BACKGROUND DISCONTINUOUS SPEECH INCREASES PERCEIVED DIFFICULTY OF A LANGUAGE-BASED TASK

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ABSTRACT

Current office designs frequently arrange several workstations in one open room. While this office design may reduce costs, background speech in this environment may hinder an operator's ability to do one of the most common office tasks – reading. Background irrelevant speech combined with relevant linguistic processing may contribute to higher levels of mental workload. Prior cognitive research indicates that background speech degrades performance in reading comprehension tasks. This experiment examined whether background conversation affects perceptions of difficulty of another kind of linguistic processing task, a computer-based proof-reading task. There were three auditory background conditions: quiet, continuous speech (a conversation between two persons) and discontinuous speech (with one or the other person in the conversation, simulating a phone conversation). Results indicated that discontinuous speech is perceived as significantly more difficult than quiet. It is suggested that the greater disturbance by discontinuous speech is due to the combination of the distraction of speech and its unpredictable onset and offset. Implications for office work settings are discussed.

Computers have become a necessary and common element in office environments. Much of the research in human-computer interaction (HCI) relates to interactions on a molecular level between the human and the computer, and the interface between the two. Besides displays and input devices – the areas usually studied in HCI research, other variables play a role. These macro-level variables can be dispositional or situational, and could facilitate or hinder performance or satisfaction with the work environment.

Since office designs introduce macro-level factors to HCI, it is necessary to identify those variables that may affect task difficulty. By isolating environmental office factors that degrade performance and satisfaction, workplace designs can be developed that contribute to more successful utilization of office technology.

In many office environments, computers are used to perform tasks which frequently involve linguistic processing, including reading and editing. It has become common to have groups of individuals work in the same room, sometimes separated by partitions that neither reach the ceiling nor block out sound (the open plan office). Although the open plan office is less expensive to construct and produces a more egalitarian atmosphere, this design introduces a critical noise factor that is not apparent in closed office designs..

Moderate noise levels may interfere with the user's ability to process information. Specifically, background speech noise may impair performance on tasks such as document preparation, electronic mail reading and production, and any other tasks that are dependent upon linguistic processing resources. Young and Berry (1979) found that speech was considered by office workers to be the most undesirable type of noise. Likewise, Sundstrom, Town, Rice, Osborn, and Brill (1994) found that face-to-face and phone conversations were two of the top three sources of office noise and that these types of noise reduced job satisfaction and satisfaction with the work environment.

In open plan offices background irrelevant speech may cause interference by threatening the operator's ability to focus on the primary task. According to Wickens (1984), when processing competes for the same resources, performance in one or more of the concurrent tasks is degraded. An office worker doing document composition is using mental resources primarily loaded on verbal processing. Likewise, concurrent background speech may make additional attentional demands that load on verbal processing resources. The amount of interference is determined by the degree to which the operator diffuses attentional resources in preparation to respond to other stimuli (Crawford, Brown, & Moon, 1993). Conversations that are directed at the operator would be expected to produce the most interference. Here, the is more likely to stop their activities on the computer in order to process the speech for meaning and respond appropriately. However, background speech may inhibit performance and satisfaction even when it is irrelevant.

Martin, Wogalter, and Forlano (1988) conducted a series of experiments which compared the effects of various types of irrelevant background noise on reading comprehension. Participants were given passages to read, and comprehension was determined by using a subsequent multiple choice test on the material. Martin et al. (1988) found that the presence of background continuous speech disrupted reading comprehension performance more than other kinds of noise (e.g., music) and quiet. They theorized that the interference was due to phonological disruption by the vocal activity of the two sources of linguistic processing. However, they did not test another speech condition, the effect of discontinuous speech which frequently occurs in office environments, e.g., one side of a two person telephone conversation. Although the purpose of the Martin et al.(1988) study was to advance cognitive theory, it has implications for applied settings.

Discontinuous speech may have more negative effects than continuous speech because the worker may not be able to ignore this type of noise due to its unpredictable onset-offset pattern. Discontinuous speech may be highly attention-capturing because parts of the conversation abruptly start and stop. This causes automatic shifts in attention away from the primary task.

The focus of this research is to determine whether irrelevant background speech/operator conversations interfere with computer performance. The present study simulated the auditory conditions of current office environments by manipulating three kinds of auditory conditions: quiet (control), both parts of a conversation (continuous speech), and one part of a two part conversation (discontinuous speech). Both experimental conditions contained speech that was irrelevant to the participant's task. It was expected that the presence of both continuous and discontinuous background speech would increase the perceived difficulty of a primary verbal task. Because of its intermittent nature, discontinuous speech was expected to be perceived as being more difficult than continuous speech. .

METHOD

Participants

A total of 42 college students (19 females and 23 males) participated in the study. All but one participant reported having at least one year of experience using computers. The ages ranged from 18 to 27 (M = 19.41, SD = 1.94).

Materials and Apparatus

The primary linguistic-based processing task involved the editing of a document on a computer.

For both speech conditions, the sound level was held constant at an average level of 75 dB(A). The ambient sound level for the quiet conditions was 45 dB(A). The fan noise from the computer accounted for part of this measurement. The sound source was located eight feet behind the participant who was facing away from the source. The recordings in the two speech conditions were presented through one speaker. The recorded speech consisted of two individuals discussing life insurance in an ongoing question, answer, and comment dialogue. When the recording was made, the voices were controlled to avoid emotions or word stresses. Both of the individuals on tape spoke for roughly equal intervals. The pace of speech averaged 2 words per second. In the discontinuous speech recording, one side of the two-sided conversation was played to half of the participants in the condition and the other side of the two sided conversation was played to the other half of participants. The discontinuous speech condition had periods of quiet and spoken voice.

Participants edited a four page document that contained errors. The participant's task was to find the errors and mark them using the space bar. Two additional keys allowed the participant to move left-to-right and down. The task was designed so that the cursor could move only from left to right and top to bottom. If a word containing an error was missed, the participant could not return to that word. No other keys were operational. The computer's mouse was removed.

Three types of errors were included in the document: misspelled words, homonyms, and spoilers. Homonyms are more difficult to detect than misspelled words because homonym detection requires semantic processing, while basic misspellings of words can sometimes be detected by processing word shape. Spoilers are illogical words that are placed in a sentence. According to Jorna (1991), detection of spoilers requires contextual processing which increases the level of task difficulty. The example below contains all three types of errors:

> In general, there free (spoiler) are too (homonym) ways of quantifying drect (misspelled word) nursing care activities: self-reporting by the nurse who gives was (spoiler) the care, and observation of teh (misspelled word) caregiver buy (homonym) a trained observer.

Participants rated task difficulty using the following question: "How hard do you think the task was?" The scale was anchored at the extreme ends with 1 (extremely easy) and 10 (extremely difficult).

Procedure

Participants were given instructions regarding the editing task. Each participant was asked to focus on the task and complete it as quickly and as accurately as possible. A practice task, which required the participant to edit a paragraph, was provided so the participant could become familiar with key operation and error marking. Most participants completed the practice task in less than two minutes. Once the practice task was completed, participants were given instructions for the experimental session.

Participants were assigned randomly to one of three conditions. In the quiet condition, participants performed the task with no ambient speech and were told to complete the task as quickly and as accurately as possible. In the continuous speech condition, participants were told that they would hear a recorded conversation, but they were instructed to focus on the editing task and to complete it is quickly and as accurately as possible. In the discontinuous speech condition, the same instructions were given except participants were told that they would hear a recording of a person speaking. The editing session was limited to 10 minutes, followed by participants completing the subjective difficulty rating scale.

Later, participants were debriefed, thanked, and released.

RESULTS

Planned comparisons (Keppel, 1982) were used to determine the effects of speech condition on perceived difficulty. The mean difficulty ratings for each of the three conditions are included in Figure 1.

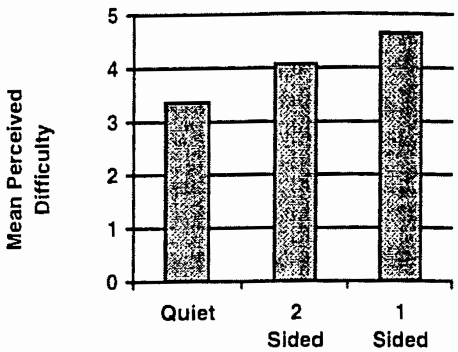

Figure 1: Mean difficulty ratings. 2 Sided = Continuous Speech Condition. 1 Sided = Discontinuous Speech condition.

A statistically significant difference was found between the one-sided/discontinuous speech condition (M = 4.64, SD = 1.50) and the quiet condition (M = 3.36, SD = 1.69), t (26) = 2.13, $p <$ .05.

The two-sided/continuous speech condition (M = 4.07, SD = 2.16) was perceived as slightly more difficult than the quiet condition, but the difference was not significant, t (26) = .97, p = .34. The comparison between the discontinuous and continuous conditions was not significant, t (26) = .81, p = .42.

DISCUSSION

This study provides evidence for interference by irrelevant background speech on linguistic-based computer tasks. Both speech conditions produced higher difficulty ratings than the quiet condition (one was significant). The hypothesis predicting relatively higher perceived task difficulty under the discontinuous speech condition compared to the quiet condition was confirmed. It may be more difficult to block out a one-sided (discontinuous) conversation, because people try to mentally fill in the gaps (despite being told that they should ignore the speech background). Another explanation is that discontinuous speech is made up of multiple unpredictable onsets and offsets., that cause automatic shifts in attention away from the primary task.

Although not significant, the mean perceived difficulty ratings of the continuous and the discontinuous speech conditions were in the predicted direction. The continuous speech condition produced intermediate levels of difficulty compared to the quiet and discontinuous speech conditions. Both speech conditions were rated higher than the difficulty ratings in the quiet condition. The direction of the means is consistent with the results of Martin et al. (1988) who found that reading comprehension performance was degraded under various irrelevant background continuous speech conditions. The performance decrement and the higher perceived difficulty seems to be a consequence of overlapping resources resulting from the performance of the proofreading task (which draws on verbal resources) and the intrusion of a separate verbal source. The task load was higher in the speech conditions than in the quiet condition.

Designers of office environments might benefit from the application of the present study's findings. For example, when performance of a primarily verbal task is critical, then discontinuous speech should be limited and may require a closed office plan with walls separating the workstations.

Another related application is in environments which are making use of recent voice recognition technology. Closed plan offices may be a necessity in these cases, because background voice may undermine the productivity of adjacent workers involved in linguistic processing tasks. The results point to the need to re-examine workspace designs in order to increase performance and satisfaction in HCI tasks. One way to do this, according to the present research, is to limit background speech that may compete for processing resources used in the primary task. Additional research is currently underway that examines performance differences, in particular, error detection rates, among the speech conditions.

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