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ABSTRACT

Web site delays are often unavoidable and have consistently been a major complaint of users online. Feedback can be provided to help alleviate users' frustrations with delay. Two theories of time estimation—the internal clock theory and the attentional gate theory—are compared to determine how feedback may impact users' estimations of delay length. Attentional and uncertainty reduction perspectives are then utilized to establish how feedback can influence perceived acceptability of a delay as well as satisfaction with and intention to return to a Web site. An experiment was conducted using a simulated online bookstore and search task. Perceptual data were collected using a questionnaire, and physiological data were collected using eye tracking equipment. Results of the analysis suggest that providing feedback does not affect estimations of delay but does increase perceived acceptability of the delay, satisfaction with the site, and intention to return to the site.

Keywords

Delay, Feedback, Attention, Satisfaction, Intention, Eye Tracking

INTRODUCTION

It is well known that Web site delays have consistently been a major complaint of users online (Dennis and Taylor, 2006; Galletta, Henry, McCoY, and Polak, 2006). A delay is said to occur "when a user clicks on a hyperlink and nothing seems to happen for several seconds" (Galletta, Henry, McCoy, and Polak, 2004, p. 2). Web site delays have serious implications for e-commerce. One study found that more than one third of users give up purchasing an item after encountering delays, leading to losses of $4.35 billion in potential US online sales (Sliwa, 1999).

One method of alleviating the problems associated with delays is to provide users with feedback, reflecting Nielsen's first principle of usability heuristics: visibility of system status (Nielsen, 1994). Various forms of feedback—including static displays, sequentially moving dots, and percent-done progress bars—have been shown to impact perceptions of delay (Branaghan and Sanchez, 2009; Nah, 2004). While it may not be possible to control the actual length of delays online, certain forms of feedback can be used to improve attitudes toward delays. Weinberg (2000) and Nah (2004) argued that it is more important to study perceptions of download delays rather than actual delays. Two theories that have been used to describe time estimation are the internal clock theory and the attentional gate theory. The internal clock theory proposes that time estimation is based on an internal clock which is unaffected by attention (Matell and Meck, 2000). Conversely, the attentional gate theory proposes that the attentional demands of a task will impact time estimation (Zakay and Block, 1997). The attentional gate theory has been applied to studies linking feedback methods with delay estimation and acceptability (Branaghan and Sanchez, 2009; Nah, 2004). However, it is still unclear whether there is support for the internal clock theory in the context of delay feedback and to what extent attention really plays in explaining previous findings.

PRIOR LITERATURE

Time Estimation

Internal Clock Theory

Several different models based on the internal clock theory exist, but they all share at least one common element: an internal timing mechanism (i.e., a clock). The general explanation is that neurons in certain areas of the brain are activated to accurately estimate time durations. One assumption of this theory is that the internal timing mechanism does not require any attention, and errors in time estimation are simply due to noise.

Attentional Gate Theory

The attentional gate theory also incorporates an internal timing mechanism, called a pacemaker, which produces a stream of pulses (Zakay and Block, 1997). These pulses are passed to a cognitive counter that is used to keep track of time. Unlike the internal clock theory, the pacemaker requires attention. Pulses must first pass through a gate—which is only open when an individual is attending to time—before they are accumulated by the counter. In addition, a switch allows pulses to pass once it is activated by a start signal at the beginning of a time period. Accumulated pulses are then compared to labels stored in reference memory to determine the duration of a period of time.

Estimated Delay and Feedback

Applying the internal clock theory to estimations of delay would suggest that feedback will not influence duration estimates. This is because each individual's internal clock can accurately time events regardless of where the individual's attention is focused. Thus the first hypothesis reflects this argument that, although feedback may impact a user's attention, estimates of delay will be unaffected:

H1a: Estimations of Web site delay will be the same regardless of whether feedback is provided.

Providing feedback to users can draw attention to a Web site delay. Focusing on the feedback then provides one continuous event that is stored in a user's memory. Once the user is asked to estimate the length of the delay, few contextual changes are remembered, leading to a shorter estimate of delay length. Without feedback, a user will suffer from uncertainty about the length of the delay and whether the site is even functioning properly (Hui and Tse, 1996; Nah, 2004). Such uncertainty will cause a user to scan the page looking for signals that the system is processing the request. Heightened cognitive activity and continuously changing visual stimuli (from scanning) will likely lead to an increased number of contextual changes being stored in the user's memory. When estimating the delay length, the user will then perceive the delay as being longer. The second hypothesis reflects the attentional gate argument that feedback will reduce the number of contextual changes in a user's memory, leading to reduced delay length estimations:

H1b: Estimations of Web site delay will be shorter when feedback is provided.

Acceptability of Delay

Prior research suggests that feedback can help reduce the negative effect of delay on attitudes toward that delay. In this study, the attitude of interest will be called perceived acceptability of the delay. Applying the internal clock theory, users would not be expected to judge durations any differently with feedback versus no feedback. However, feedback provided during a delay can help fill time, causing that time to appear to pass more quickly (Gilliland, Hofeld, and Eckstrand, 1946; Katz, Larson, and Larson, 1991). In addition, the reduction in uncertainty provided by feedback can reduce boredom, tension, and anxiety (Taylor, 1994). Applying the attentional gate theory, feedback is expected to focus a user's attention and shorten estimates of delay time. Again, feedback would fill time and reduce boredom, tension, and anxiety. Using either theory of time estimation, feedback is expected to increase acceptability of the delay:

H2: Feedback will increase perceived acceptability of Web site delay.

Web Site Delay, Satisfaction, and Intention to Return

Web site delay, both actual and perceived, has been linked to satisfaction with and intention to return to a site. Using the same uncertainty reduction arguments as above, it is expected that overall satisfaction with a Web site will increase when feedback is provided:

H3: Feedback will increase overall satisfaction with a Web site.

Delays can also impact a user's intention to return to a Web site.

H4: Feedback will increase intention to return to a Web site.

METHOD

We conducted a between-subject experiment in a laboratory setting. A Web site was developed to simulate an online bookstore. Two versions of the Web site were created to represent the feedback versus no-feedback conditions. Both Web sites had the same design and content on the homepage, and both had ten-second delays in returning users' search results. One of them offered a feedback page which indicated the system status during delay. We presented the research stimulus on a Tobii eye tracker. The eye movement data was collected and analyzed in Tobii's ClearView software.

A total of 40 subjects participated in this study. The subjects were randomly assigned to either the feedback group or no-feedback group. Each participant was asked to search for a specific book using the search function on the homepage. After completion of the task, the participants were instructed to complete a questionnaire.

DATA ANALYSIS

Mean Score Comparisons

MANCOVA was conducted to compare the difference of means between the feedback group and non-feedback group. Results from the analysis are shown in Table 1.

As hypothesized by H1b, the estimated delay was shorter in the feedback condition compared to the no-feedback condition. However, these mean differences were not statistically significant. It must be concluded then that both groups estimated the same duration for the delay. Based on these results, H1a is supported and H1b is not supported.

The means for acceptability of delay, Web site satisfaction, and intention to return were all significantly different across conditions. Specifically, subjects in the feedback condition reported higher acceptability of the delay, Web site satisfaction, and intention to return compared to subjects in the no-feedback condition. These results provide support for H2, H3, and H4.

Construct	No Feedback (n=20)		Feedback (n=20)		F(1,34)	*p*
	Mean	*Std. Dev.*	*Mean*	*Std. Dev.*		
Estimation of Delay	4.97	1.61	4.52	1.80	0.131	0.720
Acceptability of Delay	2.85	1.02	5.17	1.31	30.132	0.000
Web Site Satisfaction	4.00	0.95	5.18	1.37	8.702	0.006
Intention to Return	3.00	1.24	4.65	1.48	12.546	0.001

Table 1. Multivariate Analysis of Covariance Results

Although the MANCOVA indicated no difference in delay estimates across conditions, it should be noted that both means were less than 5 seconds. The actual length of delay for both conditions was 10 seconds. As a follow-up to the test of H1, the mean value of estimated delay for all subjects was compared to the actual value of 10 using a one-sample t-test (t=-19.507, p<0.001).

Eye Tracking Analysis

It was theorized that attention plays an important role in time estimation, regardless of theory, as well as attitudes toward delay, satisfaction, and behavioral intention. Previous research suggested that what is being fixated at is an indication of what is being processed in the mind, which is called the eye-mind hypothesis (Just and Carpenter, 1976). Therefore, eye tracking can provide a dynamic trace of a user's attention over a visual display (Poole and Ball, 2005). Eye tracking data can be visualized in two popular formats, namely gaze plots and heat maps.

Gaze Plots

A gaze plot shows the sequence and position of fixations (represented as dots) on a static media (e.g. an image or a scene). Figure 1 shows the gaze plot of a representative user from the non-feedback condition. Figure 2 represents the gaze pattern of another participant in the feedback condition.

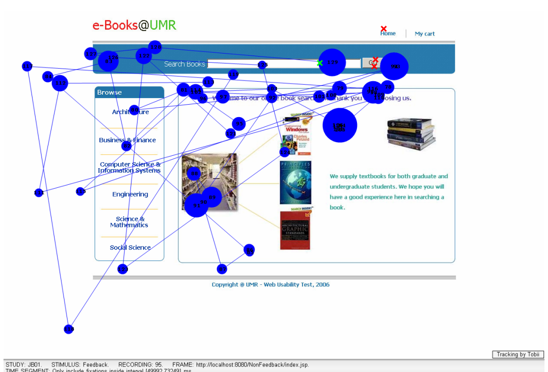

Figure 1. Gaze Plot on the Web site – No-Feedback Condition

Aggregated Heat Map

Heat maps are aggregated over multiple participants. A heat map uses different colors to show the number of fixations participants made in certain areas of the image or for how long they fixated within that area. Figure 3 contains the aggregated heat maps of the no-feedback and feedback groups during the 10-second delay.

Area of Interests (AOI)

A further analysis on participants' fixation data was conducted to examine the percentage of time the participants were attending to different types of information provided in the feedback. The results suggest that on average, participants spent 12% of time fixating on the feedbacks, including the text, images, and animated dots. Among the three types of feedbacks, the image received the most attention, with 50% of the time fixated on it. This could be due to the fact that the size of the image was larger compared to the other feedback elements.

Pupil Dilation

Previous research has found that pupil dilation is not only a good indicator of cognitive workload (Colman and Paivio, 1969; Kahneman, Tursky, Shapiro, and Crider, 1969), but also provides insights into one's emotional state (Partala, Jokiniemi, and Surakka, 2000).

In this study, baseline pupil dilation values were calculated by averaging the dilation of each subject's left and right eye for 100 milliseconds prior to the Web site delay. Dilation measures were then obtained again 1 second and 5 seconds after the start of the delay. This was done to examine possible changes in dilation over the 10-second delay period. These measures were calculated by averaging the dilation of each subject's left and right eye for 1 second. The baseline was subtracted from the 1-second and 5-second dilations to obtain a change in dilation during the wait. A few subjects from each condition were dropped due to insufficient data points.

A simple analysis of variance (ANOVA) was conducted to compare the dilation changes across feedback groups. The results indicated that subjects in the no-feedback condition, on average, experienced greater pupil dilation than subjects in the feedback condition (Δ 1 second: $F(1,30)=5.992$, $p<0.05$; Δ 5 seconds: $F(1,30)=5.174$, $p<0.05$). Figure 4 shows a plot of the changes in pupil dilation 1 second and 5 seconds into the delay across the feedback conditions. The graph clearly indicates that dilations are much lower in the feedback condition.

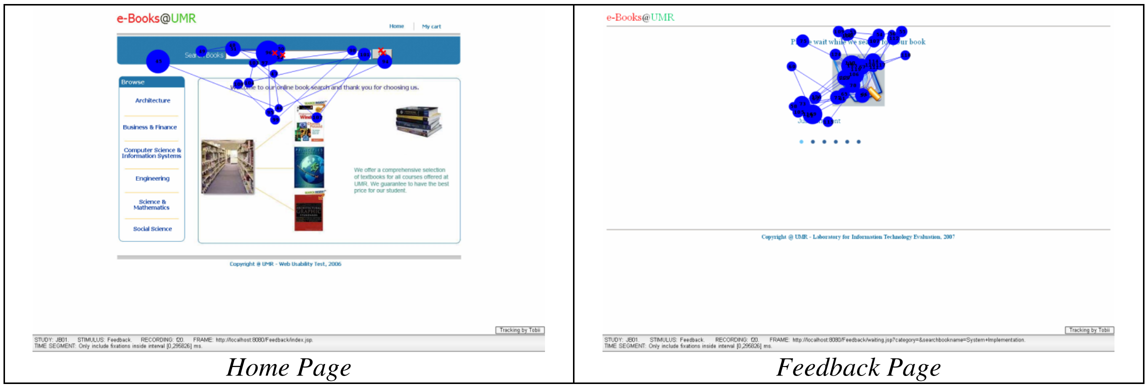

Figure 2. Gaze Plots on the Web site – Feedback Condition

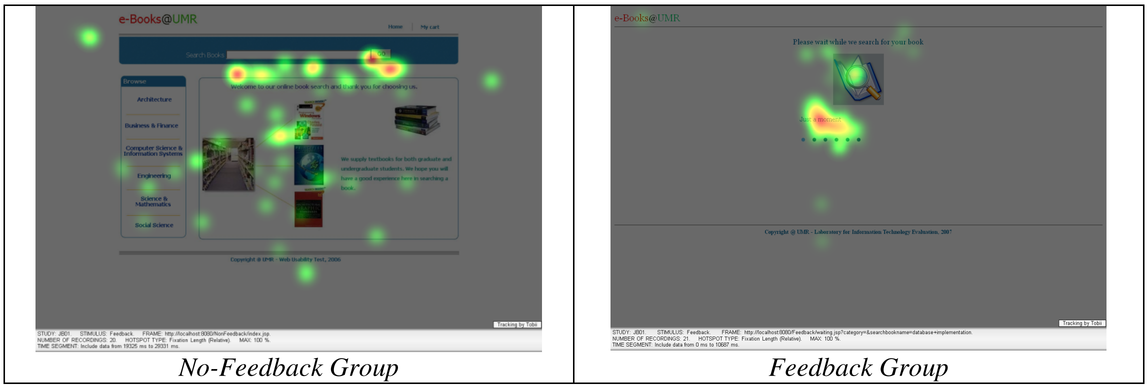

Figure 3. Aggregated Heat Maps during the Delay

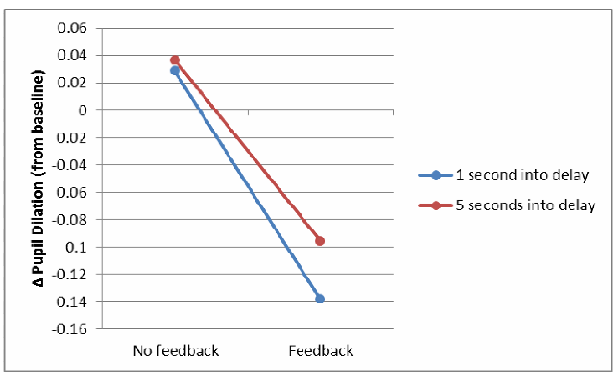

Figure 4. Pupil Dilation Change Graph

DISCUSSION

In this study, the effects of feedback on estimations and attitudes of Web site delay were examined. In an experiment, subjects encountered a delay of 10 seconds while searching for a particular book in a simulated online bookstore. Half of the subjects were presented with feedback indicating that they would need to wait, while the other half received no feedback. Survey responses and eye tracking data were analyzed to determine differences in subjects' perceptions across conditions.

The contributions of this study were threefold. First, two competing theories of time estimation were compared to determine which more accurately describes the effect of feedback on estimation of Web site delays. MANCOVA results indicated that delay estimates were not significantly different across conditions, providing support for the internal clock theory. However, those estimates were significantly different from the actual length of the delay—specifically, they were about half of the actual delay. This suggests that, while an internal clock mechanism may exist, it does not seem to be very accurate.

Follow-up analysis using eye tracking data revealed that subjects in the feedback condition focused heavily on the delay feedback, but subjects in the no-feedback condition did not seem to focus on any one particular part of the screen. These results support the argument that users will scan a page in search of signals that the system is processing their request. Using the attentional gate perspective, such scanning should increase contextual changes stored in memory, thus leading to increased estimations of delay.

Even though differences in delay estimates were not found, the mean estimate for the feedback group was lower than that for the no-feedback group. It is possible that, while attention did influence delay estimation, the sample size was too small to find a statistically significant effect. Unfortunately, a limited subject pool prevented the use of more powerful statistical tests. Given the current results, the internal clock theory receives at least partial support and the attentional gate theory does not receive support with regard to time estimation.

Second, it was determined that feedback does have an effect on perceived acceptability of a delay and satisfaction with and intention to return to a Web site. All of these scores were higher for the feedback group than for the no-feedback group. As indicated by the eye tracking analysis, feedback subjects were focused on the delay feedback. This provides evidence that the feedback was indeed processed by the subjects and likely reduced uncertainty about the delay. No-feedback subjects scanned the page, presumably looking for feedback, which may indicate some level of uncertainty, tension, and anxiety.

Pupil dilation analysis also indicated that subjects experienced greater cognitive workload and arousal in the no-feedback condition. While it is difficult to determine whether subjects' arousal was positive or negative, these results do support the theoretical argument that a lack of feedback promotes tension and anxiety. Also, the fact that more subjects in the no-feedback condition seemed to be looking away from the screen could be a sign of boredom. The feedback subjects then generally had more positive attitudes toward the delay and, ultimately, the Web site as a whole.

Third, subjects in this study were presented with multiple forms of feedback on one page (i.e., text, static image, and animation). Previous studies have attempted to compare these different forms of feedback (Branaghan and Sanchez, 2009), but the eye tracking data in the current study allowed for an examination of which form of feedback users will focus on given all three at once. The AOI analysis indicated that users fixated on the image feedback twice as much as the text or animation feedback. While this may be due to the relative size of the image, it could also be an indication that the image was more visually appealing and thus help "fill" the wait time more effectively than the text or animation feedback.

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