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# Time Delays and System Response Time Display in Human-Computer Interaction

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The time delay between which a user initiates a command and the system's completion and display of the result is known as the system response time (SRT). System response times can range from milliseconds to minutes depending on numerous variables, including the complexity of the task and the processing power of the system. The psychological and physiological ramifications of SRTs have been clearly defined by previous research. Studies on the effect of SRTs on physiological stress reactions, subjective ratings and task performance have shown that users under time pressure experiencing long SRTs displayed negative emotional states, but higher levels of performance. Longer SRTs also caused increased skin conductance responses, whereas fast SRTs led to an increase in blood pressure (Kuhmann et al, 1987). However, when no time pressure was present, SRTs had no effect on physiological responses. Longer SRT without time pressure also led to a decrease in task performance, but a higher subjective evaluation (Kuhmann et al., 1990; Schaefer, 1990).

In fact, SRT has been shown to be one of the strongest stressors in human-computer interaction (Schneiderman, 1987). The stress-inducing factors of SRTs have been determined to be duration, variability, and expectation (Boucsein et al, 1984). Of these three factors, the only one that can be accurately controlled and symbolized for a singular SRT is expectation. Variability is difficult to control in a computer program and relies on multiple SRTs in order to determine the variance. However, if the user is given proper information on the duration of the delay then the effect on stress can be lessened through expectation. If SRT variability was mitigated, then users reported more positive interactions with the computer (Kuhmann et al, 1990).

Initial research on system response time delays and user performance showed that the most important factor in a workplace computer interface was the length of the SRT, with the one with the shortest SRT being the best (Dannenbring, 1983, Martin & Corl, 1986). Later work focused on the predictability of the system delay and the results indicated that the two most important factors include the ability to predict the length of the delay in relation to the type of user action, and the feedback during the delay (Rushinek & Rushinek, 1986). Further research shows that SRT, when unavoidable, should be predictable for the user (Schneiderman, 1987). When SRTs are constant, the worker can predict when the next step will occur and plan workflow accordingly. The study by Myers (1985) showed that users prefer progress indicators, with the explanation that novice users view it with the understanding that the system is functioning normally for long tasks, while expert users use the progress indicator as a gauge allowing them to perform concurrent multiple tasks. From observation during the study, the participants who had the progress indicator watched the screen, whereas those who did not have a progress indicator looked around the room and stopped paying attention to the computer display. From a productivity perspective, the progress indicator is clearly beneficial.

This research seeks to establish an optimal representation of SRT on a computer interface in terms of task performance and switching between tasks, the user's stress and frustration, and the accuracy users are able to assess the SRT based on its representation on the interface. Specifically, the following hypotheses are put forward: (1) a representation of SRT that involves a continuous object should be seen as taking a shorter amount of time to complete, and therefore be preferred by users and be more efficient, (2) a determinate representation of a time delay should be preferred by users and lead to lowered levels of frustration and improved performance, and (3) increase in preference and performance should lower user's stress levels.

Four different SRT representations will be used: (1) a segmented determinate representation, (2) a segmented indeterminate representation, (3) a continuous determinate representation, and (4) a continuous indeterminate representation. A varying system response time will be imposed on the interactions, indicating that the system is busy retrieving the required information. The participants will be given two tasks to complete in parallel. The tasks will relate to one another, so that while the participant is waiting for the computer's response on one task, he or she can work on the other. The dependent measures will include accuracy of task performance, time to completion of task, and subjective reports on satisfaction, stress, perceived SRT and preferences of SRT representation.

We expect to find that a continuous determinate progress bar will be the best for the user, followed by the segmented determinate progress bar, the continuous determinate and the segmented indeterminate. The determinate progress bar should also create the lowest levels of stress. The results of this study will be applicable to all human-computer interfaces that need to represent a system response time. Design guidelines will be developed that may improve user efficiency and performance, increase user satisfaction, and increase use in the case of websites. For the medical and flight computers, the potential benefit to human safety is of greatest consequence.

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