EMG response to fluent and disfluent speech among male and female child listeners

Ethel Cheng-Hsin Chang
The University of Montana

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EMG RESPONSE TO FLUENT AND DISFLUENT SPEECH
AMONG MALE AND FEMALE CHILD LISTENERS

By

Ethel Cheng-Hsin Chang

A.B., University of California, 1970

Presented in partial fulfillment of the requirements for the degree of

Master of Arts

UNIVERSITY OF MONTANA

1973

Approved by:

[Signatures]
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CHAPTER I

INTRODUCTION

Much research has been done relating listener reactions to disfluent speech. These studies, however, have been limited to reactions following exposure to disfluent speech. There appears to be little research concerned with an individual's response while listening to disfluent speech. This research was thus an attempt to study the effects of listening to fluent and disfluent speech in terms of the listener's tension level as measured on the frontalis muscle, using the procedure of electromyography.

The alleged onset of stuttering most often begins during the pre-school years, with apparent peaks at three and five years of age (Sheehan, 1970). This onset is characterized as involving the interaction of listener and speaker. In Johnson's study of stuttering and non-stuttering children, more similarities than differences in constitution and personality were found, and the parents of these children were also more alike than different. The parents of the experimental group of stutterers, however, were more sensitive to their child's disfluencies than those parents of the control group of non-stutterers. It was concluded that the listener's evaluative reaction was the foremost contributing factor to the development of stuttering (Johnson and Associates, 1959).
Listener reaction to disfluent speech has since been the subject of many studies. Boehmaler (1958) found that the judges' application of the stuttering label varied with the rated severity of the speech samples, and that regardless of rated severity, sound and syllable repetitions were labeled as stuttering more often than revisions and interjections. During disfluent speech, a decrease in eye contact and an increase in other bodily movements of the adult listener have been observed (Rosenberg and Curtis, 1954). The results of another study (Giolas and Williams, 1958) provide evidence that the speech patterns used in presenting a story affected kindergarten and second-grade listeners' selection of prospective teachers. That is, regardless of the story, children tended to select the least disfluent speaker as their preference for their prospective teacher. Responses to a questionnaire also indicated that children were, in general, aware of the disfluencies.

There is much documentation supporting the incidence of more young male stutters than young female stutterers, with ratios varying approximately between 2:1 and 5:1 (Bloodstein, 1969; Johnson, 1967; Sheehan, 1970). There have been several explanations for this sex difference, but none have been conclusive. Possible explanations have included factors of physiology, development, and personality. Because of this intriguing sex difference, studies have been done in which the exhibited speech of male and female non-stuttering children was compared as to the frequency and types of disfluencies. While Glass (1959) did find a significant difference with regard to total number of disfluencies, Kools and Berryman (1971) did not find this difference. Yet both studies revealed that the types of disfluencies varied between
males and females. Glass further stated that in her group of first and third-graders, females had proportionally fewer repetitions and more interjections than did males. Interestingly, Davis (1939) found earlier that the speech of non-stuttering pre-school males included more syllable repetitions than did the speech of non-stuttering pre-school females.

Most of the studies cited above relate the speaker's disfluent speech to the listener's evaluative reactions and to the listener's change in various body movements. Hanley (1972), however, mentions another possible reaction--a change in the listener's fluency pattern after exposure to disfluent speech. Hanley observed an increase in the disfluencies of adult listeners and felt that the results were consistent with other findings involving changes in attitudes and body behavior as a result of listening to disfluent speech. These behavior changes, Hanley inferred, are accompanied by an increase in tension, believed to be conducive to an increase in disfluency. If the consequent increased disfluency pattern may, in part, be attributed to an increase in tension, the question then becomes, "Does a change in muscle tension or electrical activity occur while listening to disfluent speech?"

Since a relationship exists between the strength of the muscle contraction and the number of motor units actively firing, a direct relationship exists between the force of contraction and the accompanying electrical activity (Gay and Harris, 1971; Inman et al., 1952; Sumitsuji et al., 1967). Electrical activity produced by muscle fibers can be measured and recorded by a procedure known as electromyography.
An electromyographic recorder can measure the muscle action potential present in the frontalis muscle, reportedly difficult to relax deeply (Sumitsuji et al., 1967).

Many studies suggest that anxiety is accompanied by muscle activity (Sainsbury and Gibson, 1954). Sainsbury and Gibson conducted a study using anxious patients as subjects. They found a positive correlation between the scores of the patients' feelings of anxiety and the level of muscle activity, which was based on measurements taken from two well-separated areas, the frontalis and forearm extensors. In addition, Sainsbury and Gibson found significant agreement between the muscle activity in the forehead, neck, arm and leg, and thus concluded that tension in one area could be reliably associated with an increase in other areas.

The two main types of electrodes used in electromyography are surface and inserted (wire and needle) electrodes. While surface electrodes can be used only with superficial muscles and the pick-up of electrical activity is generally widespread, surface electrodes afford minimal discomfort (Basmajian, 1967). In addition, surface electrodes provide an indication of overall muscle activity, since they sum over many motor units (Gay and Harris, 1971). Inman et al. (1952) argue that "... the type of electrode used to pick up the muscle action potential is not crucial, if they are placed on or over the central mass of the muscle to be studied."

Neurophysiological investigation of stuttering was pioneered by Lee Travis in the 1920's and 30's. Travis recorded electrical potentials from the left and right masseter muscles of stutterers and non-stutterers.
while they were speaking (Bloodstein, 1969). Williams (1955) replicated
Travis' study and also concluded that stutters and non-stutterers are
not neurophysiologically different from one another, but that the action
potential differences between stuttering and non-stuttering speech indi-
cated that "moments of stuttering characteristically involve muscular
tension in excess of that characteristic of normal speech."

As mentioned earlier, the speaker-listener interaction is a
critical factor to the development of stuttering. Because the onset of
stuttering usually begins during the pre-school years, the speaker
refers to the child, while the listener refers to the child's parents
primarily, who listen and react evaluatively (Johnson and Associates,
1959). But the child or speaker is also a listener, just as the adult
listener is also a speaker. Since Hanley (1972) found a change in the
adult listener's fluency pattern after exposure to disfluent speech,
one might expect a similar change in the child listener's fluency pat-
tern. Hanley points out that "although an increase in tension seems
to be the most plausible explanation, the listener could also have been
using the speaker as a 'linguistic model' to be imitated." If the
listener does attempt to model the speaker, the listener may also sense
the tension level of disfluent speech and may internalize this tension.
Or, the tension may be due to a decrease in the amount of information
conveyed by the speaker as a result of his disfluent pattern.

Smith et al. (1954) studied the EMG concomitants of listening
and talking. While the subjects listened to a faulty sound recording,
rising and falling gradients of tension were observed in the speech
muscles and in extensor muscles of both arms. It was hypothesized that
during those moments when the message was less intelligible, the listener made a greater effort to attend. In the same vein, when the speaker is disfluent, the amount of "information" being conveyed may decrease, in which case the listener may have to be more attentive in order to comprehend the spoken message. Whatever the reasons may be for the tension while listening to a faulty recording and for the change in fluency pattern after listening to disfluent speech, it is apparent that an objective measure of tension should be taken while individuals are listening to disfluent speech. In other words, the speaker-listener interaction should be further delineated.

**Statement of the Problem**

In view of the literature and research concerning listener responses to disfluent speech, a study of electromyographic responses while listening to fluent and disfluent speech seemed appropriate. Because stuttering most frequently begins during the pre-school years, and because of the exploratory nature of the procedures and the implications for further research, kindergarten children were selected as subjects for this study. An attempt was made to answer the following question: In comparing two different listening conditions of fluent speech and disfluent speech, will a child's level of muscle tension differ? The experimenter hypothesized that the amount of electrical activity of the frontalis muscle when listening to a disfluent speech pattern will be significantly greater than the amount of electrical activity when listening to a fluent speech pattern. A significant difference would lead to the rejection of the null hypothesis of no difference.
Definition of the Experimental Variables

The independent experimental variables were: (a) exposure to fluent speech, and (b) exposure to disfluent speech. The dependent experimental variable was the muscle tension as measured on the frontalis muscle.

**Fluent speech.** Speech containing two or fewer interruptions (sound, syllable, word, and sentence repetitions or revisions; prolongations; or interjections) per two-hundred words.

**Disfluent speech.** Speech pattern simulating the pattern of a severe stutterer who would fall around the 7th - 8th decile for female stutterers (Johnson, Darley, and Spreistersbach, 1963). The speaker attempted to spontaneously produce disfluencies as well as pitch variation, and the harsh quality often associated with severely disfluent speech.

**Listener's muscle tension.** Summated electrical potential in microvolts for the 64-second trial period, as measured with surface electrodes over the frontalis muscle.
CHAPTER II

PROCEDURE

Speech Samples

The *Runaway Bunny* (Brown, 1942) was audiotaped using a Rheem recorder and microphone. Each half of the story was recorded with a fluent speech pattern and again recorded using a disfluent speech pattern. To minimize the effects of individual and sex differences, both halves were told by the same speaker, a female graduate student. The first half of the story recorded using fluent speech was paired with the disfluent second half of the story; the disfluent first half was paired with the fluent second half. The order effect of the speech samples, if any, could thus be isolated. Because the story was written for pre-school-aged children, and because the kindergarten and nursery school teachers had not yet read this story to their classes, The *Runaway Bunny* was selected as topic material.

Listeners

The experimental subjects were pre-school children from the University of Montana Kindergarten Program and from the Playmate Nursery School in Missoula, Montana. The group of young children consisted of eight males and eight females. The mean age for the group was five years and eleven months. The boys ranged in age from five years and five months to six years and four months with a mean age of five years
and ten months. The girls ranged in age from five years and seven months to six years and five months with a mean age of six years. A letter was written to the parents requesting written permission that their child be allowed to participate in a study in which responses to certain speech situations would be observed (Appendix A and B).

As a criterion for selection, each subject passed an audiological pure tone screening test at frequencies of 250, 500, 1000 and 2000 Hertz at 25 decibels (ISO 1964 Standard). To obtain some normative data on the experimental population, the Peabody Picture Vocabulary Test was administered to each child, who obtained a receptive vocabulary age equivalent of five years or above as determined by the results of the Peabody Picture Vocabulary Test (PPVT). The average receptive vocabulary age-equivalent was seven years and five months, with seven years and four months as the mean for males and seven years and six months as the mean for females.

The subjects were grouped by sex and then randomly divided into two groups for order:

*Group B₁*: Fluent audiotape of First Half
Disfluent audiotape of Second Half

*Group B₂*: Disfluent audiotape of First Half
Fluent audiotape of Second Half

**Apparatus**

The subject was seated in a reclining chair in an area enclosed by grounded screening to screen out ambient electrical energy that might be present in the testing environment. The surface electrodes, set into an adjustable rubber headband, were adapted through a shielded cable to minimize the effect of ambient electrical activity on the
measurements. Electrode paste (Beckman) was applied on the surface of
the electrodes to improve electrical contact. The electrodes were
wired to a battery operated Medical Pre-Amplifier (Model PA-2) which
amplifies the bio-electric muscle potential which was then fed into the
integrator unit, the Bioelectric Information Feedback System (BIFS
Model B-1) just outside the screen on a table.

The electromyographic integrator unit (BIFS) provides a four-
digit numerical display of integrated EMG at the end of each designated
sampling period. EMG activity is summated and the Nixie-tube readout
panel provides the level of EMG activity in microvolts for that partic-
ular trial period. The readout is then reset to zero at the beginning
of each trial.

A green signal light, run by a six-volt DC source, was placed
in front of the reclining chair in clear view of the seated subject.
Pre-tests indicated that the low voltage was not affecting the ambient
readings of the electromyographic equipment. Controlled by the experim-
ter, this light was used to alert the subject to remain still during
EMG measurements.

The Rheem (Model Califone) audiotape recorder and Telephonics
earphones (Model TID-39) were used to present the stimuli (fluent and
disfluent speech samples). A Y-cord was plugged into the recorder,
enabling both the subject and experimenter to listen simultaneously to
the stimulus tapes. The speech samples were recorded in such a way as
to provide an auditory signal exactly 20 seconds before the stimulus,
so that the EMG recording period set by the experimenter would accur-
ately coincide with the period during which the speech sample was
presented to the subject.
Pre-Experimental Session

Two initial sessions were held, one in the kindergarten classroom, and the other at the nursery school. The experimenter briefly described the procedures of the future experimental session to the subjects:

You are each going to play an astronaut game with me. Do you all know what an astronaut is? Yes, an astronaut is someone who makes rocket flights into outer space. In our game, you can choose the planet you'd like to visit. Do you know that before astronauts take-off, they must have their heart rate checked to make sure they are in good shape for the trip.

Well, we will do a similar thing. First, I will check your hearing to make sure you can hear through these earphones. Next you will wear a headband like this. You will be hooked up through this to mission control so that I will know where you are. There will be a green light in front of you to let you know when you can wiggle around. When the green light is off, you must remember not to move and not to talk, unless I tell you to do so. OK?

A couple of headbands and a set of earphones were brought to these sessions for demonstration purposes. These items were also passed around the rooms so that each child could try them on.

Experimental Session

Each subject was individually tested between 10:00 A.M. and 3:00 P.M., Monday through Friday. After each subject entered the room, the child was seated in the reclining chair, which was in an upright position. The experimenter recorded the mean of two 64-second measures of the background electrical activity (ambient reading) present in the screened room while conversing informally with the child. This ambient reading was used as the correction factor which was subtracted from each subsequent 64-second measurement made on that subject.
If at any time during the session the child appeared frightened or unable to remain still long enough for the readings, the procedures were either discontinued or continued, depending on the individual case. If the procedures were continued, the data obtained were discarded. In either case, the child was rejected as an experimental subject.

Preceding the directions for the audiological screening test was the following comment made by the experimenter:

This is to check your hearing, so that I know you will hear me through the earphones, since I will be mission control on earth. See the green light in front of you? That means you can wiggle around. When the light goes off, you must be very still—no moving or talking, unless I tell you to do so.

The hearing test was administered, during which the green light was off. After removing the earphones and turning on the green light, the experimenter explained the purpose of the headband:

You will be wearing this headband during the entire flight. This headband will give me signals telling me where you are. Why don't we put the headband on now to get ready for our flight?

To improve electrical contact electrode paste (Beckman) was applied onto the electrodes of the headband, which was then placed on the subject's forehead. Next, the experimenter introduced the Peabody Picture Vocabulary Test:

Now you will point to the picture of the word I say to you. This also tells me whether you can understand words through the earphones.

Again, the green light was off during the PPVT, Form a, and turned on after the PPVT.

The following directions were given after the PPVT was administered:
OK (name). We're about ready for the flight. I will be mission control and you will be the first (boy/girl) to land on (planet). Now remember, the green light means you can wiggle around. But when this light goes off, you must be very, very still--no moving or talking. Otherwise, we will have to start again. During your flight, you will hear a story, but you will hear it in two parts. During those two parts, the green light will go off, meaning that you must be quiet, right? After the first part, the green light will go on, telling you you can wiggle if you want. But once it goes off, you must be very still. Are you ready?

The chair was set in the reclining position, and the screen door was closed; 32-second baseline readings were collected until stable (two consecutive readings ± .50 microvolts) readings were obtained prior to each experimental condition. This procedure was followed to minimize the effect of order and to make the subsequent reading (experimental readings) more valid. Following each baseline measurement, a 32-second rest period was allowed during which the green light was on. The Nixie-tubes were reset to zero at the end of each trial.

The first half of the story was presented through the earphones, and a 64-second reading was recorded. At the end of the first half, a 20-second rest period followed, again with the green light on.

Baseline readings were again collected using those procedures outlined above. The last half of the story was presented through the earphones and a 64-second reading was recorded.

After the entire story, the experimenter said to the subject, "OK, you're home. Congratulations! What did you see on __________?" indicating the end of the experiment. Next, the surface electrodes were removed and another ambient reading was taken to check the stability of the background electrical activity. If the final ambient reading

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was not within ± .10 microvolts of the initial ambient readings, the
data obtained were not used in this study.

The stable baseline measurements recorded were first doubled
and then used as baseline readings, thus representing a baseline reading
for a 64-second trial period.

The EMG scores were the differences between the EMG readings
summed during the 64-second experimental conditions and the doubled
baseline EMG readings obtained immediately preceding each respective
experimental condition. That is, the EMG score was the change in EMG
activity while listening to fluent or disfluent speech. The difference
score was that difference between the fluent and disfluent scores
(Appendix C).

Because this study was exploratory in nature, a coefficient of
risk of .10 was used in analyzing the data.
CHAPTER III

RESULTS

The data for this study consisted of two EMG scores for each of the sixteen children: (1) the change in EMG activity while listening to fluent speech, and (2) the change in EMG activity while listening to disfluent speech. These EMG scores depend, in part, on the baseline scores for each child. Preceding the first experimental condition, as many as ten readings were required for a few subjects before stable readings were obtained. In general, however, the EMG of most children leveled off within four to five 32-second trials. A summary of the means appears in Table 1.

TABLE 1

MEANS OF EMG SCORES FOR MALES AND FEMALES LISTENING TO FLUENT AND DISFLUENT SPEECH

<table>
<thead>
<tr>
<th></th>
<th>Fluent Speech</th>
<th>Disfluent Speech</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st Order</td>
<td>2nd Order</td>
</tr>
<tr>
<td>Male Listeners</td>
<td>-0.94</td>
<td>+0.22</td>
</tr>
<tr>
<td></td>
<td>(\bar{X} = -0.36) microvolts</td>
<td>(\bar{X} = +0.89) microvolts</td>
</tr>
<tr>
<td>Female Listeners</td>
<td>-2.88</td>
<td>-1.11</td>
</tr>
<tr>
<td></td>
<td>(\bar{X} = -2.00) microvolts</td>
<td>(\bar{X} = +0.86) microvolts</td>
</tr>
</tbody>
</table>
Results of a three-variable factorial analysis of variance are given in Table 2 (Type IV Lindquist, 1953). Since a significant interaction between treatment and sex was found ($F = 5.62, p < .05$), simple differences between sex within each treatment and between treatments within each sex were evaluated using the appropriate t-tests. A t-test for independent measures was used to determine if any difference existed between sexes within each treatment. As shown in Table 1, the means for males and females within the fluent treatment were -0.36 and -2.00 microvolts, respectively. The difference between these two means was not statistically significant ($t = 0.99$ df 14). The means for males and females for the disfluent treatment were +0.89 and +0.86 microvolts, respectively. Again, the difference between these two means was not statistically significant ($t = 0.62$ df 14).

### TABLE 2
**SUMMARY OF VARIANCE**

<table>
<thead>
<tr>
<th>Source</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>df</th>
<th>F</th>
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<tr>
<td>Total</td>
<td>435.72</td>
<td>114.06</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td>Between Subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex (S)</td>
<td>255.65</td>
<td>17.04</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Treatment X Order (TO)</td>
<td>13.97</td>
<td>13.97</td>
<td>1</td>
<td>0.29</td>
</tr>
<tr>
<td>TOSb</td>
<td>1.00</td>
<td>1.00</td>
<td>1</td>
<td>0.21</td>
</tr>
<tr>
<td>Errorb</td>
<td>232.03</td>
<td>19.34</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Within Subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment (T)</td>
<td>33.74</td>
<td>33.74</td>
<td>1</td>
<td>4.28*</td>
</tr>
<tr>
<td>Order (O)</td>
<td>0.15</td>
<td>0.15</td>
<td>1</td>
<td>0.02</td>
</tr>
<tr>
<td>TO</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>TS</td>
<td>44.37</td>
<td>44.37</td>
<td>1</td>
<td>5.62**</td>
</tr>
<tr>
<td>OS</td>
<td>7.03</td>
<td>7.03</td>
<td>1</td>
<td>0.89</td>
</tr>
<tr>
<td>TOSw</td>
<td>9.79</td>
<td>7.89</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Errorw</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

* $p < .10$  ** $p < .05$

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As shown in Table 3 the mean EMG difference between disfluent and fluent treatments for males was 1.26 microvolts. A t-test for related measures was applied, indicating that the difference of 1.25 was not statistically significant from zero (t = 0.93 df 7). The mean EMG difference for females, however, was 2.86 microvolts, which was statistically significant from zero (t = 1.80 df 7). Therefore, the change in EMG activity between disfluent and fluent treatments was found to be significantly greater than zero for females but not for males.

**TABLE 3**

<table>
<thead>
<tr>
<th>Difference between Disfluent and Fluent</th>
<th>t value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male Listeners</td>
<td>1.26 microvolts</td>
</tr>
<tr>
<td>Female Listeners</td>
<td>2.86 microvolts</td>
</tr>
</tbody>
</table>

* p < .10

Both males and females in this sample increased their EMG activity as measured on the frontalis muscle while listening to disfluent speech, and both sexes decreased their EMG activity while listening to fluent speech. As can be seen in Figure 1, the greatest change between the two treatments occurred within the female sex and was found to be statistically significant.
FIGURE 1

CHANGE IN MICROVOLTS BETWEEN FLUENT AND DISFLUENT TREATMENTS FOR MALES AND FEMALES
CHAPTER IV

DISCUSSION

This study attempted to assess the effects of listening to fluent and disfluent speech on EMG activity, using the procedure known as electromyography. It was hypothesized that subjects would show higher EMG activity levels while listening to disfluent speech than while listening to fluent speech. Two groups of eight children listened to a story, half of which was delivered with fluent speech and half of which was delivered with disfluent speech. Measurements of muscle activity on the frontalis muscle were recorded for each of the two treatments as well as the baseline readings preceding each experimental condition. The changes in EMG activity while listening to fluent speech and while listening to disfluent speech as compared to baseline readings were analyzed.

The means of EMG activity for both males and females decreased from their baselines while listening to fluent speech and increased from their baselines while listening to disfluent speech. The results of the data analysis indicated a significant treatment effect, but an interaction effect of treatment and sex was also found. Further analysis revealed a statistically significant \( p < .10 \) difference between the fluent and disfluent treatments for the females only. Interestingly, the significance of this change was attributed to the decrease in EMG activity while listening to fluent speech rather than to the slight
increase in EMG activity while listening to disfluent speech. In other words, the EMG activity for both males and females decreased while listening to fluent speech, but the amount of decrease in microvolts was greater for females than for males. This unexpected finding suggests that five to seven year-old females became more relaxed than five to seven year-old males during fluent speech.

Sex differences have typically been found in regard to speech and language acquisition skills. Although findings generally have not been significant, the results have been consistently in favor of females. As discussed in Chapter I, the incidence of young male stutterers is higher than that of young female stutterers. In this particular study, the significant treatment by sex interaction and the greater and significant change with the females suggest a sex difference, that females become relaxed while listening to fluent speech, more so than males. Perhaps this indicates that verbal communication is more "stressful" for young males than for young females. This area should be investigated.

Another explanation for the females' decrease in EMG activity might involve the sex of the speaker and its interaction with the sex of the listener, often a variable in communication situations. The stimulus tapes were recorded by a female adult, and since most of a child's early communication experiences involve the mother, the subjects' reactions may possibly reflect the mother-child relationship. As much of the literature will attest, the mother-son relationship is often the most frequent source of difficulty in the development of disfluency problems in male children. Perhaps a child is less tense
listening to adults of the same sex than he is when listening to adults of the opposite sex, which would most likely depend upon the child's relationships with female and male adults.

The possible effect of the "astronaut game" itself cannot be determined, but it should be mentioned. The males may have been more excited than females about participating in the astronaut game. If the procedures were of more interest to the males, their excitement may have precluded lower EMG activity levels. The experimenter felt, however, that there was no sex difference with regard to interest in the game.

Males have been shown to be better listeners (as related to listening comprehension) than females in some of the research dealing with the sex of adult listeners (Rossiter, 1972). If this hypothesis was valid, perhaps being a "better" listener involves more muscular tension, which is another possible explanation for males not relaxing as much as females.

Since the average change of three of the four subgroups was incremental, and twelve of the sixteen subjects had an increase in tension while listening to disfluent speech, a question of concern still remains: Does the child internalize the tension of the speaker? Is the slight increase in EMG activity a physiological correlate of his "stress"? Internalization of tension would seem to support the learning theory of stuttering.

The increase in EMG activity may also be due to the listener's reactions based on his fluency standards. At the age of five to seven years, a child may have developed his own fluency standards, and any
noticeable deviation may not be tolerated and may be judged as "abnormal." This evaluative reaction of intolerance or rejection may be manifested by an increase in muscle tension.

Another plausible explanation for the general trend is that there may be a loss of information conveyed because of the severity or frequency of disfluencies. If, in fact, stuttered speech is less informative to the listener because of the superfluous disfluencies and/or the breakdown in the flow of speech, the listener must attend with more effort to obtain the information. To compensate for any loss of information, the children may have attempted to become more attentive. Perhaps this increased tension was related to their attempts to become more attentive.

As previously mentioned, the EMG levels of twelve of the sixteen subjects increased while listening to disfluent speech. The EMG levels of the other four subjects, however, decreased while listening to disfluent speech and increased while listening to fluent speech. Compared to the general trend of the majority, the responses of these four subjects were the reverse. This minority consisted of two males and two females, with each order equally represented by each sex. Thus, neither sex nor order was a contributing factor. It appears that stuttering behavior and its relationships to the listener cannot be analyzed in any simple manner, and that individual differences play an important role.

Although this investigation was an attempt to prove a research hypothesis, it also served to test the feasibility of the procedures and instrumentation, which might prove useful to further studies. The
author was cautioned as to the possibility that children may be rather apprehensive in these experimental conditions (sitting in a screened room with surface electrodes on the forehead), and that stable baseline measurements on children may be too difficult to obtain within the time allotted for an individual experimental session. On occasion, as many as ten trials were necessary, but stable baseline readings were nevertheless obtained without losing the child's interest in the "astronaut game" (as subjectively determined by the experimenter). Because of the pre-experimental session in which the astronaut game and some of the procedures were briefly explained, interest in the game was easily aroused. Their eagerness to participate in the game was quite obvious. When entering the experiment room, the children were not intimidated and approached the screened room with curiosity and imagination, "Is this the rocket?" The applicability of this instrument for further research, indeed, looks promising.

The results of this exploratory study indicate that it is possible to determine more precisely the effects of disfluent and fluent speech on the listener in terms of muscle activity. In studying the effects, variables are isolated and manipulated experimentally. The existing possibilities are as pertinent as the need itself to further our understanding of the speaker-listener interaction. In future research, consideration could be given to the following.

Listener reactions depend, in part, on the frequency and types of disfluencies in the spoken message. As Boehmler (1958) has shown, sound and syllable repetitions were labeled as stuttering more often than revisions and interjections. Specific types of disfluencies such
as repetitions may perhaps induce more tension in the listener than interjections. Or, it may be the tension involved in the speech mechanisms in producing repetitions as opposed to that tension associated with the production of interjections. The listener may be internalizing by perceiving the tension in the speaker, depending on the specific disfluencies or the accompanying voice changes. The disfluencies themselves may not cause any effect on one's EMG activity, but the voice characteristics may.

In line with isolating those variables affecting listener reactions, the effects of auditory, visual, and the two combined should be analyzed. Again, however, individual differences may be the critical factor. Some individuals may be more visually oriented than auditorily oriented, and vice versa.

Age is definitely a macrovariable when discussing the effects of fluent and disfluent speech on the listener. Studies in which the Bioelectric Information Feedback System is employed can include younger subjects in their experimental population. The interaction between speaker and listener is most likely a function of age as well as other variables, such as sex. Even an individual's fluency standards may vary with age as does his degree of tolerance to deviant behaviors. These areas should definitely be explored.

Sex of the speaker and its interaction with the sex of the listener should be studied in more detail. The sex of the listener has been subjected to research as a variable related to speaker-listener interaction, but little attention has been given to the sex of the speaker as a variable.
Since studies using adults have shown that this instrument (BIFS) can measure the electrical activity of certain muscle groups, it could be employed in comparing the non-stuttering to the stuttering population in relation to the following: (1) reactions to disfluent speech as opposed to fluent speech, (2) comparison of reactions to the different types of disfluencies, and (3) reactions to listening to one's own disfluencies versus another individual's. Research studies could compare various age groups or use longitudinal studies to research any or all of the above.

Possibilities are not limited to the receptive aspects of communication (listening). The use of this instrumentation to study the concomitants of expressive language certainly has great potential. For example, muscle activity could be measured during fluent speech, disfluent speech, repetitions only, prolongations only, etc. In other words, the speaker's reactions to known variables should also be explored.

If studies show an increase in EMG activity, presumably as a result of isolated or known variables, it would be interesting to investigate the duration of the increased EMG. If a listener does become more tense while exposed to disfluent speech, how much time is needed to return to baseline levels? Upon which factors would this depend? Hanley (1972) has found that even the speech of the listener is affected immediately after exposure to disfluent speech. Does an increase in EMG activity accompany the listener's disfluent speech?

Like most studies, more questions have been raised than are answered, which only verifies the need for further research. The above
relationships must be more thoroughly investigated to help clarify our understanding of the speaker-listener relationship, and in general, the human communication process.
The purpose of this study was to assess the effects on EMG activity of listening to fluent and disfluent speech. An electromyographic procedure was employed to measure electrical activity of the frontalis muscle in microvolts. It was hypothesized that subjects would show higher EMG activity levels while listening to disfluent speech than while listening to fluent speech.

In particular, two groups of eight children listened to a story, half of which was delivered with fluent speech and half of which was delivered with disfluent speech. Measurements of muscle activity on the frontalis muscle were recorded for each of the two treatments as well as for the baseline readings preceding each experimental condition. As compared to baseline readings, the changes in EMG activity while listening to fluent speech and while listening to disfluent speech were analyzed.

Analysis of the data revealed a significant treatment effect ($p < .10$) and also a significant interaction between treatment and sex ($p < .05$). To further analyze the interaction effect, a t-test for related measures was applied, which indicated the mean EMG difference of 2.86 microvolts between disfluent and fluent treatments for females was significantly different from zero. A "t" of 1.80 ($df = 7$) was
obtained and was significant at the .10 level. It was pointed out that
the significance of this change was attributed not to the slight in-
crease in EMG activity while listening to disfluent speech, but rather
to the decrease in EMG activity while listening to fluent speech, which
was unexpected. The null hypothesis was rejected, and it was assumed
that there is a significant change in EMG activity between disfluent
and fluent treatments for females but not for males, thus supporting a
sex difference often found in regard to speech and language skills.

The feasibility of the procedures and instrumentation was dis-
cussed, and implications for further research were presented.
APPENDIXES
APPENDIX A

LETTER TO PARENTS OF UNIVERSITY KINDERGARDEN CHILDREN

Dear

The University of Montana Kindergarten Program will be participating in a study in which responses to certain speech situations will be observed. The study will take place at the University Speech and Hearing Clinic during the next couple of weeks. As part of this study, each child's hearing will be screened. If your child fails the screening test, you will be notified so that the appropriate steps for further audiological testing may be taken.

May we count on your cooperation in having your child participate? If so, it would be appreciated if you would sign the permission slip and return it to the Kindergarten class.

I will be explaining the project to the kindergarten class this week. If you have questions about it, I would be happy to tell you more about the simple procedures I have in mind. I can be reached at 213-131.

In advance I thank you for your cooperation.

Sincerely,

Ethel Chang
Graduate Student, Speech Pathology & Audiology

Joan Christopherson (Mrs.)
Assistant Professor, Home Economics

______________________________ has my permission to go to the Speech & Hearing Clinic to participate in the listening study and to have his/her hearing checked.

Signed__________________________

Date____________________________

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APPENDIX B

LETTER TO PARENTS OF PLAYMATE NURSERY SCHOOL CHILDREN

Dear

I am conducting a study in which responses to certain speech situations will be observed. The study will take place at the University Speech and Hearing Clinic during the next couple of weeks. As part of this study, each child's hearing will be screened. If your child fails the screening test, you will be notified so that the appropriate steps for further audiological testing may be taken.

May we count on your cooperation in having your child participate? If so, it would be appreciated if you would sign the permission slip and return it to Mrs. Jan Murdaugh at the Playmate Nursery School.

I will be explaining the project to the children this week. If you have questions about it, I would be happy to tell you more about the simple procedures I have in mind. I can be reached at 243-1313.

In advance I thank you for your cooperation.

Sincerely,

Ethel Chang
Graduate Student, Speech Pathology & Audiology

Jan Murdaugh (Mrs.)
Playmate Nursery School

______________________________ has my permission to go to the Speech and Hearing Clinic to participate in the listening study and to have his/her hearing checked. I understand transportation will be provided.

Signed______________________________
## APPENDIX C

**EMG Readings and Scores in Microvolts per 64-Second Trial**

*For Sixteen Subjects*

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BIBLIOGRAPHY


