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Effect of utterance length and meaningfulness on the speech initiation times of stuttering and nonstuttering children

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The University of Arizona, 1992
EFFECT OF UTTERANCE LENGTH AND MEANINGFULNESS ON THE SPEECH INITIATION TIMES OF STUTTERING AND NONSTUTTERING CHILDREN

by

Wendy Susanne Maske

A Thesis Submitted to the Faculty of the DEPARTMENT OF SPEECH AND HEARING SCIENCE
In Partial Fulfillment of the Requirements For the Degree of MASTER OF SCIENCE
In the Graduate College THE UNIVERSITY OF ARIZONA

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STATEMENT BY AUTHOR

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APPROVAL BY THESIS DIRECTOR

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Date: 10 May 1992
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# TABLE OF CONTENTS

LIST OF TABLES ........................................................................................................... 5  
LIST OF FIGURES ...................................................................................................... 6  
ABSTRACT .................................................................................................................. 7  
INTRODUCTION ......................................................................................................... 8  
METHOD .................................................................................................................... 17  
RESULTS ..................................................................................................................... 27  
DISCUSSION .............................................................................................................. 33  
CONCLUSION ............................................................................................................ 41  
APPENDIX A: PARENT/GUARDIAN LETTER AND CONSENT FORM .................................. 43  
APPENDIX B: SUBJECT CONSENT FORM .................................................................... 47  
APPENDIX C: SPEECH-LANGUAGE PATHOLOGIST QUESTIONNAIRE FOR EACH STUTTERING SUBJECT ........................................................................................................... 48  
APPENDIX D: LIST OF EACH SUBJECT'S REACTION TIMES ........................................ 49  
APPENDIX E: LIST OF EACH SUBJECT'S MEAN REACTION TIMES FOR EACH TASK ................................................................. 69  
APPENDIX F: RESULTS OF THE ANOVA BEFORE THE REMOVAL OF THE OUTLIERS .................................................................................................................. 70  
LIST OF REFERENCES ............................................................................................... 71
LIST OF TABLES

Table 1. Subject Information .................................................18
Table 2. Means and Standard Deviations for Each Group Across all Tasks ..........................................................27
Table 3. Means and Standard Deviations: Task Across Groups .............................................................................28
Table 4. Means and Standard Deviations: Group by Task .........................................................................................29
Table 5. Means and Standard Deviations for Each Group Across all Tasks .............................................................30
Table 6. Means and Standard Deviations by Group and Task .....................................................................................31
LIST OF FIGURES

Figure 1. Flow Diagram of the Process of Stimulus Presentation.................................19

Figure 2. Sample Signal of the Waveform..........................24

Figure 3. Diagram of Group by Task Interaction...............32
ABSTRACT

The purpose of this study was to determine the effect of utterance length and meaningfulness on the speech initiation times of stuttering and nonstuttering children. Subjects were 36 elementary school students: 18 stutterers and 18 nonstutterers matched by age, grade, and gender. Each child produced 23 each of a short meaningful, long meaningful, and long nonse utterance in response to a visual cue. Results are consistent with other studies that found stutterers to be slower than nonstutterers when responding verbally to an external cue. It is also apparent that nonstuttering, stuttering-only, and stuttering-plus children are affected differently by utterance length and meaningfulness. This indicates that the three groups may process speech motor events for verbal responses differently.
INTRODUCTION

In recent years a number of researchers have become interested in the speech production processes of people who stutter, and various theories have been proposed to explain speech production differences of stutterers and nonstutterers. Currently, it is widely believed that there is a difference in the neuromotor programming and/or execution skills of stutterers and nonstutterers (Hand & Haynes, 1983; Kent, 1984; McKay & McDonald, 1984; Perkins, Rudas, Johnson, & Bell, 1976; Prosek, Montgomery, Walden, & Schwartz, 1979).

Reaction time studies have been employed for evaluating speech production differences between groups of stutterers and nonstutterers. Such studies measure the latency between the presentation of an external cue (e.g. a tone or flash of light) and the production of a desired response (e.g. saying "uh" or "upper"). The various reaction time tasks that have been studied include voice initiation time (VIT), speech initiation time (SIT), manual reaction time (MRT), and nonspeech phonatory reaction time. VIT refers to a response of a single phoneme or a nonlinguistic voiced sound; SIT to a syllable, word, or longer linguistic response; MRT to a response such as pressing a button; and nonspeech phonatory reaction time to responses such as a cough or an audible inspiration.

A number of researchers have investigated the effect of different variables on the reaction times of groups of stutterers and
nonstutterers. Typically, it has been found that groups of stutterers have significantly slower reaction times than do groups of nonstutterers across a variety of tasks (Adams & Hayden, 1976; Cross & Luper, 1979; Cullinan & Springer, 1980; Dembowski & Watson, 1991; Hand & Haynes, 1983; McKnight & Cullinan, 1987; Peters, Hulstign, & Starkweather, 1989; Prosek, et al., 1979; Reich, Till, & Goldsmith, 1981; Starkweather, Franklin, & Smigo, 1984; Starkweather, Hirschman, & Tannenbaum, 1976; Till, Reich, Dickey, & Seiber, 1983; Watson & Alfonso, 1983).

Cross and Luper (1979) studied the VIT of stuttering and nonstuttering groups of children and adults. They found VIT to be significantly longer for groups of stutterers than groups of nonstutterers across all age groups. Other studies have shown children who stutter to have significantly slower voice initiation times (Cullinan & Springer, 1980; McKnight & Cullinan, 1987) and speech initiation times (Till et al., 1983; McKnight & Cullinan, 1987) than children who do not stutter. These findings are consistent with those of adults who stutter.

The effect of utterance length has been investigated by several researchers. McKnight and Cullinan (1987) compared the speech initiation times of groups of stuttering and nonstuttering adults across responses of three varying lengths. Both groups, stutterers and nonstutterers, produced slower SIT's for longer responses, but the effect of increased length was greater for the group of stutterers than for nonstutterers. Till et al. (1983) found that
stutterers had significantly slower SIT's than nonstutterers when saying the word "upper" than when saying "uh". They suggested that the motoric complexity of this response differentially affected the reaction times of groups of adult stutterers and nonstutterers.

The purpose of the present study was to determine how length and linguistic meaningfulness of an utterance affect the speech initiation times of stuttering and nonstuttering children.

**Literature Review**

The following review focuses on factors that might influence reaction time. These factors include: type of cue, practice effects, age, sex, severity of stuttering, concomitant speech or language problems, and type of utterance.

**Type of Cue**

Two different types of stimuli have been used to cue reaction time: auditory and visual. For example, in the Till et al. (1983) study, an auditory signal was the cue. Subjects were presented with a 1000 Hz tone, which was the warning cue, and the offset of the tone was the signal for them to produce the desired response. In contrast, Dembowski and Watson (1991) used a light-emitting diode positioned at eye level in front of the subjects. Onset of a green light provided the subjects with a warning cue, and offset of the light was the signal for subjects to respond. Regardless of which type of cue has been used, auditory or visual, reliable differences
have been found consistently between the reaction times of stuttering and nonstuttering adults and children.

**Practice Effects**

Cross and Luper (1980) found that nonstutterers exhibited little or no practice effect from one set to the next. In contrast, the stuttering group showed a marked practice effect (i.e. faster reaction times) from the first to the second set which began to taper-off during the final set. The authors suggested that stutterers require more "practice" to reach their optimum reaction time. Starkweather et al. (1976) found decreased reaction times with practice for both the stuttering and nonstuttering groups; however, Till et al. (1983) did not find a practice effect for either the stuttering or the nonstuttering group. Therefore, findings regarding practice effects have been inconsistent.

**Age**

The majority of research concerning stutterers' reaction times has been conducted with adults. It has been suggested that adults' slow reactions may be a consequence of years of stuttering and may have nothing to do with the etiology of stuttering (Cullinan & Springer, 1980). When only adults who stutter are studied, it is unlikely that a representative sample of all people who ever stuttered is being examined; instead, it is likely that researchers are studying that subgroup of stutterers who have continued to stutter into adulthood. It is important not only to study both adults
and children but also to determine how reaction times change with age.

To determine the effect of age on reaction times, Cross and Luper (1979) compared the VIT of groups of stutterers and nonstutterers at three age levels: five years, nine years, and fifteen years and older. Reaction times significantly decreased with age for both stutterers and nonstutterers. The mean reaction times for stuttering subjects, however, were significantly longer than those of nonstuttering controls at all three age levels. The authors ascertained, in fact, that slower reaction times are found in children who stutter and that reaction times become faster into young adulthood.

**Gender**

Of the studies reviewed, six included only males (Dembowski & Watson, 1991; Hand & Haynes, 1983; McKnight & Cullinan, 1987; Peters et al., 1989; Prosek et al., 1979; Reich et al., 1981) No rationale has been given for this selectivity, but it most likely reflects the greater availability of males who stutter. Additionally, no comparisons were reported between males and females in those studies that used both. Therefore, the effect of gender on reaction time is unknown.

**Severity of Stuttering**

To determine whether the severity of adult subject's stuttering affects reaction time, Watson and Alfonso (1983) compared the VIT's of ten stutterers and five nonstutterers. The authors
administered the Riley Stuttering Severity Index (SSI) and the Ryan Stuttering Interview (SI) to each subject in the stuttering group. Two severity groups were formed: five severe stutterers and five mild stutterers. The reaction times of the severe group were significantly longer than those of the mild group on all tasks. In a later study, Dembowski and Watson (1991) also classified their adult stuttering subjects into mild and severe groups. The severe group had longer reaction times than the mild group, and the mild group had longer reaction times than the nonstuttering control group. In contrast, however, Cullinan and Springer (1980) found no significant difference in the reaction times of severe, moderate, and mild stuttering children. While definitive conclusions cannot be drawn, stuttering severity may be an important variable to consider when evaluating reaction times of those who stutter.

**Concomitant Speech/Language and/or Learning Problems**

Cullinan and Springer (1980) also divided their group of stuttering children into two groups: stuttering-only and stuttering-plus. The stuttering-only group had no concomitant speech/language or learning problems. The stuttering-plus group had mild to moderate articulation and/or language and/or learning disabilities. The stuttering-plus group was significantly slower than the nonstuttering control group on the reaction time task, but not the stuttering-only group. However, when combined, the overall reaction time of these stuttering groups was significantly slower than that of the nonstuttering control group. McKnight and Cullinan
(1987) also divided their stuttering subjects into a stuttering-only group and a stuttering-plus group. The stuttering-plus group had significantly longer reaction times than the stuttering-only group across all tasks. The stuttering-only group was significantly slower than the nonstuttering control group only on voice termination time (the time that elapses between a cueing stimulus and subjects terminating their response). Murphy and Baumgartner (1981) also replicated Cullinan and Springer's (1980) findings of no difference in reaction time between groups of nonstuttering children and stuttering children with no concomitant problems. It seems likely that the presence of concomitant speech/language and/or learning problems may affect the reaction times of children who stutter. Thus it is an important factor to consider when studying reaction times of children who stutter.

**Type of Utterance**

The types of utterances employed in reaction time tasks have varied in length and linguistic meaningfulness. Length has ranged from the production of an isolated vowel (VIT) to the production of a multisyllabic word or phrase (SIT). Linguistic meaningfulness has ranged from a vocalized sound (e.g. "uh") to a linguistically meaningful combination of sounds that form an English word (e.g. "upper") to a nonse utterance (e.g. "ata"). A nonse utterance is a combination of sounds and syllables that do not form an English word or phrase (Winitz, 1975).
The findings of studies that have examined the effects of utterance length on reaction times have been inconsistent. Starkweather et al. (1976) reported that the number of syllables had no effect on the reaction times of their adult subjects. However, Peters et al. (1989) and Dembowski and Watson (1991) found that length of utterance significantly affected the reaction times of the adults in their studies. Peters et al. (1989) suggested that increases in utterance length produced, in fact, an increase in the motor complexity of an utterance. The effect of utterance length on children's reaction times is similar to that of adults. McKnight and Cullinan (1987) found that children had significantly longer reaction times when saying five one-syllable digits than when saying either one or three one-syllable digits.

Few studies have examined the effect of utterance meaningfulness on the reaction times of adult stutterers and nonstutterers. Starkweather et al. (1976) compared the reaction times of meaningful and nonmeaningful utterances. Both the stuttering and the nonstuttering groups had significantly slower reaction times when producing meaningful utterances than when producing nonmeaningful ones. However, the authors commented that this finding may have resulted from the use of voiceless phonemes to initiate the nonsense syllables and instrumentation that may not have recorded these initiations reliably.

It is plausible that both meaningfulness and length of utterance may affect the reaction times of stutterers and nonstutterers. Till
et al. (1983) noted, for example, that linguistic meaningfulness could not fully account for the significantly longer reaction times when saying the word "upper" but that motoric complexity plays a role in longer reaction times. The possible effects of linguistic meaningfulness on reaction times have not been studied among children.

**Research Questions**

After careful review of the literature concerning reaction times of stutterers, it was concluded that the reaction times of stuttering and nonstuttering children on utterances that differ in length and meaningfulness would be a viable issue for research. The variables of utterance length and meaningfulness were chosen because of the limited and inconsistent information regarding their effects on reaction times. Likewise, children were chosen for subjects because of the limited amount of research concerning children's reaction times.

The specific questions addressed were:

1. What is the effect of utterance length on the speech initiation times of stuttering and nonstuttering children?
2. What is the effect of utterance meaningfulness on the speech initiation times of stuttering and nonstuttering children?
3. Do these effects differ for groups of stuttering and nonstuttering children?
METHOD

Subjects

Eighteen stutterers enrolled in kindergarten through fifth grade, and eighteen nonstutterers matched for age (within eleven months), gender, and grade participated in this study. They were recruited from the Tucson Unified School District and from the files of the University of Arizona Speech-Langage Clinic. Appendices A through C contain copies of the consent forms and the speech-language pathologist questionnaire that were used. None of the subjects had a history of motor disorders, neurological disorders, or visual problems, and all were reported by their classroom teachers to be performing academically at grade level. Each of the stuttering subjects had been previously identified by a speech-language pathologist and was confirmed as a stutterer by the examiner during the initial portion of the experimental session using the Riley SSI (1972). None of the nonstuttering subjects had been identified as exhibiting any speech or language problems and were never observed by the experimenter to exhibit disruptions in fluency that appeared to be abnormal or suggested that the subject might be a stutterer. In addition, the speech-language pathologists were asked to report whether or not the stuttering children exhibited concomitant speech, language, or learning problems. Information on the subjects is summarized in Table 1 including age, grade, and gender, for all
subjects and SSI rating and presence of concomitant problems of those who stutter.

TABLE 1
SUBJECT INFORMATION

<table>
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<tr>
<th>S#</th>
<th>Age</th>
<th>Gender</th>
<th>SSI</th>
<th>CP</th>
<th>NS#</th>
<th>Age</th>
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<td>lang</td>
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<tr>
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<td>7;3</td>
<td>M</td>
<td>mod</td>
<td>lang</td>
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Note. S# = Stuttering Subject #; SSI = SSI rating; CP = Concomitant Problems; NS# = Nonstuttering Subject #; lang = language; artic = articulation; LD = learning disability.

Stimulus Presentation and Response Collection

A flow diagram of the process of stimulus presentation is illustrated in Figure 1. The cue to respond was visual and was presented via the screen of a microcomputer (Macintosh SE). When the subject pressed the mouse of the computer, a black circle
appeared on the screen as a warning signal. After one of five randomly varied foreperiods of 300 to 1500 ms. (300 ms. increments), the computer displayed a black square and sent a tone to a tape recorder (Realistic, model #14-808B) at the same time. The black square was the cue for the subject to respond. The tone served as a time marker for later measurement of the subject's response time but was not heard by the subject. The subject's response was also recorded by the tape recorder using a headset microphone (Shure, SM10A) that was placed approximately three centimeters in front of the mouth. All recordings were made in a quiet room.

FIGURE 1
FLOW DIAGRAM OF STIMULUS PRESENTATION

Screen prompts "press mouse to start"

Subject presses mouse

Circle appears on screen

Circle changes to square: cue to respond

Variable foreperiod 500-1500ms
Response Conditions

There were three responses that varied in length and meaningfulness. One utterance was a one-syllable word, the second was a four-syllable utterance in a linguistically meaningful two-word sequence, and the third was a nonmeaningful four-syllable combination of sounds and syllables that do not form an English word or phrase. The latter will be referred to as the nonse utterance. The subjects were instructed to say each response as soon as the visual cue, the black square, appeared on the screen.

All three responses began with the same phoneme to control for any effects that initial phoneme production differences might have on speech initiation time. The length of the long utterances was set at four syllables since Dembowski and Watson (1991) found that reaction times of adults differed significantly between one- and two-syllable utterances. The responses were:

- short meaningful utterance - nine
- long meaningful utterance - ninja turtles
- long nonse utterance - /nərdʒo bərələs/

The subjects were told which response they were to produce and given time to practice it before each set of trials began. The nine possible different orders of response tasks were assigned to the subjects so that each order occurred an equal number of times in the two groups. Twenty-three error-free and stutter-free responses in each response condition were obtained from each subject.
Response Acceptance Criteria

For this study, only speech utterances that were judged by the experimenter to be fluent were analyzed. Two fluency criteria were used. First, if a subject evidenced a tense pause, audible prolongation, or repetition during any part of an utterance, the trial was repeated. Second, if a subject evidenced any visible muscular tension, tremor, or struggle immediately before or during a trial, the utterance was not analyzed, and the trial was repeated. To control for subjects who anticipated the visual cue and responded prematurely, any response during the warning signal or within 1/60 of a second after the onset of the signal to respond were automatically rejected by the computer, and the trial was recycled through the program. If an utterance was spoken incorrectly, the experimenter stopped the program, reminded the subject of the correct response, and then restarted the program.

Procedures

Each child was seen for one session, most of which were completed within thirty minutes. The session was divided into three parts: 1) administration of the SSI, 2) practice, and 3) data collection.

Written consent was initially obtained from each subject and the parent or guardian of each subject. The SSI was then administered to each stuttering child and the job task from the SSI to those who did not stutter. This permitted the examiner to observe each child's speech and to verify his or her placement in the stuttering or
nonstuttering group. If the examiner had had any concerns regarding
a specific child's status as a stutterer or nonstutterer, the child
would have been dismissed from the experiment. None of the
children had to be dismissed.

After testing was complete, the examiner described the
experimental task and had each subject practice tasks that were
similar to those that would be used to gather data. Each subject
practiced each response condition a minimum of five times until
three or more consecutive error-free responses were produced. Each
matched stutterer-nonstutterer pair was given the same amount of
practice. The instructions to the subjects were: "I want to see how
fast you can begin talking when this screen changes from a circle to
a square. I will tell you what to say. When you're ready, you need to
push this mouse and look at the circle on the screen, then get ready
to say the words. As soon as the screen turns to a square, you say
the words as soon as you can. Let's try one." The responses used for
these practice trials were:

short meaningful utterance - tap
long meaningful utterance - tap dancing
long nonse utterance - / tap dance /

After these practice trials were completed, data gathering began.
Before each of the three response conditions, a subject practiced the
appropriate test response until it was said correctly three times
consecutively with no errors or signs of stuttering. The examiner
stated the number of each response before the child pressed the
mouse which later helped to orient the examiner to the location of every response on the tape. To encourage subjects to stay on-task and perform at an optimum level, each was given frequent verbal feedback and encouragement (e.g. "good", "keep going", "do your best", "be as fast as you can", etc.) throughout the session. Each nonstuttering subject received the same number of reinforcements as the stuttering child with whom he or she was matched. Each child was also given an opportunity to take a three-minute break between each response condition.

Acoustic Analysis of the Data

The reaction times of the subjects were measured using an acoustic waveform editor (Farallon, SoundEdit). The tape-recorded response trials were digitized into the computer (Macintosh) using a sampling frequency of 22kHz and quantization level of 8 Bit and displayed on the computer's monitor. The examiner listened to the portions of the tape that had been digitized into the computer and checked its number with those of the rejected responses marked on each subject's score sheet. In this way, the previously determined rejected responses were not analyzed. On five occasions a computer-generated tone was not recorded on the tape, and those were also discarded from acoustic analysis. Reaction time was measured visually as the duration between the offset of the tone and the onset of continuous voicing of the subject's response. The duration of the tone was consistent across all responses, therefore, beginning the measurement at the offset of the tone instead of the
onset would not affect the results. The resolution of the time
cursor for these measurements was 0.045 millisecond. The first
twenty-three stutter-free, error-free responses for each subject in
each condition were analyzed. A sample response is displayed in
Figure 2.

FIGURE 2
SAMPLE RESPONSE

Note. A = the computer-generated tone
B = production of the word "nine"

Statistical Analysis of the Data

Because a number of extreme outlying response measures were
present, apparently due to subjects' failure to attend to the cueing
stimulus, it was decided to eliminate this source of extraneous
variability from the data set. Extreme values were excluded from
analysis by assuming that the measures reflected a normal
underlying distribution and that those measures in the far two tails
of this distribution (.005 in each tail) should be eliminated. This
criterion led to the exclusion of all values at or beyond + 2.575 standard deviations from the mean from formal data analysis. This procedure did not affect the faster responses but excluded 68 of the slowest responses. In order to demonstrate that these adjustments to the data set did not distort the main effects or the trend of the means, a two-way analysis of variance (ANOVA) (Toothaker, 1986) was completed using the unadjusted data set. The results of this analysis are in Appendix F (c.f. Tables 2 and 4).

Data analysis was performed using the Statistical Analysis Software (SAS) program. From the set of adjusted data, the means and standard deviations of response times for each condition in each group were computed. These data were further subjected to analyses of variance using the general linear models procedure for an unbalanced design (Toothaker, 1985). Post-hoc analyses were accomplished with t-tests.

Reliability of Response Time Data

Reliability of the response time data was evaluated by re-measuring the data points from two subjects who were randomly selected from each group (approximately 5% of the data set). These re-measurements were obtained approximately one week after the original measurements were made, and the experimenter was blind to the original set of measures. These values were compared to the original measures using a Pearson Product-Moment Correlation Analysis and a correlation of .96 was obtained. The average
deviation between the two sets of measurements was less than 1 millisecond.
RESULTS

The results of the two-way ANOVA and post-hoc comparisons of the stuttering and nonstuttering group data set will be reported first. The results of the analysis of a regrouped data set, consisting of stuttering-plus, stuttering-only, and stuttering-plus groups, will then be presented.

Group and Task Effects

The mean speech initiation times and standard deviations for the stuttering and nonstuttering children across all three tasks is presented in Table 2. The ANOVA main effect for group was significant, $F(1,34) = 4.38, p < .05$. Nonstutterers were faster than stutterers across all tasks.

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean (ms.)</th>
<th>Standard Deviation (ms.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonstutterers</td>
<td>319.271254</td>
<td>150.657355</td>
</tr>
<tr>
<td>Stutterers</td>
<td>384.271254</td>
<td>189.917233</td>
</tr>
</tbody>
</table>

The means and standard deviations for each task across groups are shown in Table 3. The main effect for task was significant, $F(2,68) = 3.49, p < .05$. It can be seen that reaction times increase
from the short meaningful utterance to the long meaningful utterance to the long nonse utterance. The differences between the short meaningful and the long meaningful and between the long meaningful and the long nonse responses were similar, 19.89 and 18.02 respectively. A t-test that controlled for Type I comparisonwise error rate was conducted. Only the comparison between the short meaningful and the long nonse utterance was significant \((p<.05)\).

**TABLE 3**
**MEANS AND STANDARD DEVIATIONS TASK ACROSS GROUPS**

<table>
<thead>
<tr>
<th>Task</th>
<th>Mean (ms.)</th>
<th>Standard Deviation (ms.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short meaningful</td>
<td>332.056603</td>
<td>170.156984</td>
</tr>
<tr>
<td>Long meaningful</td>
<td>351.950487</td>
<td>170.812932</td>
</tr>
<tr>
<td>Long nonse</td>
<td>369.971196</td>
<td>179.725935</td>
</tr>
</tbody>
</table>

No statistically significant interaction effect was found, \(F(2,2308) = 1.5, p > .05\). The means and standard deviations pertinent to this analysis are presented in Table 4.
TABLE 4
MEANS AND STANDARD DEVIATIONS
GROUP BY TASK

<table>
<thead>
<tr>
<th>Group</th>
<th>Task</th>
<th>Mean (ms.)</th>
<th>Standard Deviation (ms.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NS</td>
<td>short</td>
<td>361.030752</td>
<td>188.445024</td>
</tr>
<tr>
<td>NS</td>
<td>long</td>
<td>391.592217</td>
<td>181.897538</td>
</tr>
<tr>
<td>NS</td>
<td>nonse</td>
<td>400.187600</td>
<td>197.273894</td>
</tr>
<tr>
<td>ST</td>
<td>short</td>
<td>303.721591</td>
<td>144.857117</td>
</tr>
<tr>
<td>ST</td>
<td>long</td>
<td>312.704187</td>
<td>149.250249</td>
</tr>
<tr>
<td>ST</td>
<td>nonse</td>
<td>340.563504</td>
<td>155.513425</td>
</tr>
</tbody>
</table>

Note. NS=Nonstutterers, ST=Stutterers

Group Effects - Regrouped Data

Cullinan and Springer (1980) suggested that stuttering children should be divided into separate groups based on the presence or absence of concomitant speech, language, or learning problems. Therefore, the stuttering group was divided into stuttering-plus (children with concomitant speech, language, or learning problems) and stuttering-only (children with no concomitant problems) groups. Of the eighteen stuttering children, ten only stuttered, while eight had one or more concomitant problems. The means and standard deviations for each group across all three tasks are presented in Table 5. These regrouped data were subjected to another analysis of variance using the general linear models procedure for an unbalanced design. Again, the main effect for group was significant, $F(2,33) = 3.6$, $p < .05$. It is apparent that reaction times became increasingly
slower from the nonstuttering to the stuttering-only to the stuttering-plus group. The means of the three groups were then subjected to a series of t-tests that controlled for Type I comparisonwise error rate. The only statistically significant comparison (.05 level) was between the stuttering-plus and the nonstuttering groups. Power analyses (Neter & Wasserman, 1974) were carried out to determine the probability of a Type II error when comparing the nonstuttering group with the stuttering-only and the stuttering-only with the stuttering-plus group. The probability of a Type II error was .85 and .66 respectively.

### TABLE 5
MEANS AND STANDARD DEVIATIONS FOR EACH GROUP ACROSS ALL TASKS

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean (ms.)</th>
<th>Standard Deviation (ms.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonstutterers</td>
<td>303.721591</td>
<td>150.657355</td>
</tr>
<tr>
<td>Stutterers-only</td>
<td>353.494012</td>
<td>161.521656</td>
</tr>
<tr>
<td>Stutterers-plus</td>
<td>423.209129</td>
<td>214.587155</td>
</tr>
</tbody>
</table>

The means and standard deviations for each task for the three groups are presented in Table 6.
TABLE 6
MEANS AND STANDARD DEVIATIONS BY GROUP AND TASK

<table>
<thead>
<tr>
<th>Group</th>
<th>Task</th>
<th>Mean (ms.)</th>
<th>Standard Deviation (ms.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NS</td>
<td>short</td>
<td>303.721591</td>
<td>144.857117</td>
</tr>
<tr>
<td>NS</td>
<td>long</td>
<td>312.704187</td>
<td>149.250249</td>
</tr>
<tr>
<td>NS</td>
<td>nonse</td>
<td>340.563504</td>
<td>155.513425</td>
</tr>
<tr>
<td>SO</td>
<td>short</td>
<td>356.282009</td>
<td>170.905558</td>
</tr>
<tr>
<td>SO</td>
<td>long</td>
<td>349.197841</td>
<td>151.051983</td>
</tr>
<tr>
<td>SO</td>
<td>nonse</td>
<td>355.136622</td>
<td>162.989080</td>
</tr>
<tr>
<td>SP</td>
<td>short</td>
<td>366.808389</td>
<td>208.146139</td>
</tr>
<tr>
<td>SP</td>
<td>long</td>
<td>448.201176</td>
<td>203.417597</td>
</tr>
<tr>
<td>SP</td>
<td>nonse</td>
<td>456.374775</td>
<td>220.994178</td>
</tr>
</tbody>
</table>

Note. NS=Nonstutterers, SO=Stutterers-Only, SP=Stutterers-Plus.

Interactions

A significant group by task interaction was present only after the data were divided into nonstutterer, stutterer-only, and stutterer-plus groups, $F(4) = 7.89, p < .05$. Figure 3 depicts that interaction. As can be seen, the mean reaction times of the nonstuttering group were similar for the short and long meaningful utterances but slower for the long nonse utterance. The mean difference between the short and long meaningful utterances was less than nine milliseconds. The mean reaction times of the stuttering-only group were similar, within 7 milliseconds of each other, for all three response conditions. And finally, the stuttering-
plus group's mean reaction times were faster for the short meaningful utterance but similarly slower for both the long meaningful and nonse utterances. The mean difference between the two long utterances was less than 9 milliseconds.

FIGURE 3
GROUP BY TASK INTERACTION

Note. NS=Nonstutterers, SO=Stutterers-Only, SP=Stutterers-Plus
DISCUSSION

The discussion will focus initially on those findings that address the research questions that were posed for this study. The remainder of the discussion will compare selected findings from the present study with those of other pertinent studies.

The Effect of Utterance Length on Reaction Times

The results of this study indicate that both stuttering and nonstuttering children are significantly slower to respond when producing longer rather than shorter utterances. This finding is consistent with those of Peters et al. (1989) and Dembowski and Watson (1991) with adults. Dembowski and Watson found that both stutterers and nonstutterers have slower reaction times for two-syllable than for one-syllable utterances, but this difference was statistically significant only for the nonstuttering group.

Peters et al. (1989) hypothesized that increasing the length of an utterance increases its motoric complexity and that increases in reaction time reflect the additional time needed to program and execute the motor event. If correct, both the long meaningful and nonse utterances involved greater motoric complexity than the short meaningful utterance which could account for the slower reaction times found for both stutterers and nonstutterers in the present study.

When the stuttering children were regrouped into stuttering-only and stuttering-plus groups, the interaction between the three
response tasks and groups (Figure 3) indicates that the stuttering-plus group was the group that was most affected by length. In contrast, the stuttering-only group seemed little affected by utterance length with mean speech reaction times that were highly similar across all tasks. This group's fastest mean reaction time was nearly 15 milliseconds longer than the nonstuttering group's slowest mean reaction time, and its slowest mean reaction time was about 10 milliseconds shorter than the stuttering-plus group's fastest mean reaction time. There was substantial overlap in the range of reaction times in these comparisons and neither difference was statistically significant. Although utterance length may have affected the speech initiation times of the nonstuttering group, another factor also appeared to be involved which will be discussed in the next section.

**Effect of Utterance Meaningfulness on Reaction Times**

The comparison between the long meaningful and the nonse utterances, each of which was 4 syllables long, directly assesses the effect of utterance meaningfulness on the speech initiation times of stuttering and nonstuttering children. The 18 millisecond difference between the two groups was not statistically significant. There was, however, a statistically significant increase in reaction time across all subjects between the short meaningful utterance and the long nonse utterance. It could be argued that this difference is present solely because of the increase in utterance length and the presumed increase in motoric complexity. The increases in
subjects' reaction times are assumed to result from the additional time that was needed for processing and executing a more motorically complex response. Although there was a somewhat smaller mean difference between the reaction times of the short meaningful and the long meaningful responses, this difference was not statistically significant. Therefore, it is plausible that the lack of meaning of the nonse response was combined with the increased motoric complexity that is associated with its increased length to produce longer reaction times. The combination of increased utterance length and reduced meaning appears to have affected the nonstuttering group's reaction times much more than the similarly long, meaningful response. The interaction depicted in Figure 3 shows that the speech initiation times of the nonstuttering group were substantially faster for both the short and long meaningful utterances than for the long nonse utterance. The stuttering-plus group, on the other hand, which had slower reaction times for all three types of utterances, evidenced dramatically longer times (>80 ms.) for both the long meaningful and nonse responses.

Some of these differences in the reactions of the three groups to the three tasks may be accounted for, in part, as follows. The speech initiation processes of nonstuttering children are little affected by the length of an utterance as long as it is familiar and meaningful to them. But when a longer utterance lacks meaning, and perhaps has never been heard or said before, motor processing is slowed to permit time for programming this novel, nonmeaningful
response. The stuttering-plus group was affected most by the length of an utterance, regardless of its meaningfulness. Perhaps the motoric complexity of an utterance places greater demands on limited motor processing capacities of this group. Reducing the meaning of an utterance may have contributed slightly to this effect perhaps by increasing the programming execution demands for a group whose motor processing capacities may be more limited than those of the other two groups.

At this point, there is no readily apparent explanation for the results of the stuttering-only children. Although the mean reaction times of these children were longer than those of nonstutterers and shorter than those of the stuttering-plus group, these differences did not achieve statistical significance. Furthermore, their reaction times for these three tasks differed little (<6 ms.) from one task to the other. Therefore, neither length nor utterance meaningfulness affected this group's reaction times. Based on the findings of this study, it is tempting to speculate that the motor programming systems of the stuttering-only group may be more similar to those of the nonstuttering group and that these children, who stutter-only, may evidence a higher remission rate.

Comparisons of These Findings with Other Studies

Overall, the results of this study indicate that stuttering children are slower than nonstutterers when initiating speech in response to a visual cue. This is consistent with the findings of most studies comparing the speech initiation times of stuttering
and nonstuttering children and adults. The mean speech initiation
times of the stuttering and nonstuttering children in this study
ranged from approximately 50 milliseconds slower (Till et al. 1983)
to 100-500 milliseconds faster (Cross & Luper, 1979; Cullinan &
Springer, 1980; and McKnight & Cullinan, 1987) than those reported
in previous studies. The standard deviations in the present study are
similar to those in the Till et al. (1983) study; however, other
studies with similarly aged children (Cross & Luper, 1979; Cullinan
& Springer, 1980; McKnight & Cullinan, 1987) reported standard
deviations that were approximately 100 milliseconds smaller.

The age range of the children in the present study was similar
to that of children who have participated in previous studies (Cross
& Luper, 1979; Cullinan & Springer, 1980; McKnight & Cullinan,
1987). Therefore, age would not account for the differences found
among the studies. Severity of stuttering ratings from the SSI were
not used to regroup the data for further analyses in the present
study because of the uneven distribution of ratings (14 mild and 4
moderate stutterers) and the relatively restricted range of severity.
None of the children's studies that were reviewed have examined the
relationship between speech reaction times and severity ratings.
Thus, the differences in speech reaction times among these studies
likely result from differences in the types of responses and
procedures employed and from the variability that characterizes
such responses across different samples of a population.
The pattern of results after the stuttering children were regrouped into stuttering-only and stuttering-plus groups is consistent with the findings of Cullinan & Springer (1980) and McKnight & Cullinan (1987). The stuttering-plus group was slower than the stuttering-only group which was slower than the nonstuttering group. The only statistically significant difference found was between the stuttering-plus and nonstuttering groups. It should be noted, however, that it is unlikely that the speech reaction times of the stuttering-only group are comparable to either of the other two groups. As was reported earlier, accepting the hypothesis of no difference in the mean reaction times of the stuttering-plus and stuttering-only groups and the stuttering-only and nonstuttering groups has a high probability of being incorrect (.85 and .66, respectively). This finding suggests that there may be a difference in speech initiation time among all three groups but that the power of this study's t-test was not strong enough to detect it.

Cullinan & Springer (1980) hypothesized that the slower performance of the entire stuttering group appeared to be related to the high incidence of other speech or language problems in this population. McKnight & Cullinan (1987) stressed that such differences demonstrate the importance of subgrouping stuttering children when comparing them with nonstuttering children. Recently, Watson et al. (1991) subgrouped stuttering adults into linguistically-impaired stutterers and linguistically normal stutterers, before comparing them with linguistically normal
nonstutterers in a speech reaction time paradigm. The three response tasks included a simple "nonlinguistic" response, /a/, a simple linguistic response, "Oscar", and a linguistically complex response, "Oscar took Pete's cat". It was found that all three groups evidenced longer reaction times for the two linguistic responses but that the magnitude of the increase was greater for the linguistically-impaired stutterers. A significant difference was also found between nonstuttering controls and linguistically-impaired stutterers for both word and sentence reaction times, but no other between group differences were significant. These results are similar to those of the present study which found significant differences between the nonstuttering and stuttering-plus groups but no difference between the stuttering-plus and stuttering-only groups. This suggests that it may be important to consider subgrouping adult stutterers in the same way that has been proposed for subgrouping stuttering children when comparing them to nonstutterers. The response tasks in the Watson et al. (1991) study increased utterance length together with linguistic complexity and did not control for either of these factors. Thus it is not possible to determine if the length of a response, its linguistic complexity, or a combination of the two is responsible for the increases in reaction times that were reported. In contrast, in the present study, the lengths of the nonse and the long meaningful utterances were the same, and it was found that the length and meaningfulness of a
response apparently place different demands on the motor processing capacities of the three groups.

The results of this study could be applied to the "Demands and Capacities" (DC) model (Adams, 1990). Adams stated that "fluency breaks down when environmental and/or self-imposed demands exceed the speaker's cognitive, linguistic, motoric and/or emotional capacities for responding" (page 136). Perhaps, in the present study, the environmental demands (the use of utterances of different lengths and meaningfulness and the instructions of the examiner to respond as quickly as possible) and self-imposed demands (subjects' responses to these environmental demands, e.g. increased attention, motivation, and/or apprehension) resulted in reaction times that may have reflected differences in the children's capacities among the three groups. If so, either the self-imposed demands were greater for the stuttering-plus group than for the stuttering-only group, or the capacities of the stuttering-plus group were lower, or perhaps, there was an interaction of both factors.
CONCLUSIONS AND IMPLICATIONS

This study found that children who stutter are slower than children who do not stutter when responding verbally to an external stimulus. The conclusions that can be drawn from this study include:

1) Length of utterance contributes to slower speech reaction times for both stuttering and nonstuttering children;
2) The lack of meaning, singly or in combination with increased utterance length, contributes to slower verbal reaction times for some stuttering and nonstuttering children;
3) The verbal reaction times of nonstuttering, stuttering-only, and stuttering-plus children are affected differently by utterance length and meaning. This suggests that these three groups may also process and execute speech motor events for verbal responses differently. Consequently, it is important to emphasize the need for subgrouping stuttering children when comparing them with nonstuttering children.

LIMITATIONS OF THIS STUDY AND IMPLICATIONS FOR FURTHER RESEARCH

One limitation of this study was the limited range in severity among the stuttering subjects which eliminated the possibility of analyzing the data in terms of stuttering severity. Another possible
limitation was that the number of trials in each condition may have been so numerous that the attention of many of the young children in this study lagged. It should be noted, however, that the subjects' speech response times across trials was displayed and no practice or fatigue effects were apparent. In addition, the elimination of these outlying, slower responses (> +2.575 SD) ensured that the responses that were retained included the subjects' best and average response times, even if their attention may have lagged.

Future research should study the effect of longer and shorter responses that vary in meaning on the reaction times of stuttering and nonstuttering children. Moreover, such research should include nonstuttering children with speech, language or learning problems in addition to groups of nonstuttering, stuttering-only, stuttering-plus children. It would also be of interest to follow the stuttering children in these studies for a number of years in order to determine if speech reaction time may be related to persistence or remission of stuttering.
APPENDIX A

PARENT/GUARDIAN LETTER AND CONSENT FORM

PARENTAL COVER LETTER – TUCSON UNIFIED SCHOOL DISTRICT

FROM: WENDY S. MASKE, B.S.
GRADUATE STUDENT
DEPARTMENT OF SPEECH AND HEARING SCIENCES
UNIVERSITY OF ARIZONA

Dear Parents:

Over the next few months, I will be asking children in the Tucson Unified School District to help me with my Master's Thesis. This project will help us to gain information about the nature of stuttering in young children.

We do not yet know what causes children to stutter or why some children will stop stuttering and others do not.

However, by gathering as much information as we can on the different aspects of stuttering, we hope to soon discover the cause.

In my study I am questioning whether the speech reaction time of stuttering children is affected by the length and meaningfulness of the utterance. Most studies to date have focused on adults, but I am studying children to see if slow speech reaction times are characteristic of all stutterers, not just the fraction who continue to stutter as adults.

I need children to participate in my study as a member of either a stuttering or nonstuttering group. The nonstuttering group is needed so that we can compare their reaction times with those of the stuttering group.

Your child would be seen for two brief 20 minute sessions at his or her school. He will miss no important classroom activities or assignments. In the first session, I will ask your child to read aloud a passage or describe a picture to me (depending on your child's reading level), to confirm that he or she has been appropriately identified as a stutterer or a nonstutterer. I will next describe the experimental task to your child and allow him/her to practice.

During the second session (approximately a week later), after a brief practice period, I will record how quickly he or she says three phrases.

The experimental task consists of the child saying a word or a phrase as soon as a circle on a computer screen changes to a square. Your child will be told which word or phrase to say, and when the picture on the computer screen changes, he/she will be asked to say the word or words as soon as possible. Your child will be asked to say each response 20 times. These responses will be recorded and analyzed later.

Each session should require 20 minutes or less, with the first session possibly lasting a little longer than the second.

Before the first session, I will explain to your child what I will do, but I will not tell him that the "game" concerns stuttering. After the final session I will thank your child for playing my game and take him/her back to class.

In addition to the reaction time data I will be collecting at this time, I will also send a postcard each year for the next five years to parents of the stuttering children and ask if their child is still stuttering. I am hoping to be able to determine if the children's reaction times distinguish those who stop from those who continue to stutter.
Thank you for your time. If you have any questions please contact me at home. My phone number is 790-3437.

Sincerely,

Wendy S. Maske

A consent form is attached.

Please return the consent form in the addressed, stamped envelope provided.
UNIVERSITY OF ARIZONA
PARENT CONSENT FORM

Title of Project: The Effects of Utterance Length and Complexity on the Speech Initiation Time of Stuttering and Nonstuttering Children

Wendy S. Maske
Graduate Student
University of Arizona

Phone: 790-3437

YOU ARE BEING ASKED TO READ THE FOLLOWING MATERIAL TO ENSURE THAT YOU ARE INFORMED OF THE NATURE OF THIS RESEARCH STUDY AND OF HOW YOUR CHILD WILL PARTICIPATE IN IT, IF YOU CONSENT TO LET HIM/HER. SIGNING THIS FORM WILL INDICATE THAT YOU HAVE BEEN SO INFORMED AND THAT YOU GIVE YOUR CONSENT. FEDERAL REGULATIONS REQUIRE WRITTEN INFORMED CONSENT PRIOR TO PARTICIPATION IN THIS RESEARCH STUDY SO THAT YOU KNOW THE NATURE AND THE RISKS OF YOUR CHILD'S PARTICIPATION AND CAN DECIDE TO ALLOW YOUR CHILD TO PARTICIPATE OR NOT PARTICIPATE IN A FREE AND INFORMED MANNER.

I, ________________________, hereby agree to allow my child, (your name, please print)

_________________________, to participate as a volunteer in the above (your child's name, please print) named research project, which has been fully explained to me.

IN GIVING MY CONSENT BY SIGNING THIS FORM, I AGREE THAT THE METHODS, INCONVENIENCES, RISKS, AND BENEFITS HAVE BEEN EXPLAINED TO ME AND MY QUESTIONS HAVE BEEN ANSWERED. I UNDERSTAND THAT I OR MY CHILD MAY ASK QUESTIONS AT ANY TIME AND THAT MY CHILD IS FREE TO WITHDRAW FROM THE PROJECT AT ANY TIME WITHOUT CAUSING BAD FEELINGS OR AFFECTING HIS/HER MEDICAL CARE. MY CHILD'S PARTICIPATION IN THIS PROJECT MAY BE ENDED BY THE INVESTIGATOR OR BY THE SPONSOR FOR REASONS THAT WOULD BE EXPLAINED. NEW INFORMATION DEVELOPED DURING THE COURSE OF THIS STUDY WHICH MAY AFFECT MY CHILD'S WILLINGNESS TO CONTINUE IN THIS RESEARCH PROJECT WILL BE GIVEN TO ME AS IT BECOMES AVAILABLE. I UNDERSTAND THAT THIS CONSENT FORM WILL BE FILED IN AN AREA DESIGNATED BY THE HUMAN SUBJECTS COMMITTEE WITH ACCESS RESTRICTED TO THE PRINCIPAL INVESTIGATOR, WENDY MASKE, OR AUTHORIZED REPRESENTATIVE OF THE SPEECH AND HEARING DEPARTMENT. I UNDERSTAND THAT NEITHER MY CHILD OR I WILL GIVE UP ANY OF OUR LEGAL RIGHTS BY SIGNING THIS FORM. A COPY OF THIS SIGNED CONSENT FORM WILL BE GIVEN TO ME.

_________________________ ____________________________
DATE PARENT/LEGAL GUARDIAN
Investigator's Affidavit

I have carefully explained to the subject's parent or legal guardian the nature of the above project. I hereby certify that to the best of my knowledge the person who is signing this consent form understands clearly the nature, demands, benefits, and risks involved in his/her child's participation, and his/her signature is legally valid. A medical problem or language or educational barrier has not precluded this understanding.

Signature of Investigator       Date
APPENDIX B
SUBJECT CONSENT FORM

Title of Project: The Effects of Utterance Length and Complexity on the Speech Initiation Time of Stuttering and Nonstuttering Children

Wendy S. Maske
Graduate Student
University of Arizona

Phone: 790-3437

I, ______________________, hereby agree to participate as a
(subject's name)

volunteer in the above named research project, which has been fully explained to me.

I understand that I am free to refuse to participate in any procedure or refuse to answer any question at any time. I also understand that I am free to withdraw my consent and to withdraw from the research project at any time.

I understand that by agreeing to participate in this research and signing this form I do not waive any of my legal rights.

_________________________ __________________________
Date Subject Signature

Subject agreement to participated
APPENDIX C
SPEECH-LANGUAGE PATHOLOGIST QUESTIONNAIRE
FOR STUTTERING SUBJECTS

Articulation
Has the child been identified with an articulation problem?
   Yes/No
Is the child receiving services for an articulation problem?
   Yes/No
What sounds are being targeted?

Language
Has the child been identified as being language impaired?
   Yes/No
Is the child receiving services for a language impairment?
   Yes/No
What is the nature of the problem?

Learning Disability
Has the child been identified as having a learning disability?
   Yes/No
Is the child receiving services for a learning disability?
   Yes/No
What is the nature of the problem?

Voice
Has the child been identified with a voice disorder?
   Yes/No
Is the child receiving services for a voice disorder?
   Yes/No
What is the nature of the voice disorder?

Other (Emotionally Handicapped, etc.)
Has the child been identified with any other problem not previously listed?
   Yes/No
Is the child receiving services for this problem? Yes/No
What is the nature of this problem?
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<th>1</th>
<th>1</th>
<th>SUBJECT</th>
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<th>2</th>
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<td>TASK</td>
<td>0</td>
<td>1</td>
<td>2</td>
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<tr>
<td>C.P.</td>
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Note. Subjects #1-18 = stutterers, Subjects #19-36 = nonstutterers; Task: 0 = short, 1 = long, 2 = nonse; SSI Rating: 0 = none, 1 = mild, 2 = moderate, 3 = severe; C.P. (concomitant problems): 0 = no, 1 = yes
### APPENDIX E

**EACH SUBJECT'S MEAN REACTION TIMES FOR EACH TASK**

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APPENDIX F
RESULTS OF THE ANOVA BEFORE REMOVAL OF THE OUTLIERS

The main effect for group was significant, $F(1,34) = 4.50$, $p < .05$, with the stuttering group being slower than the nonstuttering group. The main effect for task was not significant, $F(2, 68) = 1.26$, $p > .05$. The means and standard deviations of the reaction times for the groups collapsed across tasks and the tasks across groups are as follows:

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