counterparts, and two pairs demonstrated no significant difference.

Table 8. Sum of Rehearsal Period for Bilabial and Nonlabial Word Groups

Pair	Experimental	Control	U	Significance
1	155	55	0	.001*
2	63	147	8	.001+
3	155	55	0	.001*
4	98.5	111.5	43.5	
5	148	62	7	.001*
6	59	151	4	.001+
7	135	75	20	.001*
8	137	73	18	.01 *
9	79	131	24	.05 +
10	129	81	26	.05 *
11	92	118	37	
12	55	155	0	.001+
13	145	65	10	.001*

*=Greater significance for experimental subject
+=Greater significance for control subject

Table 9 presents the results of subvocalization activity during the presentation and rehearsal periods of the ten word groups. Seven experimental subjects demonstrate significantly more activity than their matched controls. Three of the controls show greater activity than their matched experimental counterparts, and two pairs demonstrated no significant difference.

Table 9. Sum of Presentation and Rehearsal Periods for Bilabial and Nonlabial Word Groups

Pair	Experimental	Control	U	Significance
1	155	55	0	.001*
2	63	147	8	.001+
3	155	55	0	.001*
4	107	103	48	
5	152	58	3	.001*
6	63	147	8	.001+
7	140	70	15	.01 *
8	138	72	17	.01 *
9	84	126	29	
10	138	72	17	.01 *
11	106	104	49	
12	55	155	0	.001+
13	147	63	8	.001*

*=Greater significance for experimental subject
+=Greater significance for control subject

Table 10 presents the results of subvocalization activity during the presentation period of bilabial word groups. Six experimental subjects demonstrate significantly more activity than their matched controls. Three of the controls show greater activity than their matched experimental counterparts, and four pairs demonstrated no significant difference.

Table 10. Presentation Period of Bilabial Word Groups

Pair	Experimental	Control	U	Significance
1	40	15	0	.004*
2	16	39	1	.008+
3	39	16	1	.008*
4	30.5	24.5	9.5	
5	39	16	1	.008*
6	15	40	0	.004+
7	39	16	1	.008*
8	35	20	5	
9	27	28	12	
10	40	15	0	.004*
11	28	27	12	
12	15	40	0	.004+
13	40	15	0	.004*

*=Greater significance for experimental subject
+=Greater significance for control subject

Table 11 presents the results of subvocalization activity during the rehearsal period of bilabial word groups. Five experimental subjects demonstrate significantly more activity than their matched controls. Four of the controls show greater activity than their matched experimental counterparts, and four pairs demonstrated no significant difference.

Table 11. Rehearsal Period of Bilabial Word Groups

Pair	Experimental	Control	U	Significance
1	40	15	0	.004*
2	15	40	0	.004+
3	40	15	0	.004*
4	23.5	31.5	8.5	
5	36.5	18.5	3.5	.038*
6	15	40	0	.004+
7	36	19	4	.048*
8	35	20	5	
9	21	34	6	
10	38	17	2	.016*
11	19	36	4	.048+
12	15	40	0	.004+
13	35	20	5	

*=Greater significance for experimental subject
+=Greater significance for control subject

Table 12 presents the results of subvocalization activity during the presentation and rehearsal periods of the five bilabial word groups. Seven experimental subjects demonstrate significantly more activity than their matched controls. Four of the controls show greater activity, and two pairs demonstrated no significant difference.

Table 12. Presentation and Rehearsal Periods of Bilabial Word Groups

Pair	Experimental	Control	U	Significance
1	40	15	0	.004*
2	15	40	0	.004+
3	40	15	0	.004*
4	26	29	11	
5	38	17	2	.016*
6	15	40	0	.004+
7	37	18	3	.028*
8	36	19	4	.048*
9	16	39	1	.008+
10	40	15	0	.004*
11	24	31	9	
12	15	40	0	.004+
13	40	15	0	.004*

*=Greater significance for experimental subject
+=Greater significance for control subject

Table 13 presents the results of subvocalization activity during the presentation period of the five nonlabial word groups. Five of the experimental subjects demonstrate significantly more activity than their matched controls. Two of the controls show greater activity than their matched experimental counterparts, and six pairs demonstrated no significant difference.

Table 13. Presentation Period of Nonlabial Word Groups

Pair	Experimental	Control	U	Significance
1	40	15	0	.004*
2	18	37	3	.028+
3	40	15	0	.004*
4	39	16	1	.009*
5	40	15	0	.004*
6	26	29	11	
7	32.5	22.5	7.5	
8	39	20	5	
9	28.5	26.5	11.5	
10	33	22	7	
11	30	25	10	
12	15	40	0	.004+
13	36	19	4	.048*

*=Greater significance for experimental subject
+=Greater significance for control subject

Table 14 presents the results of subvocalization during the rehearsal of the five nonlabial word groups. Five of the experimental subjects demonstrate significantly more activity than their matched controls. Five of the controls show greater activity than their matched experimental counterparts, and three pairs demonstrated no significant difference.

Table 14. Rehearsal of Nonlabial Word Groups

Pair	Experimental	Control	U	Significance
1	40	15	0	.004*
2	18	37	3	.028+
3	40	15	0	.004*
4	19	36	4	.048+
5	39	16	1	.008*
6	16	39	1	.008+
7	35	20	5	
8	36	19	4	.048*
9	19	36	4	.048+
10	32	23	8	
11	29	26	11	
12	15	40	0	.004+
13	40	15	0	.004*

*=Greater significance for experimental subject
+=Greater significance for control subject

Table 15 presents the results of subvocalization activity during the presentation and rehearsal of the five nonlabial word groups. Five experimental subjects demonstrate significantly more activity than their matched controls. Two of the controls show greater activity than their matched experimental counterparts, and six pairs demonstrated no significant difference.

Table 15. Presentation and Rehearsal for Nonlabial Word Groups

Pair	Experimental	Control	U	Significance
1	40	15	0	.004*
2	19	36	4	.048+
3	40	15	0	.004*
4	28	27	12	
5	40	15	0	.004*
6	21	34	6	
7	36	19	4	.048*
8	35	20	5	
9	21	34	6	
10	34	21	6	
11	32	23	8	
12	15	40	0	.004+
13	38	17	2	.016*

*=Greater significance for experimental subject
+=Greater significance for control subject

CHAPTER V

DISCUSSION AND CONCLUSIONS

DISCUSSION

For many years, stuttering has been considered to be an expressive-communication problem. Until recently, the possibility that it is complicated by receptive dysfunction has not been fully explored. Within the last six to eight years, researchers have attempted to determine whether stutterers perform differently on receptive language-related tasks. The present study was designed to compare the subvocal articulatory patterns of dysfluent speakers and fluent speakers during a test of auditory reception.

Twenty-six subjects were evaluated for subvocal muscle activity during a listening task in which specially selected lists of words were presented. Analysis of the data, by both a computerized t-test and a three-factor mixed design, with repeated measures on two factors, revealed subvocal activity differences between the experimental and control groups which were so slight that no support can be given to the theory that "groups of dysfluent speakers and groups of fluent speakers have significantly different levels of subvocal articulatory activity during a verbal-listening task." However, this finding did lead the investigator to re-evaluate Canter's (1971) statement, in which he indicated:

> "It must be recognized that such statistical techniques (i.e., t-tests for group differences)

> tell us only about the means of the population. Individual data are buried in the group statistics. In fact, individual differences are utilized statistically as error terms. Findings that emerge from studies of differing central tendencies have certain undeniable statistical and conceptual significances, but they have virtually no meaning clinically."

Analysis of the data (linear and excursion), using the Mann-Whitney U-test, revealed significant individual differences. In seven of the subject pairs (1, 3, 5, 7, 8, 10, 13), the nonfluent individual was found to have significantly higher levels of subvocal articulatory activity during presentation and rehearsal of bilabial and nonlabial word groups. Among the remaining six pairs of subjects, three experimental subjects (2, 6, 12) were significantly less active than their control counterparts. Three pairs of subjects (4, 9, 11) were approximately equal in the amount of subvocal articulatory activity produced by the experimental subject and his fluent control. This new research finding was interpreted as support for the idea that stutterers may be categorized into three groups, according to subvocal patterns:

A) "Hyperactive Subvocalizers," including the majority of stutterers who are more tense or emit nonfluent subvocal articulatory movements;

B) "Hypoactive Subvocalizers" who are subvocalizing very little and/or are, perhaps, blocking;

C) "Active Subvocalizers" are those individuals with

subvocal articulatory patterns similar to those of the general population.

Theoretically, there are possible correlations between the three categories of subvocalizers and stuttering's etiology. The results of several recent studies, investigating the possibility of a neurogenic component to stuttering, all indicate that the performance of stutterers is different from that of their fluent counterparts in tests of perceptual-motor skills (Riley and Riley, 1974), dichotic listening (Perrin, 1969; Curry and Gregory, 1969), tachistoscopic recognition (Cohen, 1971), and auditory-visual integration (Cohen, 1973). "Hyperactive Subvocalizers" might be the stutterers who possess such neurological dysfunctions.

Sheehan (1958) has theorized that the stutterer approaches motor movements but avoids expression because of an inhibitory conflict. Stuttering which is traceable to such a psychogenic etiology may result in less subvocalizing because thoughts of fear, anticipation or failure are affecting the individual's central nervous system in such a way that he inhibits normal subvocal articulatory patterns--thus, the "Hypoactive Subvocalizer."

Brutten and Shoemaker (1967) have suggested that stuttering responses are instrumentally conditioned. The person who stutters during overt speech may have learned to stutter during the period of normal nonfluency, which

occurs during children's development of speech. This behavior, instrumentally conditioned to expressive speech, did not affect subvocalization--thus, the "Active Subvocalizer."

If positive correlations between stuttering's etiologies and symptoms can be demonstrated, it would appear that a differential diagnostic test battery should be designed, using information from the latest research concerned with abnormal receptive processing among stutterers. Performance on tests of perceptual-motor skills, dichotic listening, tachistoscopic recognition, auditory-visual integration, and subvocal articulatory activity might be combined into a battery of tests useful in the differential diagnosis of stuttering.

A comprehensive test battery may help speech pathologists to determine those methods of treatment to which an individual stutterer would respond most favorably. For example, "Hyperactive Subvocalizers" (neurogenic stutterers) may respond most favorably to therapy techniques involving bio-feedback (which are currently being developed). Aten and Blanchard (1974) have reported on the therapeutic application of bio-feedback, using the frontalis muscle of a thirty-year-old male. This sensitive indicator of anxiety in this severe stutterer enabled him to control his tension so that after four sessions, he demonstrated an improvement in stating his address, counting from one

to ten, naming ten objects, producing one-hundred words of spontaneous speech and one-hundred words of oral reading. For those individuals with a neurological predisposition which, when triggered by tension, results in stuttering, bio-feedback techniques which teach the patient to deal with or control anxiety may help to inhibit the predisposition from manifesting itself in nonfluent speech.

"Hypoactive Subvocalizers" (psychogenic stutterers) may respond best to psychotherapeutic techniques. "Active Subvocalizers," whose learned dysfluencies are a part of expressive speech, may respond most favorably to operant procedures--such as those of Mowrer (1971) and Ryan (1971).

SUMMARY

1) Stutterers perform differently than fluent speakers on tasks involving perceptual-motor skills, dichotic listening, tachistoscopic recognition, auditory-visual integration, and subvocal articulation.

2) Dysfluent speakers may show "Hyperactive," "Hypoactive," or "Active" subvocalization patterns.

3) It is speculated that "Hyperactive Subvocalizing" may be linked to neurogenic stuttering. "Hypoactive Subvocalizing" may be related to psychogenic stuttering, and "Active Subvocalizing" may accompany instrumentally conditioned stuttering.

4) If the components which are active in the manifestation of stuttering can be identified and remediated, treat-

ment of the disorder may result in greater success for the clinician and his patients.

CONCLUSIONS

A battery of test instruments, designed to assess a stutterer's performance on tasks of subvocalization, dichotic listening, tachistoscopic recognition, and auditory-visual integration, might be effectively used by clinicians to more accurately determine the etiology, prognosis and best method of treatment for each nonfluent patient. When the clinician is able to identify the underlying components of the disorder, treatment might then be designed to attack the neurogenic, psychogenic or operant features of the syndrome, thereby reducing the "symptoms" of stuttering.

The null hypothesis of the present study has been rejected; differences were found in the electrical activity patterns produced by stutterers and by fluent speakers during auditory reception and subvocal rehearsal of groups of words, some lacking bilabial speech sounds and others containing high percentages of the sounds /p/, /b/ and /m/.

Subvocal articulatory patterns were classified as "Hyperactive," "Hypoactive," and "Active." Analysis of subvocal articulatory activity between pairs of stuttering and fluent subjects revealed that in fifty-four percent of the subject pairs, the experimental subjects were significantly more active subvocally ("Hyperactive Subvocalizers"); and, in twenty-three percent of the pairs, the experimental and control subjects were approximately equal in subvocal articulatory activity ("Active Subvocalizers").

SUGGESTIONS FOR FURTHER RESEARCH

It is recommended that future research in subvocalization include a pre-test analysis of each subject. The following procedures are suggested:

1) Determination of speech reception threshold, auditory discrimination, and most comfortable loudness level for presentation of the speech stimuli.

2) An objective test be administered to determine whether an experimental subject is "generally" or "bilabially" dysfluent. This would serve to more accurately determine the site of electrode placement for each subject.

3) Instructions should be used which are less complicated than those of the present study. Then, if a subject does make an error while graphically recording the word groups, this word group might either be discarded or the sample of subvocal activity should be analyzed, based on the distinctive phonetic features which correlate with the word actually written by the subject.

BIBLIOGRAPHY

Andrews, G., and Harris, M., The Syndrome of Stuttering, London: Heinemann Medical Books, Ltd., 1964.

Aten, J. L., and Blanchard, S., "EMG Biofeedback in the Treatment of Stuttering: Selected Case Studies." Paper presented at the annual convention of the American Speech and Hearing Association, Las Vegas, Nevada, November 7, 1974.

Barbara, D. A., American Handbook of Psychiatry, Vol. 1, p. 953, 1957.

Beech, R., "Stuttering and Stammering," Psychology Today, Vol. 1, pp. 49-51, 61, 1967.

Beech, H., and Fransella, F., "Explanations of the Rhythm Effect in Stuttering," in Gray, B., and Egland, G. (eds.), Stuttering and Conditioning Therapies, Monterey, CA, Monterey Institute for Speech and Hearing, 1969.

Bohme, G., "Stammering and Cerebral Lesions in Early Childhood," Folia Phoniatrica, Vol. 20, pp. 239-249, 1968.

Bruning, J. L., and Kintz, B. L., Computational Handbook of Statistics, Glenview, IL: Scott Foresman Co., 1968.

Brutten, E. J., and Shoemaker, D. J., The Modification of Stuttering, New Jersey: Prentice-Hall, 1967.

Busse, E. W., and Clarke, R. M., "The Use of the Electroencephalogram in Diagnosing Speech Disorders in Children," Folia Phoniatrica, Vol. 9, pp. 182-187, 1957.

Canter, G. J., "Observations on Neurogenic Stuttering: A Contribution of Differential Diagnosis," British Journal of Disorders of Communication, Vol. 6, 2, pp. 139-143, 1971.

Cherry, C., and Sayers, B., "Experiments Upon the Total Inhibition of Stammering by External Control and Some Clinical Results," Journal of Psychosomatic Research, Vol. 1, pp. 233-246, 1956.

Cobb, S., Borderlands of Psychiatry, Cambridge, MS: Harvard, 1943.

Cohen, M. S., "Differential Performance of Stutterers and Fluent Speakers in the Perception of Tachistoscopically Presented Visual Forms." M.A. Thesis: University of Pacific, CA, 1971.

Cohen, M. S., "Intersensory Processing Efficiency of Fluent Speakers and Stutterers." Ph.D. Dissertation: University of Utah, 1973.

Curlee, R. F., and Perkins, W. H., "Conversational Rate Control Therapy for Stuttering," Journal of Speech and Hearing Disorders, Vol. 34, 3, pp. 245-250, 1969.

Curry, F. K. W., and Gregory, H. H., "The Performance of Stutterers on Dichotic Listening Tasks Thought to Reflect Cerebral Dominance," Journal of Speech and Hearing Research, Vol. 12, pp. 73-82, 1969.

Douglass, L. C., "A Study of Bilaterally Recorded Electroencephalograms of Adult Stutterers," Journal of Experimental Psychology, Vol. 32, pp. 247-265, 1943.

Fox, D. R., "Electroencephalographic Analysis During Stuttering and Nonstuttering," Journal of Speech and Hearing Research, Vol. 9, pp. 488-497, 1966.

Freestone, N. W., "A Brain-Wave Interpretation of Stuttering," Quarterly Journal of Speech, Vol. 28, pp. 466-468, 1942.

Glauber, I., "The Psychoanalysis of Stuttering," Stuttering: A Symposium, New York: Harper and Rowe, 1958, Eisenson, J., editor.

Goldiamond, I., "Stuttering and Fluency as a Manipulable Operant," Research in Behavior Modification, New York: Holt, Rhinehart and Winstone, Inc., 1965, Krasner, L., and Ullman, L., editors.

Johnson, W., Brown, S. F., Curtis, J. F., Edney, C. W., and Keaster, Jacqueline, Speech Handicapped School Children, New York: Harper, 1948.

Karlin, I., "A Psychosomatic Theory of Stuttering," Journal of Speech Disorders, Vol. 12, pp. 319-322, 1947.

Knott, J. R., Johnson, W., and Webster, Mary, "A Quantitative Evaluation of Expectation of Stuttering in Relation to the Occurrence of Stuttering," Journal of Speech Disorders, Vol. 2, pp. 20-22, 1937.

Knott, J. R., and Tjossem, T. D., "Bilateral Electroencephalograms from Normal Speakers and Stutterers," Journal of Experimental Psychology, Vol. 35, pp. 356-362, 1943.

Locke, J. L., "Subvocal Speech and Speech," ASHA, Vol. 12, 1. pp. 7-14, 1970.

Locke, J. L., "Phonemic Processing in Silent Reading," Perceptual and Motor Skills, Vol. 32, pp. 905-906, 1971.

Locke, J. L., and Fehr, F. S., "Subvocal Rehearsal as a Form of Speech." Journal of Verbal Learning and Verbal Behavior, Vol. 9, pp. 495-498, 1970.

Locke, J. L., and Fehr, F. S., "Subvocalization of Heard or Seen Words Prior to Spoken or Written Recall," American Journal of Psychology, Vol. 85, 1, pp. 63-68, 1972.

Luper, H. L., and Mulder, R. L., Stuttering Therapy for Children, New Jersey: Prentice-Hall, Inc., 1964.

Meyer, V., and Comley, J., "A Preliminary Report of the Treatment of Stammer by the Use of Rhythmic Stimulation," Stuttering and the Conditioning Therapies, Monterey, CA: Monterey Institute for Speech and Hearing, Gray, B., and Egland, G., editors.

Mowrer, D. E., Technical Research Report S-1: Reduction of Stuttering Behavior, Arizona: Arizona State University Book Store, 1971.

National Institute of Neurological Diseases and Stroke Council, "Human Communication and Its Disorders--An Overview," Maryland: U. S. Dept. of Health, Education and Welfare, 1969.

Neaves, A. I., "To Establish a Basis for Prognosis in Stammering," British Journal of Disorders of Communication, Vol. 5, 1, pp. 46-58, 1970.

Ojemann, G. A., Fedio, P., and VanBuren, J. M., "Anomia from Pulvinar and Subcortical Parietal Stimulation," Brain, Vol. 91, pp. 99-116, 1968.

Penfield, W., and Roberts, L., Speech and Brain Mechanisms, New Jersey: Princeton University Press, 1959.

Perkins, W. H., Speech Pathology, St. Louis: C. V. Mosby Co., 1971.

Perrin, K. L., "An Examination of Ear Preference for Speech and Non-Speech Stimuli in a Stuttering Population." Ph.D. Dissertation, Stanford University, 1969.

Riley, Glyndon, and Riley, Jeanna, Diagnosis and Therapy of Stuttering in Early Childhood. Paper presented at the annual meeting of the California Speech and Hearing Association, Lake Tahoe, NV, March, 1974.

Ryan, Bruce P., "Operant Procedures Applied to Stuttering Therapy for Children," Journal of Speech and Hearing Disorders, Vol. 36, pp. 264-280, 1971.

Scarbrough, H. E., "A Quantitative Analysis of the Electro-encephalograms of Stutterers and Non-Stutterers," Journal of Experimental Research, Vol. 33, pp. 156-167, 1943.

Sem-Jacobsen, C. W., Depth-Electroencephalographic Stimulation of the Human Brain and Behavior, Illinois: Charles C. Thomas, publisher, 1968.

Sheehan, J., "Conflict Theory of Stuttering," Stuttering: A Symposium, New York: Harper, 1958, Eisenson, J., editor.

Sheehan, J., and Vaos, R., "Tension Patterns During Stuttering in Relation to Conflict, Anxiety-Binding and Reinforcement," Speech Monographs, Vol. 21, pp. 272-279, 1954.

Siegel, S., Nonparametric Statistics for the Behavioral Sciences, McGraw-Hill: New York, 1956.

Travis, Lee Edward, Speech Pathology, D. Appleton-Century Co.: New York and London, 1931.

Travis, Lee Edward, Handbook of Speech Pathology and Audiology, New York: Meredith Corp., 1971.

Trotter, W., and Lesch, M., "Personal Experiences with a Stutter-Aid," Journal of Speech and Hearing Disorders, Vol. 32, pp. 270-272, 1967.

Tuckman, B. W., Conducting Educational Research, Harcourt, Brace and Jovanovich, Inc., 1972.

Van Riper, Charles, The Nature of Stuttering, New Jersey: Englewood Cliffs, 1971.

Zemlin, W. R., Speech and Hearing Science, New Jersey: Prentice-Hall, Inc., 1968.

APPENDIX

DESCRIPTION OF SUBJECTS

Subject	Age	Sex	Fluency	Subject	Age	Sex	Fluency
1-E	42-6	F	DB	1-C	43-5	F	FL
2-E	18-0	M	DG	2-C	18-8	M	FL
3-E	17-11	M	DB	3-C	18-2	M	FL
4-E	28-9	M	DG	4-C	29-2	M	FL
5-E	23-8	M	DB	5-C	23-3	M	FL
6-E	24-7	M	DB	6-C	23-0	M	FL
7-E	27-0	M	DG	7-C	25-2	M	FL
8-E	24-10	M	DG	8-C	22-10	M	FL
9-E	16-7	M	DG	9-C	15-4	M	FL
10-E	7-2	F	DG	10-C	9-1	F	FL
11-E	36-9	M	DG	11-C	33-6	M	FL
12-E	23-9	M	DB	12-C	22-6	M	FL
13-E	22-4	M	DG	13-C	21-6	M	FL
14-E	13-3	M	DB	14-C	27-11	M	FL
15-E	59-9	M	DB	-	-	-	-

Subjects: E = Experimental
C = Control

Fluency: DG = Generally Dysfluent
DB = Bilabially Dysfluent
FL = Fluent