

THE EFFECTS OF TASK PREFERENCE ON SPEECH AND MOTOR  
PERFORMANCE UNDER DIVIDED ATTENTION CONDITIONS

by

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## ABSTRACT

### THE EFFECTS OF TASK PREFERENCE ON SPEECH AND MOTOR PERFORMANCE UNDER DIVIDED ATTENTION CONDITIONS

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#### Abstract

Dual task performance and the interaction of tasks has been the subject of much research. When tasks are performed together they affect each other to varying degrees depending upon such factors as the similarity of the tasks, their difficulty, and whether one task is given preference over another. In this study, task preference was investigated under divided attention conditions in order to determine what effect preference had on task performance. Twenty young adults took part in this study and were randomly assigned into two groups. Each group was experimentally motivated to favor one of the two tasks – either speaking a “tongue-twister” or tracking a moving target on a screen with a computer mouse. Each participant performed the tasks in both an isolated and combined conditions. The measurements of task performance (tracking scores, utterance duration, lower lip and jaw displacement, lower lip and jaw velocity, upper lip-lower lip

correlation, spatiotemporal index, and sound pressure level) were then analyzed to determine how task preference affected the participant's performance. It was expected that the preferred task's performance would not suffer when performed in the dual task situation. Although some trends were noted in the predicted direction, no statistically significant results were found as a function of task preference. There were, however, some gender effects. Men were found to have significantly higher intensity than women during the speaking tasks in both the dual and isolated task conditions, and they were also found to perform better than women on the motor tracking task in both the dual and isolated task conditions.

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## Introduction

Speech is the main form of communication for most people, but it is not always done alone; speaking is often accompanied by day-to-day tasks as well. These tasks could include driving while talking on the phone or doing homework and watching television. Divided attention occurs when an individual is concentrating on two tasks at the same time. When speech tasks are involved, it is important to understand divided attention and that it may differ in normal and disordered speakers. Knowledge of these differences may allow clinicians to better adapt their therapy to a client's needs, thus making it more effective.

In general, when two tasks are performed simultaneously, they may *interfere* with each other (Norman & Bobrow, 1975). When a person is performing a task to the best of their ability and a second task is initiated, the individual's attention is reallocated, leaving fewer resources available to perform the initial task resulting in a decrease in its performance. The interference between two concurrently performed tasks influences how effectively individuals are able to perform each task.

When speech has been studied in the context of dual task performance, a variety of speech tasks have been employed. Participants have been asked to repeat short stories as accurately as possible, either verbally or silently, while tapping their finger (Seth-Smith, Ashton, & McFarland, 1989). Others have been asked to repeat monosyllabic stimuli while tapping their fingers in a cyclic manner (Chang & Hammond, 1987) or to *sound-shadow* words that were presented to them (Carnahan, Elliott, & Lee, 1986; Elliot, Weeks, Lindley, & Jones, 1986; Klapp, Porter-Graham, & Hoifjeld, 1991). Sound-shadowing involves repeating the stimulus words that the participants hear or see. Some studies required participants to sound-shadow words while they were simultaneously required to provide a certain amount of force to a foot-pedal or by squeezing on a ball. The participants knew they

were providing the right amount of force because of continuous feedback from a light source that would be illuminated when they were doing the task appropriately (Carnahan et al., 1986; Elliot et al., 1986). These tasks were selected to reveal interactions between the two activities.

The analysis performed on the data collected has differed across experiments. The tasks that Carnahan et al. (1986) and Elliot et al. (1986) used involved very crude measures of speech, namely counting the number of misarticulations or omissions. These measures only enabled Carnahan et al. (1986) and Elliot et al. (1986) to evaluate the effects that simultaneous manual motor movements had on speech at a very basic level. On the basis of this superficial analysis these researchers were not able to conclude that the hand movements had a significant impact on speech. Greater precision was applied to the analysis of the motor tasks when Carnahan et al. (1986) and Elliot et al. (1986) calculated the proportion of time during which the pressure applied to the foot pedal was on target. It was discovered that there were more errors in pressure maintenance when the participants were simultaneously speaking. With these results the researchers were able to conclude that limb motor movements were affected by speech, but not the other way around (Carnahan et al., 1986; Elliot et al., 1986). If these researchers had made more precise measures of speech, they might have found more subtle evidence of interference

#### *Bidirectional Influences in Dual Task Situations*

Bidirectional influences arise when tasks that are being simultaneously performed have an effect on each other; the speech task causes the motor task to be performed differently than in the isolated condition and the motor task causes the speech task to change. Smith, McFarland, and Weber (1986) discovered a bidirectional effect of rate when a monosyllabic word was repeated at the same time that the participants were tapping a finger.

During dual task performance the participants modified their rate of performance. The participants did not make their finger-tapping fit their speech rate or vice versa; instead, when the two tasks were performed simultaneously, their rates were averaged together to get a new rate for this dual task situation. This indicates that neither task was dominant, and thus both tasks were modified. Klapp et al. (1991) had their participants draw circles within certain boundaries while sound-shadowing numbers. The results of their study indicate that there was increased hesitation in both the drawing and the sound-shadowing when the tasks were performed simultaneously. In other words, there was mutual interference between these tasks.

Mutual interference was also found in a study by Chang and Hammond (1987). These researchers had their participants tap a finger while sound-shadowing the syllable /stak/. The participants were asked to repeat the syllable over and over while alternating a stressed and unstressed syllable. While the participants were completing this task, it was discovered that they were unable to keep the amplitude of their finger-tapping steady and instead varied the amplitude. Conversely, when the participants were asked to vary the amplitude of the finger-tapping, but to pronounce the string of syllables with constant stress, they were unable to keep the stress constant. When finger-tapping was performed concurrently with the speech task, there was more variability in the rate of speech and finger-tapping than when the tasks were performed individually. Through these studies it is apparent that there is mutual interference when tasks are performed simultaneously.

#### *Theories of Dual Task Performance*

As a result of the research on concurrent task performance, several theories have been developed. These theories try to account for what the researchers observe as participants perform tasks simultaneously. There are three main types of theory: neurological, bottleneck,

and capacity theories. The neurological theories include the functional distance hypothesis which takes into account cortical mapping research documenting that certain tasks are regulated by particular areas of the brain (Kinsbourne & Hicks, 1978). The functional distance hypothesis predicts that the interference from dual task performance decreases as the functional locations of the two tasks in the brain grow more distant.

The bottleneck theories have been founded on data from reaction time experiments. In these paradigms, participants are presented with two tasks in quick succession and reaction time is evaluated. Reaction time has been found to be directly related to cognitive processing. It has been determined that the reaction time for the second task is significantly longer than the first. This is because of the response selection phase in the reaction time process (Pashler & Johnson, 1998). The response selection phase is the interval during which the participant chooses the appropriate motor behaviors given their situation and their goals (Schumacher, Elston, & D'Esposito, 2003). It is hypothesized that the response selection phase is responsible for adding to the participant's overall reaction time because there is only a single pathway for the response selection process to follow; the participants were currently processing the first task when the second task was initiated. Consequently, there were insufficient resources to process the second task as quickly as when it was performed alone.

The idea that the brain is composed of a pool of finite resources stems from the single processor hypothesis of the capacity theory on divided attention (Allport, Antonis, & Reynolds, 1972). These resources are accessed as the brain is required to perform different tasks. This hypothesis suggests that as more demands are placed upon the system, more resources are used. The resources are divided among the different tasks based upon complexity; the more complex the task, the more resources are used. This system works very

well for task performance until the system has used all of its available resources. Once the system has reached capacity, the performance of the tasks decreases. After the capacity is reached, the person performing the tasks must decide which of the tasks they are more motivated to perform. Once that is decided, they begin to give preference to one task over the other (Kahneman, 1973).

Continued research based on the capacity theory led to a new theoretical model: the multi-channel hypothesis (Allport et al., 1972). In Allport et al.'s study two separate experiments were performed. In the first experiment, participants sound-shadowed a passage that was presented to them from an audio recording. While the participants were sound-shadowing the passage, they were asked to memorize a list of 15 items presented. These items were presented in three different ways: in writing, as a recorded voice, and through pictures. The performance of the recorded and visually presented word lists decreased dramatically when presented with the sound-shadowing task. However, the items that were presented through pictures were remembered just as well in the isolated and dual task conditions. These results indicated that when tasks are similar in nature they interfere more with each other. The second experiment supported this notion. In this experiment, participants were asked to sight-read piano music and sound-shadow a recorded passage. These tasks were completed simultaneously with little loss of efficiency in either task.

On the basis of these results, Allport et al. (1972) suggested the multi-channel hypothesis to add to the capacity theories. This hypothesis proposes that there are a number of independent, parallel channels that the brain uses when processing task demands. When performing complex tasks, the brain breaks them down, and different specialized processors work together to complete the task. Two similar tasks being performed together will require

the same specialized processor, which causes interference, and thus the tasks cannot be effectively completed at the same time. However, if two other tasks are being completed at the same time and do not require any of the same channels, they can be accomplished with little or no interference.

The multi-channel hypothesis opened a new avenue of research that explored task preference and task motivation. Concurrent task performance requires the participant to be working under the conditions of divided attention. Task preference has an impact on the performance of each task (Gopher, Brickner, & Navon, 1982). This is the case only when the two tasks being performed compete for the available resources in the brain. In the Gopher et al. study participants were asked to track a target on the computer with a mouse and simultaneously type Hebrew letters that each required two key strokes. The typing task had three different levels of difficulty (easy, medium, and difficult). A decrease in the performance of both tasks when performed concurrently showed that these two tasks were competing for available resources. The researchers motivated participants to prefer one task over the other by promising monetary rewards for good performance. Gopher et al. (1982) hypothesized that the more difficult the task, the greater the detrimental effect would be on the other task. The results of their study supported this hypothesis.

#### *Task Motivation*

Motivation is a key factor in studies of task preference and interference in concurrent performance. Some researchers have used different instructions to encourage their participants to prefer one task over the other (Hiscock, Cheeseman, & Inch, 1989, Marincola & Long, 1985). In these studies the instructions were the only motivation for the participant to give preference to a particular task. Other studies have relied on rewards to motivate the participants to put more effort into the task the researcher selected (Erez, 1977; Waersted,

Bjorklund, & Westgaard, 1994). Monetary rewards have been the most popular incentive in this type of research (Freidman, Polsun, & Dafoe, 1988, Friedman, Polsun, Dafoe, and Gaskill, 1982, Gopher et al., 1982). Friedman et al. (1982) used a simple system in which the participants were given 8 cents per correct trial of the preferred task and 2 cents for every correct trial of the other task. This simple method allowed the participants to be informed between trials how well they were doing, allowing them to monitor their own progress. It was noted that when participants were allowed to monitor their own progress throughout the experiment, they were able to make self-corrections, thus improving performance.

#### *Studies Conducted at BYU*

Previous investigations at Brigham Young University have focused on several aspects of divided attention. Dromey and Benson (2003) reported an increase in speech movement variability when speech was being performed in a concurrent task situation. The cognitive, language, and visuomotor tasks were not measured, but instead were used as distractor tasks in order to learn whether these tasks influenced speech performance. A subsequent study by Dromey and Bates (2005) investigated the bidirectional effects of speech and the concurrently performed tasks. Dromey and Bates (2005) had their participants perform linguistic, cognitive, and visuomotor tasks, in isolated and concurrent conditions, and found support for the hypothesis that when enough demands are placed on a system, less attention is available for each activity, resulting in decreased performance. The lower lip and jaw movements they measured decreased in displacement and velocity for the combined tasks. Spatiotemporal index (STI) and sound pressure level (SPL) measurements increased when the tasks were performed in a concurrent manner. The STI calculation allows for the analysis of the consistency of speech movements over multiple repetitions. In this study, however, speech was not the only task affected when it was performed concurrently with another

activity. When the linguistic (constructing sentences) or cognitive (two-digit subtraction) tasks were performed concurrently with speech, the latencies and errors increased when compared to the isolated task condition.

Hamblin (2005) built upon these previous studies by examining performance asymmetries in right and left handed manual motor tasks versus speech and language tasks that challenged one hemisphere more than the other. She hypothesized that right hand performance would interfere more with speech and language activity because of the left hemisphere processing for both activities. Hamblin (2005) did not find that the data supported this hypothesis, but made other observations that contributed to the research in this area. It was observed that there was decreased velocity and displacement, and increased spatiotemporal index (STI) when speech was performed with the motor task. Interestingly, the motor task score also decreased when performed with the language task. The manual motor task required the participants to place washers and pegs in a peg board as quickly as possible. This study revealed that the functional distance hypothesis cannot fully account for performance during divided attention tasks. Although the right versus left hand tasks were shown to have some effect on the performance of dual tasks, this variable did not account for all of the observed task interference. Taken together, these studies have used specific and precise measures of speech, language, cognitive, and motor tasks, which have shown how the different tasks affect each other when performed concurrently. Although these studies have built a good foundation in divided attention research, the issue of task preference has not yet been studied. Task preference is an important concept in divided attention situations that can affect the outcome of a study. To consider task preference, the researcher must find a way to

motivate the participants into putting more effort into performing one task versus another task. This control allows task preference to be used as an independent variable.

The purpose of the present study was to incorporate the variable of task preference into the dual task performance paradigm to see what effect it would have on the performance of each task. In the present study, two different, randomly assigned groups participated; each group was assigned to give preference to one of the two tasks. The random assignment of participants to different groups helped to avoid confounding the results of the study, as each participant was not asked to prefer both tasks at different times during the experiment. To narrow the scope of the experiment to focus on task preference, this study examined the interference between visuomotor and speech tasks. It was hypothesized that the task that is given preference through promised rewards will be the task that is performed superiorly; the other task's performance scores would be predicted to diminish.

## Method

### *Participants*

Twenty young adults participated in this study, 10 males and 10 females. The males and females were randomly assigned into two groups with five males and five females in each. All participants were native English speakers who had no history of speech, language, or hearing problems. Each participant took part in a hearing screening and passed at 15 dB HL at 500, 1000, 2000, and 4000 Hz. Each participant signed a written consent form approved by the Brigham Young University IRB.

### *Instrumentation*

Each participant was comfortably seated in a single-walled sound booth to obtain acoustically optimal recordings. A head mounted strain gauge system was used to measure the participant's lip and jaw movements (Barlow, Cole, & Abbs, 1983). Cantilever beams were attached using double-sided tape next to the midpoint of the vermillion border of the upper and lower lips as well as to the skin under the chin. These three kinematic signals were digitized using a Windaq 720 (DATAQ Instruments) analog/digital converter at 1 kHz. A sound level meter (Larson Davis model 712) was placed 1 m in front of the participant to measure vocal intensity. A microphone was attached to the strain gauge system in order to record the participant's speech. The participant's speech was digitized at 25 kHz after being low-pass filtered (Frequency Devices 9002) at 12 kHz. A computer monitor and mouse were used for the visuomotor task. Each participant used the mouse to click on the randomly moving target that traveled across the computer screen.

### *Speech motor task*

Each participant was asked to repeat the utterance "Peter Piper picked a peck of pickled peppers." This utterance was chosen because of the high incidence of bilabials

(which helps with kinematic segmentation), and because it was a moderately challenging utterance to repeat. The participant was asked to repeat the utterance after hearing a beep. There were 15 instances of beeps where the participant had to repeat the utterance. Lip and jaw movements were recorded under each condition that involved speaking the target phrase.

#### *Visuomotor task*

This task involved clicking on a randomly moving target with a computer mouse. The participant was instructed to click on the moving object as often as possible during a two minute trial. The 15 utterances spoken after a beep were randomly spaced throughout the two minute trial in both the isolated and dual conditions.

#### *Procedures*

Each participant came to the lab the day before the experimental session to practice the different tasks and become familiar with the instrumentation that would be used in the study. This was done in order to minimize the effects of a learning curve as the participant took part in the study. When a participant came in on the day of the study, they were allowed to re-familiarize themselves with the tasks at hand before beginning the experimental work.

Each participant was required to perform both isolated and dual tasks. The order of the tasks was fully randomized because the participant was already familiar with the tasks being administered. The two groups of participants were given different tasks to prefer; they were experimentally motivated to perform better on one task than the other. The participant was informed that they would receive monetary compensation based on their performance of the tasks in the dual task situations. When the participant was asked to prefer the speech task they were informed that they would be paid 50 cents for every utterance they completed without any perceptual errors in articulation or prosody and 5 cents for every time they clicked on the target. When the participant was asked to prefer the visuomotor task, they

were informed that they would receive 10 cents every time they clicked on the target and 5 cents for every utterance that was performed without perceptual errors. Each participant was informed of which task to give preference to, based on the instructions given to them before the experiment was performed. The participant's speech was recorded during all trials.

### *Data Analysis*

Measures of performance were made for each task in the isolated as well as the dual task condition. Windaq lip and jaw recordings were exported as binary files and analyzed with custom Matlab applications. The kinematic signals were low pass filtered at 10 Hz in Matlab prior to the analysis. A computer monitor was used to display the three movement channels in order to segment the phrases and make semi-automated measures of the dependent variables. The audio signal served as a guide and was not analyzed acoustically. The movement measures that were analyzed are discussed below. The lower lip signal represents the combined lower lip and jaw signal; the two were not decoupled. Kinematic analysis was completed on 10 repetitions of "Peter Piper picked a peck of pickled peppers." These were the final 10 out of the 15 phrases produced.

*Utterance Duration.* This measure was made in order to determine the rate of speech production for each participant under the different experimental conditions. It was also used to determine whether having the participant perform concurrent tasks would influence their rate of speech production. This measure was obtained by taking the time between the peak velocity for the first opening movement (release of /p/ in the word *Peter*) and the peak velocity of the last closing movement (closure of the last /p/ in *peppers*, Figure 1).

*Displacement and Velocity.* The displacement of the combined lower lip and jaw signal was measured during the closing movement from /aI/ to /p/ in *piper*. The velocity of this movement was calculated using a two-point difference method. The displacement and

velocity were measured to evaluate the effect of dual task performance on the amplitude of the selected articulatory gesture. Point measures have been used in previous kinematic studies to examine the impact of vocal effort (Dromey, 2000), rate (Dromey & Ramig, 1998a, Figure 2), and inspiratory level (Dromey & Ramig, 1998b).

*Spatiotemporal Index for the Lower Lip-Plus Jaw.* The STI is a motor measurement that is used to calculate the consistency of speech movements across repetitions. It has been used in many recent studies to evaluate the consistency of speech production (Dromey & Bates, 2003; Dromey and Benson, 2003; Smith et al., 1995). For this measure the entire utterance is used, the same segmentation as the duration measure. Each participant's utterances were normalized for time and amplitude (Figure 3). Fourier analysis and re-synthesis were used to compute a linear interpolation for time normalization. Amplitude was normalized by subtracting the mean and dividing by the standard deviation of each displacement. The normalizing of these utterances allows for statistical analysis of multiple productions using the same sample points (Smith et al., 1995). Fifty equally spaced points along the normalized waveforms were used. The standard deviations of displacement were calculated and summed to yield the STI. Previous studies have discovered a decrease in consistency when speech is produced concurrently with cognitive, motor, or linguistic tasks (Dromey and Bates, 2005; Dromey and Benson; 2003).

*Sound Pressure Level.* This measure was obtained by finding the mean sound pressure level between the start and end points for the utterance. These measures were obtained from the digitized signal from the sound level meter. It has been discovered in previous studies that there are changes in SPL in a dual task situation (Dromey and Bates, 2005). The vocal effort the speaker expends either increases or decreases as they perform

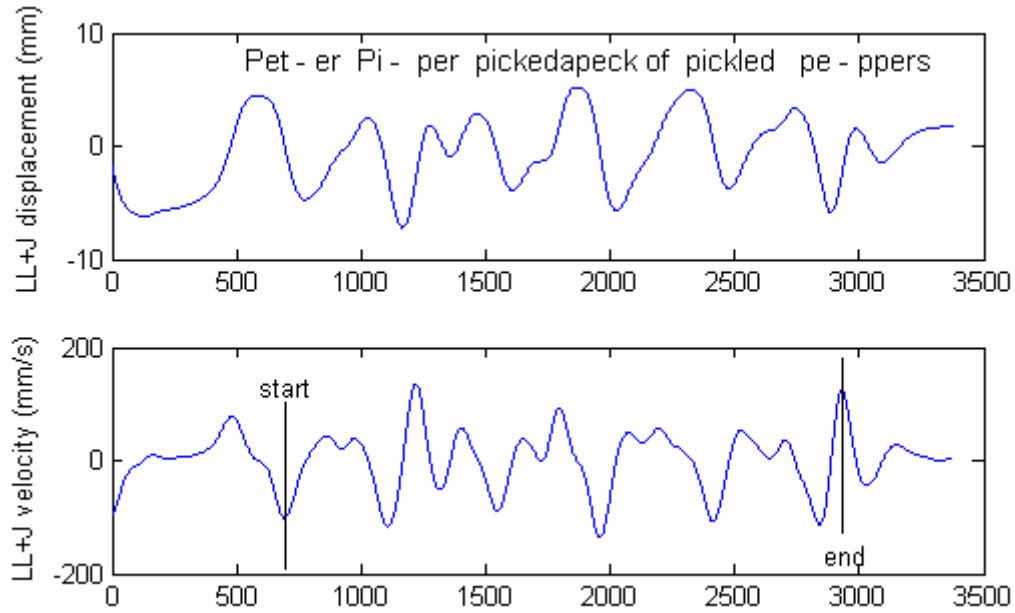
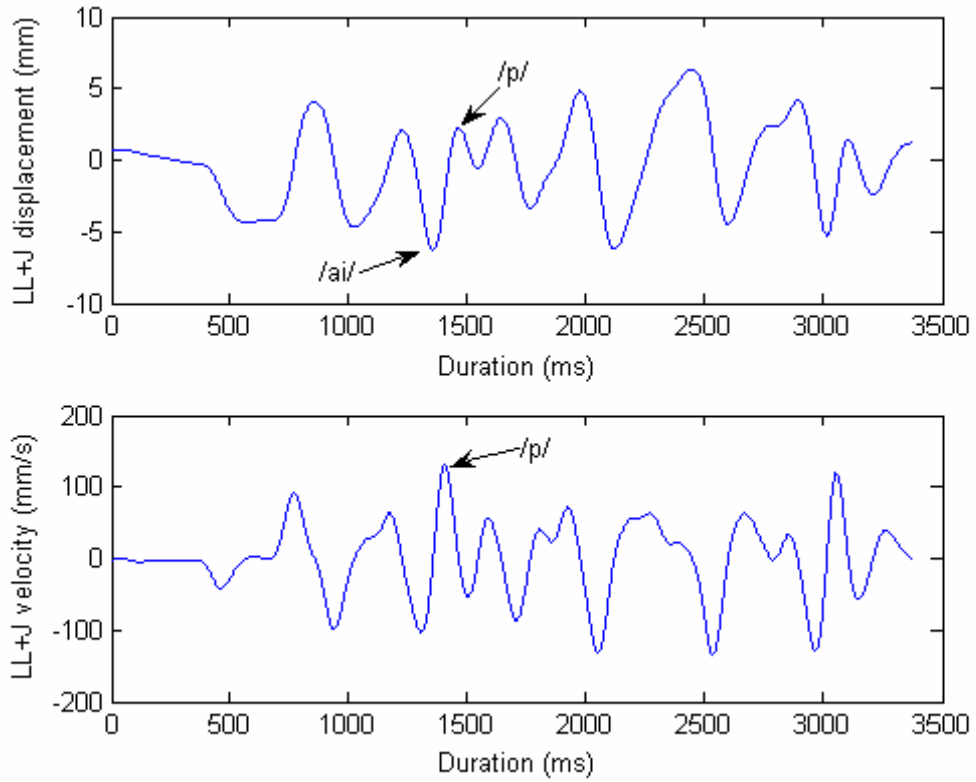
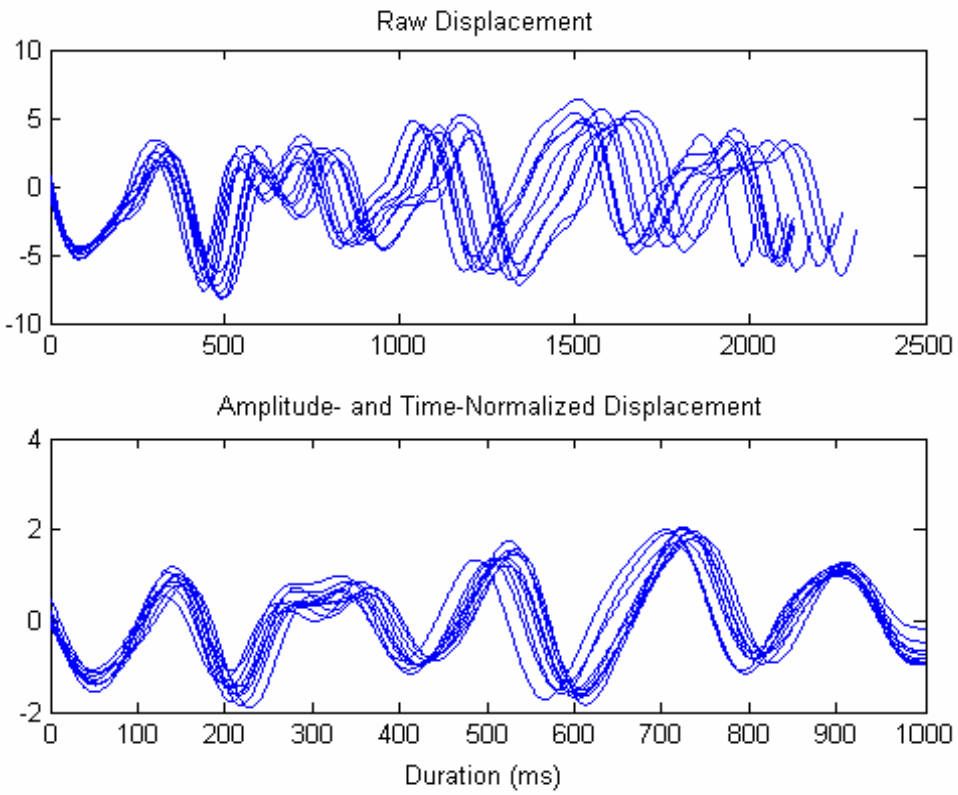


Figure 1. Displacement (upper pane) and velocity (lower pane) of the lower lip during one token of the target utterance. The kinematic record used for analysis was segmented from the peak velocity of the opening movement of /p/ in Peter to the peak closing velocity of the second /p/ in peppers.



*Figure 2.* Point measures for displacement (upper pane) from the /ai/ to the final /p/ in Piper, and peak velocity (lower pane) of the closing gesture of the final /p/ in Piper.



*Figure 3.* Displacement records (upper pane) of the lower lip and jaw for 10 repetitions of the speech task of one participant. The corresponding amplitude- and time-normalized displacement record (lower pane) for the same 10 repetitions.

concurrent tasks. SPL has been associated with changes in respiratory, laryngeal, and articulatory processes (Dromey & Ramig, 1998a; Dromey & Ramig, 1998b; Dromey, Ramig, & Johnson, 1995; Dromey, Stathopoulos, & Sapienza, 1992).

*Visuomotor.* Performance in the motor task was determined by the score the participant received. The participant was given 10 points every time they clicked on the target. The total score was then calculated as the sum of these points.

ANOVA procedures were used to analyze the dependent measures. The experimental conditions that the tasks were performed under (either isolated or dual) and the group the participant was assigned to were the main independent variables of this study.

## Results

The statistical analysis of the kinematic and sound pressure data involved a comparison of the performance by the speech emphasis and motor emphasis groups. Due to technical difficulties with the sound recordings, data on two subjects could not be included in the analysis. Therefore, the speech portion of the analysis included 18 participants. The means and standard deviations for the dependent variables for the two groups are found in Table 1. Table 2 presents the descriptive statistics for the kinematic and sound pressure measures for males and females. Results for the one way ANOVA for the males and females are reported in Table 3. There were no statistically significant differences on any of the measures between the motor emphasis and speech emphasis groups. Upon further examination of the data it was discovered that there were some gender effects. Only those results that were found to be statistically significant are summarized in the text below.

### *Motor*

When the motor task was performed in the dual task situation, the group that emphasized the motor task performed better than the group that emphasized speech (Figure 4). These results were not found to be significant, but the trend in the data supported the expectation that the preferred task would be performed better. There was, however, a significant difference between the men and women in how they performed the motor task both in the dual and isolated conditions. The men had a significantly higher score than the women. This gender effect was more prominent when the motor task was performed in isolation than when it was performed in the dual task condition.

Table 1

*Descriptive Statistics for the Manual Motor, Kinematic and Sound Pressure Measures in the Motor Emphasis and Speech Emphasis Groups in the Speech-only and Dual Conditions.*

Group	Motor Emphasis				Speech Emphasis			
Condition	Isolated		Dual		Isolated		Dual	
Variable	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Motor	1071.00	300.68	1146.00	307.54	1091.00	260.83	1003.00	285.89
Duration (ms)	1906.32	339.61	1802.38	347.39	1844.46	214.27	1912.73	291.73
LL + J Displacement (mm)	8.87	3.19	9.27	2.71	8.19	1.93	8.69	2.25
LL + J Velocity (mm/s)	150.22	49.18	163.13	42.09	145.34	34.06	149.22	33.68
Correlation	-0.86	0.09	-0.90	0.05	-0.78	0.17	-0.81	0.16
STI LL+J	18.29	8.77	21.13	8.16	16.87	4.75	18.15	6.09
dB SPL at 100 cm	69.45	2.71	70.45	4.02	67.41	3.16	68.93	3.61

*Note:* Duration = utterance duration; LL = lower lip; J = jaw; STI = spatiotemporal index

Table 2

*Descriptive Statistics for the Manual Motor, Kinematic and Sound Pressure Measures in the Speech-only and Dual conditions in the Male and Female Groups.*

Group	Female				Male			
Condition	Isolated		Dual		Isolated		Dual	
Variable	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Motor	911.00	189.24	912.00	148.83	1251.00	242.14	1237.00	326.87
Duration (ms)	1861.65	281.42	1868.22	341.42	1892.83	102.65	1844.23	304.58
LL + J Displacement (mm)	8.05	2.62	8.08	1.98	9.13	2.57	10.11	2.61
LL + J Velocity (mm/s)	140.44	48.52	142.01	37.45	156.95	30.11	173.89	31.59
Correlation	-0.79	0.21	-0.88	0.11	-0.87	0.04	-0.83	0.14
STI LL+J	18.53	6.59	20.13	7.01	16.40	7.49	19.02	7.76
dB SPL at 100 cm	66.38	3.83	67.97	2.46	69.89	2.94	72.38	1.95

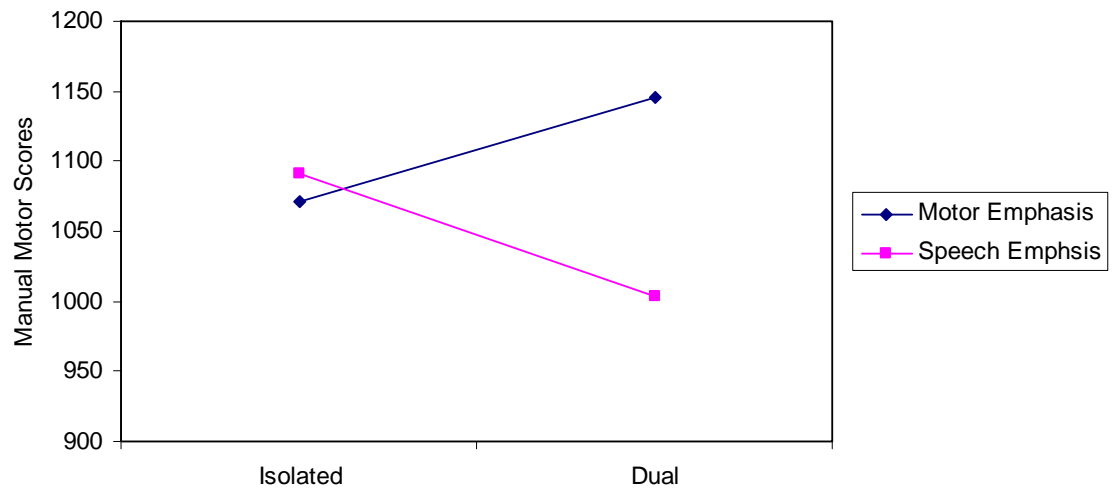
*Note:* Duration = utterance duration; LL = lower lip; J = jaw; STI = spatiotemporal index

Table 3

*One way ANOVA Comparing Male/Female Differences on the Manual Motor, Kinematic, and Sound Pressure Measures.*

Group	Isolated		Dual	
	F-ratio	P-value	F-Ratio	P-value
Motor	12.24	0.002**	8.19	0.01**
Duration (ms)	0.05	0.82	0.02	0.88
LL + J Displacement (mm)	0.77	0.39	3.51	0.08
LL + J Velocity (mm/s)	0.70	0.41	3.68	0.07
Correlation	0.01	0.91	0.81	0.38
STI LL+J	0.41	0.53	0.10	0.75
dB SPL at 100 cm	4.53	0.05*	17.11	0.0007**

*Note.* Degrees of freedom are 1,16 for the ANOVA. Duration = utterance duration; LL = lower lip; J = jaw; STI = spatiotemporal index\*  $p < 0.05$ , \*\*  $p < 0.01$



*Figure 4.* Scores for the isolated and dual conditions of the manual motor task for the motor and speech emphasis groups.

*Sound Pressure Level*

When analyzing differences on the dependent measures between men and women it was discovered that there was a significant difference in their intensity levels. Men had a higher intensity level than women, and this difference was more prominent in the dual task condition.

## Discussion

The aim of this study was to build upon the research of Dromey and Bates (2005), Dromey and Benson (2003), and Hamblin (2005) by analyzing how task preference affects dual task performance. Isolated and concurrent tasks were performed by participants who were experimentally motivated to give priority to either the speech or motor task in the dual condition. This was done to evaluate whether the non-preferred task performance would decline in the dual task situation, which would support the multi-channel hypothesis (Allport et al., 1972).

Although none of the results proved to be statistically significant, the data did show some trends that supported the hypothesis that the task that is given preference through promised rewards will be the task that is performed superiorly and also revealed some unexpected significant findings in the gender effects. We speculate that the main analysis based on task preference did not yield significant results because the tasks used were too simple and became automatic to the participant; this would result in reduced or no interference when performing the tasks concurrently. Another possible reason for the lack of significant results could be because the tasks were not similar enough to interfere with each other. According to the multi-channel hypothesis, two tasks only interfere if they are similar enough to partially occupy the same channels when processed by the brain (Allport et al., 1972).

### *Motor*

The motor emphasis group performed better in the dual task condition than the speech emphasis group. This trend suggests that when the participants were motivated to give priority to the motor task they were able to put more effort into that task and perform

better. Although these results were not significant, this trend suggested that with more challenging activities, task preference could have a significant effect on the outcome.

An unanticipated, statistically significant gender effect was discovered for the motor task. The men performed better than the women in both the isolated and dual task conditions. However, during the dual task condition, the amount of difference decreased. Dromey and Benson (2003) found that male participants decreased more than females in dual task performance. The present results are congruent with this earlier finding, since the scoring gap between men and women decreased in the dual task condition.

### *Speech*

*Duration.* When a person is focusing their attention on speech, it is easy for them to slow down and articulate more clearly, since they may associate this with 'better' utterances. This pattern emerged in the speech emphasis group when the utterance duration increased from the isolated to the dual condition. The opposite may be true when a person is paying less attention to their speaking and does not place an emphasis on it; in this case, they are more likely to speed up and not articulate as clearly. In the motor emphasis group, the mean utterance duration decreased for the dual task condition. Finally, the speech emphasis group had longer mean utterance duration than the motor emphasis group in the dual task condition. This further supports the suggestion that when less attention is placed on speech there is a tendency to speak more quickly.

*Velocity.* In contrast to Dromey and Bates (2003) and Hamblin (2005), the present study found that the velocity increased for the dual task condition. Also, the motor emphasis group had a higher velocity than the speech emphasis group in the dual task condition. Lindblom (1990) has reported that velocity is linked to the energy expended while speaking. This suggests that when emphasis was placed on the motor task more

effort was put into speech. This does not mean that the participants placed more attention on their speech, but rather they had to put more effort into their speaking in order to produce the utterance. This could imply a connection between overall psychological arousal levels for the motor task and the effort expended in speech.

*STI.* When comparing the isolated and dual conditions, the STI measure increased for the dual condition. When a participant performed the speaking task with the manual motor task, the STI increase indicated greater variability in the speech movements. Furthermore, the motor emphasis group has a higher STI value than the speech emphasis group. Although these results were not statistically significant, they suggest that having the two groups focus on a different emphasis did affect their speech patterns subtly.

*SPL.* The men who participated in the study consistently spoke at a higher intensity than the women. There was an even higher discrepancy between the male and female SPL in the dual task situation. In this condition, attention was divided between the manual motor task and the speech task. A previous study revealed greater decrements in dual task performance for men than for women (Dromey & Benson, 2005). In the present study it could be speculated that when men were performing the two tasks concurrently, their elevated engagement in the computer task carried over into their speech as an increase in intensity.

This study explored the variable of task preference in the context of dual task performance. The impact of task preference on performance is important because it plays a role in everyday life: people perform dual tasks in most situations. Although no significant results were found in this study, the trends suggest that more challenging tasks might reveal an influence of preference on speech and other concurrent tasks.

*Directions for Future Research*

The findings of this study indicate the need for further research in the area of task preference. Several studies have found that task preference can have an effect on performance (Freidman, et al., 1988, Friedman et al., 1982, Gopher et al., 1982, Hiscock et al., 1989, & Marincola & Long, 1985). However, the present study did not reveal any significant effects from task preference. In future research it would be important to evaluate the tasks to ensure that they are difficult enough so that the participant is not able to perform them automatically after modest practice.

Also, it would be important to determine whether these tasks interfere during a basic dual task situation. To ensure this, the participants would need to perform the tasks in three different conditions: isolated, dual, and dual with a task preference (Gopher et al., 1982). When the participants are performing two tasks concurrently, the researcher should be able to determine that there is definite interference between the two tasks. Then the researcher would have the participant perform the tasks again, and assign them a task preference so that it could be verified whether task preference was implicated in any performance changes.

Understanding how people prioritize tasks and how task preference affects their performance would make a useful contribution to the existing knowledge base on dual task performance. This line of research could be expanded and applied to people with communication disorders in order to more effectively treat their disabilities in the context of everyday settings where dual task performance is the rule, rather than the exception.

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*Appendix A*

## Instructions

Speech isolation task: During this trial you will be asked to say the phrase “Peter Piper picked a peck of pickled peppers.” Please say this phrase once after you hear each beep. Please speak as naturally and accurately as possible.

Visuomotor task: During this trial you will try to click on a moving object as many times as possible with a mouse.

Dual task (speech emphasis): In this trial you will be completing both the computer game and saying the phrase simultaneously. You will be clicking on the moving object on the computer while being required to say the phrase “Peter Piper picked a peck of pickled peppers” once after each beep. During this trial it is important that you focus on your speech. Your speech needs to sound as natural as possible during this trial even while doing the computer task. Each time you say the phrase with normal articulation and natural intonation you will be paid 50 cents. Also, you will be paid 5 cents every time you click on the target during the trial.

Dual task (visuomotor emphasis) In this trial you will be completing both the computer game and saying the phrase simultaneously. You will be clicking the moving object on the computer while being required to say the phrase “Peter Piper picked a peck of pickled peppers” once after each beep. During this trial it is important that you focus on the computer task. You need to click on the target as many times as possible even while you are saying the phrase. You will be paid 10 cents every time you click on the target during the trial. Each time you say the phrase with normal articulation and natural intonation you will be paid 5 cents.

## Appendix B

### Consent to be a Research Participant

#### Introduction

You are invited to participate in a research study, designed to help us learn more about the simultaneous performance of speech and hand movement tasks. Your participation will provide valuable information about how the brain processes the demands placed on it and prioritizes performance. This study is being conducted by Amy Leiter, a graduate student at Brigham Young University under the supervision of Christopher Dromey, PhD, an associate professor in the Communication Disorders Department. You were selected for participation because you are an English speaker with no history of speech, language, or hearing disorders.

#### Procedures

You will be asked to participate in two 1-hour sessions on separate days. You will be seated in a sound booth and complete a fine motor task (tracking an object on the computer) and a speech task (repeating a sentence). You will perform each task on its own, and then in combination. Measurement of your performance will involve the use of audio and video recordings. A head-mounted strain gauge system will also be used to measure your lip and jaw movement patterns while you speak. The first session is intended to let you practice the experimental tasks before we make recordings of your performance. The second session is for recording data. Each session will take approximately 1 hour.

#### Risks/Discomforts

There are no known risks associated with participation in this study. All the equipment we use in this study has been used here and elsewhere without any problems.

#### Benefits

There are no direct benefits to you as a participant. The results of the study will provide valuable information about dual task performance or a person's ability to perform two tasks concurrently. This may eventually contribute to advances in our treatment of disordered communication.

#### Confidentiality

There will be no reference to your identification in paper or electronic records at any point during the research. An identification number will be used to organize the data we collect.

#### Participation

Participation in this research study is voluntary. You have the right to withdraw at anytime or refuse to participate entirely without jeopardy to standing with the university.

Questions about the Research If you have any questions about this study, you may contact Christopher Dromey at (801)422-6461.

#### Questions about your Rights as a Research Participant

If you have questions you do not feel comfortable asking the researcher, you may contact Dr. Scott Ferrin, IRB Chair, 422-4804, 306H MKCB, ferrin@byu.edu.

#### Signatures

I have read the above and understand what is involved in participating in this study. My questions have been answered and I have been offered a copy of this form for my

records. I understand that I may withdraw my participation at any time. I agree to participate in this study.

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Signature

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Date