EFFECTS OF EVERYDAY COMPUTER TASKS ON ACOUSTIC MEASURES OF SPEECH PRODUCTION

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ABSTRACT

We examined bidirectional interference between concurrent speaking and computer tasks in 30 young adults. Participants completed a speech-only task (procedural discourse) and two computer-based tasks. These included formatting changes to a paragraph of text with a word processor (two difficulty levels) or typing items from a shopping list into categories in a spreadsheet. Participants also performed the speaking and computer tasks concurrently. Acoustic measures included the mean and standard deviation of intensity and fundamental frequency as indices of prosody, speaking time ratio to reflect pausing/hesitation, and speech rate. The number of items correctly completed was tallied for each computer task. Statistical analysis revealed a significant decrease in spoken words per minute during the data entry and the easier document formatting task. The relative proportion of speaking vs. pausing time decreased for all three concurrent computer tasks. Performance on all computer tasks was poorer while participants were speaking, reflected in a significant decrease in the number of words correctly sorted and the number of correct formatting changes. These findings reflect interference between concurrent speaking and everyday computer tasks, suggesting that cognitive demands can significantly influence acoustic measures of speech production.

Keywords: *multitasking, interference, discourse*

1. INTRODUCTION

Everyday communication often takes place while speakers are engaged in other activities, such as driving or performing household tasks. Such multitasking involves a division of attention that may lead to reduced performance in speaking and/or the concurrent task [1]. This is often referred to as *interference*. Divided attention is different from task-switching, or switching attention, which is the ability to change focus quickly and effectively between two or more tasks. Previous work in our lab has addressed selective attention, which is the ability to tune out distractions while performing a task, such as speaking in the presence of background sounds that include linguistic information or simpler types of noise [2]. While each type of attention plays a role in daily life, divided attention during speech was the focus of the present study, because of the prevalence of situations requiring speech while other tasks are being performed.

Usually, speech therapy is provided in quiet, distraction-free settings to optimize results, but the gains patients make in treatment may diminish when they return to noisier environments or when they need to multi-task. Therefore, it would be valuable to learn more about interference between speaking and other tasks with the long-term goal of improving speech rehabilitation. Previous research has relied on rote sentence repetition and contrived non-speech tasks to quantify the degree to which they affect each other [3-4]. The goal of the present work was to measure acoustic changes in a more natural spoken language task while speakers completed computer-based activities that they might perform in everyday situations. It was reasoned that this would allow greater ecological validity and could provide a foundation for future clinical research.

2. METHOD

Thirty adults aged 18-30 (15 men, 15 women) provided informed consent as approved by the institutional review board and passed a 30 dB HL hearing screening. They wore a head-mounted microphone and sat at a desk in a sound booth. The speaking task was a 60-second procedural discourse about topics such as planning a

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birthday party for a 6-year-old or explaining how to prepare a favorite meal. The participants used a laptop computer to complete two types of tasks. The first was to apply formatting changes to a page of text by highlighting each instance of the word 'the' in the passage (difficulty level 1) or underlining the word 'a' in addition to highlighting 'the' in a passage of text (difficulty level 2). The second computer task involved reading words from a list of groceries and typing each item into the correct category in a spreadsheet, such as dairy products or baking supplies. No instructions were given about prioritizing task speed versus accuracy or whether speech or the computer task should take precedence. The speaking task and the computer tasks were completed separately and in a combined condition, the sequence of which was randomized. Before completing each kind of task for the first time, both written and verbal instructions were given, and the participants were allowed a short practice period to become comfortable with the task. They were asked to complete as many items as they could in 60 seconds.

Praat software was used to analyze 60-second speech samples. Acoustic measures included the mean and standard deviation of intensity and fundamental frequency as indices of prosody. Speech rate was determined in words per minute. Speaking time ratio, a measure of the time spent speaking versus pausing was computed in a Matlab application and expressed as a proportion; 0.75 would reflect 75% speaking with 25% pausing.

Performance on the text formatting tasks was quantified as the number of words correctly formatted and the number of highlights and/or underlines missed. Scores on the spreadsheet data entry task were calculated by counting the total number of words correctly sorted.

A repeated measures analysis of variance (ANOVA) tested changes in the dependent measures across conditions. Significant differences between the experimental conditions were examined using concurrent contrast analyses within the ANOVA procedure. Data from three randomly selected participants were measured by a second experimenter, and Pearson correlations were computed between the original and remeasured values. The average interrater reliability correlation was .982.

3. RESULTS

There were no significant changes across conditions in the fundamental frequency or intensity measures. The ANOVA revealed a significant main effect of condition on speech rate in words per minute $F(2.812, 78.732) = 8.910$, $p < .001$, $ES = .241$. Concurrent contrasts revealed that the discourse with data entry led to a significant decrease in words per minute (M 71.2, SD 13.6) compared to the discourse only condition (M 84.9, SD 18.4) $F(1, 28) = 31.293$, $p < .001$, $ES = .528$. Words per minute also decreased significantly in Level 1 formatting with discourse (M 78.3, SD 17.9) compared to the discourse only condition $F(1, 28) = 5.124$, $p = .032$, $ES = .155$.

A significant main effect of condition on speaking time ratio was revealed by the ANOVA $F(3, 84) = 11.751$, $p < .001$, $ES = .296$. The ANOVA also revealed a condition by gender interaction $F(3, 84) = 4.111$, p = .009 , $ES = .128$. Concurrent contrasts revealed that the data entry with discourse $F(1, 28) = 29.057$, $p < .001$, $ES = .509$, Level 1 formatting $F(1, 28) = 4.944$, $p = .034$, $ES = .150$, and Level 2 formatting $F(1, 28) = 6.669$, $p = .015$, $ES = .192$ led to a significant decrease in speaking time compared to the discourse only condition. The contrasts also revealed a gender interaction during data entry $F(1, 28) = 5.352$, $p = .028$, $ES = .160$ and Level 2 formatting $F(1, 28) = 8.280$, $p = .008$, $ES = .228$ with women decreasing and men remaining the same compared to the discourse only condition. Descriptive statistics for this measure by gender are shown in Table 1.

Table 1. Mean (M) and Standard Deviation (SD) of Speaking Time Ratio for Discourse (Dis) Conditions with Data Entry (DE) and Text Formatting Levels (Lev).

	Female		Male	
	M	SD	M	SD
Dis Only	0.82	0.05	0.76	0.07
Dis DE	0.71	0.10	0.71	0.09
Dis Lev 1	0.79	0.05	0.73	0.11
Dis Lev 2	0.76	0.06	0.76	0.08

There was a significant decrease in the number of correct highlights in both the Level 1 formatting with discourse task (M 6.5, SD 2.3) compared to the Level 1 formatting only task (M 8.4, SD 2.6) $F(1, 29) = 17.978$, $p < .001$, *ES* = .383 and the Level 2 formatting with discourse task (M 4.4, SD 1.8) compared to the Level 2 formatting only task (M 5.7, SD 1.7) $F(1, 29) = 8.855$, $p = .006$, $ES = .234$. A significant decrease of correct underlines was also revealed when comparing Level 2 formatting with discourse (M 3.6, SD 1.4) to Level 2 formatting only (M 4.6, SD 1.5) $F(1, 29) = 13.470$, $p < .001$, $ES = .317$.

The ANOVA revealed a significant decrease in the number of words correctly sorted in the data entry with discourse task (M 7.5, SD 2.3) compared to the data entry only task (M 13.2, SD 3.4) $F(1, 29) = 91.115$, $p < .001$, $ES = .759$.

4. DISCUSSION

4.1 Effects on speech

The results showed that performing computer tasks while speaking can negatively impact speech. Speech rate in words per minute decreased during both the data entry and Level 1 formatting tasks and speaking time ratio decreased during all three concurrent computer tasks. These acoustic findings are consistent with previous research on speech multitasking using kinematic measures [3-4]. Our finding of decreased speaking rate is consistent with the report from Kemper et al. [5], that paragraph level changes (decline in utterance length, grammatical complexity, and information content) occurred when performing motor tasks and speaking. Another study [6] examined an everyday task (speaking while driving) and found a bidirectional effect between these two activities. These authors used similar speech measures to the current study to reflect passage-level changes in speech prosody and timing, rather than segmental level details. Both studies showed a decrease in overall speaking time during divided attention conditions. The results of the current study also align with literature reporting that computer-based tracking tasks can lead to more pause time in speech [1].

One possible explanation for the decrease in speech rate and speaking time ratio is that the participants required more time to process and form their spoken language while performing the computer tasks. It may have taken more cognitive effort to plan and produce the procedural discourse tasks during completion of the computer tasks (which both required enough focus to either highlight a specific word from a paragraph or sort a list of words into categories). Both the speaking and computer tasks required enough attention to lead to interference.

4.2 Effects on computer tasks

Performance on all computer tasks was negatively impacted by speaking. This impact was observed through a significant decrease in the number of words correctly sorted in the data entry task and the number of correct highlights and underlines in the formatting tasks. This indicates a decrease in the speed with which the computer task can be performed while speaking. The results are consistent with a report that speech multitasking negatively impacted computer-based manual tracking tasks [1]. The computer-based tasks in the present study were selected to allow measurable performance on activities that people may perform on a computer in everyday life. It can therefore be inferred that speaking while performing tasks on the computer can have a negative impact on the speed with which the work can be done.

4.3 Study limitations and future directions

The speech measures in the current study reflected prosody and speech timing because of the naturalistic speech tasks the participants were asked to perform. Since they were producing spontaneous discourse, the participants did not use the same words for the different experimental conditions, which precluded the comparison of specific phonetic details across conditions. The measures of mean and standard deviation of fundamental frequency and intensity, speaking time compared to pausing time, and speech rate lend themselves to paragraph-level recordings where the phonetic content varies freely. However, these measures may not have been sensitive to subtle changes in speech at the segmental level which could have been detected through articulatory acoustic analysis.

This study focused on interference during concurrent speech and computer tasks in young adults with typical speech and language. However, it is possible that these findings would differ for older adults or people with speech or language disorders. Future research could examine whether older adults or individuals from clinical populations might perform differently.

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