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Information Foraging on the Web: The Effects of â€œAcceptableâ€ Internet Delays on Multi-page Information Search Behavior

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Abstract
Delays on the Web are a persistent and highly publicized problem. Long delays have been shown to reduce information search, but less is known about the impact of more modest â acceptableâ delays â delays that do not reduce user satisfaction. Prior research suggests that as the time and effort required to complete a task increases, decision-makers tend to minimize effort by reducing information search activities and let decision quality slip rather than increase effort to maintain a consistent level of decision quality. In this study, we examined the effects of an acceptable time delay (seven seconds) on information search and decision making behavior. We found that the increased time and effort caused by acceptable delays provoked increased information search.

Keywords: Internet, time, delay, service delays, information search, information foraging, decision making, laboratory experiment.

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ABSTRACT

Delays on the Web are a persistent and highly publicized problem. Long delays have been shown to reduce information search, but less is known about the impact of more modest "acceptable" delays – delays that do not reduce user satisfaction. Prior research suggests that as the time and effort required to complete a task increases, decision-makers tend to minimize effort by reducing information search activities and let decision quality slip rather than increase effort to maintain a consistent level of decision quality. In this study, we examined the effects of an acceptable time delay (seven seconds) on information search and decision making behavior. We found that the increased time and effort caused by acceptable delays provoked *increased* information search.

Subject Areas: Internet, time, delay, service delays, information search, information foraging, decision making, laboratory experiment.

INTRODUCTION

The ubiquitous nature of the World Wide Web makes it an important component in current and decision making information systems. Inside organizations, the Web interface is increasingly being used as a front end for a variety of systems including older (legacy) systems [3] and newer systems such as data warehouses [13], enterprise resource planning (ERP) systems [59], and the rapidly growing number of corporate intranets. Moreover, the Web as a user interface is becoming the universal interface for supporting decision makers external to the firm including sales personnel, traveling staff, telecommuters and the firm's most important decision makers, the customers.

Delays are one of the most frequently cited and highly rated concerns of using the Web [29, 30, 32]. So universal is this perception, that the Web has been called the World Wide Wait [34]. More than a widely acknowledged nuisance, these delays have implications for corporate bottom lines. One study suggests that over one third of Web users may simply give up trying to buy an item over the Internet after encountering excessive delays, resulting in loss of as much as $4.35B in US e-commerce sales [60]. These service delays have caused many sites to offer "low bandwidth" or "text-only" versions of their primary sites to reduce the delay in retrieving pages. In many cases, delays can be reduced but not completely eliminated. Thus, even with minimal network delays, a site may still consist of several pages with "acceptable" presentation delays due to client-side factors such as browser plug-in initialization and HTML table rendering or server side issues such as database operations.

From the perspective of the decision maker, delays represent a cost to the information search component of decision making process. Cost-benefit theory has been frequently used to explain information search and decision making behavior in the presence of computerized and noncomputerized decision aids [7, 27, 48, 53, 58]. This research suggests that decision makers tend to be effort minimizers and thus in the face of increased cost or effort, tend to adopt effort-minimizing strategies that reduce the extent of *information search* or reduce the amount of *time* used to consider the acquired information. Such effort reduction may impair the decision quality because decision makers may make premature decisions based on incomplete information, rather than conducting a more thorough, compensatory information search [6, 21, 25].

A new theory called information foraging theory offers a complementary view of information search behavior [41]. In the "hunt" for information, information sources in the decision maker's environment will vary in terms of value and relevance. This non-uniformity results in information "patches" of varying importance. Rather than effort reduction, "informavores" (i.e., information carnivores) seek to maximize their gains of valuable information per unit cost [41, p3]. The cost of information search not only includes actual costs of obtaining information, but the opportunity cost of viewing one piece of information over another. Thus, information search may be characterized as a repeated pattern of extracting information from individual information patches (e.g., a Web page) until a point at which the value of additional information (i.e., the anticipated benefits less the cost to acquire) can only be increased by moving to a new information patch.

This paper reports the results of a study examining the impact of delays on information search and decision making in a Web environment. Section 2 presents previous research in the study of service delays, information search and information foraging theory, leading to the development of hypotheses about decision processes and outcomes. Section 3 describes the methods while Section 4 presents the results. Section 5 discusses the results and draws implications for decision making practice and future research.

ONLINE INFORMATION SEARCH

Web use has increased dramatically over the last decade. One of the key attractions to the Web is the ability to link to literally millions of information sources. With this hypertext capability, a single page can contain links to information located on different pages or even different Web servers. In a decision making situation, the hypertext Web structure can be used to display information contained in organizational databases organized as a set of pages that provide information about the alternatives under consideration. From one central page, for example, one could click on a link to another page that provides more information about alternative(s).

The way in which decision makers choose to navigate these web pages in search of information is affected by a variety of factors of personal, task, technology, and contextual factors. In this paper we focus on the effects of just one factor: response time delay. We begin by discussing delay, and then examine how delays can affect search behavior by changing the perceptions of the cost and effort required to perform the task.

Service delays

Time is a limited resource. Response time delays in using computer systems and the Web take away from the time that can be devoted to the actual accomplishment of a task. Such interruptions in the anticipated information search can adversely impact decision performance[49]. Delays increase the cost of performing a task by extending the time required to complete it. Assuming the marginal cost of time spent in an analysis is a constant, then the cost of analytical effort can be expressed as a linear function of the time required to complete the task [42].

Although the actual amount of time imposed by response time delays may be small relative to the time devoted to the task (e.g., a few seconds per transaction), it is the behavioral response triggered by delays that can have a significant impact on performance. Wait periods may produce a sense of time pressure [2, 40] and produce a psychological burden termed disutility, stress, or dissatisfaction [43]. For example, traffic delays have been associated with the psychological condition known as road rage. In reaction to these delays, the motorist might engage in risky behavior such driving faster and/or park illegally in response to the time pressure. Such situations can lead to the need to “decompress” and thus may also have effects which carry over long past the actual delay itself.

Delays are a key source of customer dissatisfaction across a number of services [8]. Research has noted a negative relationship between performance evaluations and delays in a number of services areas including restaurants [19], banks [28], airlines [52], grocery stores [57], fast food service [15] and Internet usage [29, 30, 32]. This body of research has attempted to quantify what constitutes an ***excessive*** delay, as well as examining the effects of excessive delays, but this is difficult. For any specific objective measure of time delay, the subjective interpretation of the delay (whether long or short) vary from individual to individual and context to context [28].

When delays were considered long, significant changes in satisfaction and information processing have been noted. Delays as short as 30 seconds for *complete download* of Webzine have been associated with negative evaluations with respect to the non-delayed condition [16]. Similarly, delays of 13 seconds for the response of a *single page* were rated as "long" and resulted in significantly lower satisfaction and abandonment of searches [34]. Practitioners have suggested 10 seconds [37] and the oft-quoted “8 second rule” [60] as the thresholds for "long" delays.

Research has shown "long" delays significantly reduce search behavior and impact decision making performance [1, 20, 33] So rather than focus on "long" delays, we seek to determine the impact on search behavior of delays that are viewed as *perceptible* but *acceptable* to the user. Given there exists a range of delay times between barely perceptible and completely intolerable, it is likely within this range, there is also a range of waiting times which may have a negative impact on information search behavior, and decision quality, while still being perceived as tolerable to the user (i.e., some "acceptable delay").

Some research has attempted to quantify the range of acceptable delays. From a cognitive standpoint, delays are bounded by the perceptual limit of sensory memory (less than 1 second) and the limit of working memory (around 7 seconds) [9]. Similarly, Shneiderman [47] and Davis and Olson [14] argue reasonable response time is bounded by a "short" delay of 2 seconds or less and a "long" delay of more than 10 seconds. Delays of less than 8-10 seconds in accessing individual Web pages have typically been interpreted as perceptible but "acceptable" delays [35, 36].

Acceptable delays, by definition, should not trigger user dissatisfaction. The question is do they impact user behavior and performance? Delays increase the cost of information search; increasing the time it takes to retrieve a Web page increases the actual – and more importantly the perceived – time and effort to acquire more information before making a decision. The effects of long delays leading to a perceived increase in time pressure can result in more selective acquisition of information [5], fewer alternative comparisons via backtracking (i.e., revisiting known information) [44] and most importantly, a switch to simpler, noncompensatory decision rules [39], can lead to lower decision quality [1, 6, 25]. But, do *acceptable* delays have a similar impact?

Information search

Different decision makers may choose to search for information in different ways and to devote more or less effort into the information search process before making a decision. One factor that has been shown to influence the breadth and depth of information search is the effort or cost of the information search [55]. One factor influencing the cost of information search is delay – how long it takes for a decision maker to acquire desired information [42].

As the cost of information search due to delay increases, decision makers often trade off the amount of effort to be spent in making a decision and the benefits they expect as a consequence of the effort expenditure [4, 56]. Decision makers can react in one of two basic ways [55, 56]. A decision maker could place primary importance on decision accuracy rather than decision effort. In the face of increasing information search costs, the decision maker who values accuracy would not change his or her information search behavior but would simply extend the total decision time. That is, information search (e.g., the amount of data examined) would not differ significantly between delayed and non-delayed cases – and thus neither should decision accuracy – but the amount of time taken would increase.

Alternately, a decision maker could place primary importance on the amount of effort expended, rather than on decision accuracy. In the face of increasing information search costs, the decision maker who values effort would change his or her information search behavior to reduce effort or decision time. That is, information search (the amount of data examined) would be significantly reduced when there is a delay and thus decision accuracy might suffer.

Previous research suggests decision makers often place more value on effort expended than potential benefit received [22, 31, 46]. In general, decision makers tend to minimize effort rather than preserve accuracy [55, 56]. In the face of increased cost or effort for information search, they tend to adopt effort-minimizing strategies that reduce the amount of information examined before making a decision [6, 7, 21, 25, 48, 55].

Information search on the Web

Most prior research on information search has examined situations in which information is presented in one large pool of information (e.g., [10, 55, 56]). On the Web, information is typically organized in pages or subsets of information. Rather than retrieving information directly, decision makers typically access information one page at a time. Once a page is displayed, decision makers have access to all the information it contains.

In situations in which information is available in one large pool, the cost to access any specific piece of data is relatively uniform; retrieving one data point costs about the same as retrieving another. On the Web however, additional costs are incurred in moving from page to page. Acquiring data located on another page costs more than acquiring data on the currently displayed page, so information search costs are not uniform.

The information foraging theory has recently been advanced as an explanation of information search choices [41]. Based on optimal foraging theory, information foraging theory draws parallels between the complex behaviors associated with foraging activities in the wild and information foraging choices in information environments. In both cases, the goal of the forager is to maximize the utility returned per unit of effort. Common to other optimization models, optimal foraging theory includes an actor and three factors: a strategy set, currency, and constraints [41, 45].

A *strategy set* specifies all of the choices or decisions available to an actor at any point in time. *Currency* includes the costs and benefits of a decision or activity including the activities associated with the actual expenditures of time and energy such as tracking, pursuing, and consuming the prey. Foraging costs also include opportunity costs (the benefits that could have been achieved by engaging in other activities, but forfeited by engaging the chosen activity). *Constraints* include limits to foraging activities beyond the actor's control. These constraints include both intrinsic constraints (strength, skills, etc.) and extrinsic constraints (terrain, weather conditions, etc.).

Rather than assuming the uniform cost of effort suggested by economic theory [42], information foraging theory assumes greater complexity in both the information environment and cost perceptions. Foraging for information on the Web and foraging for food in the wild share several features. Resources tend to be unevenly distributed in the environment (currency), all foragers have limited time and experience opportunity costs by choosing to exploit one resource over another (constraints), and uncertainty and risk characterize resource procurement [45, p420]. The decision maker then decides on a sequence of pages (strategy) based on varying information value, time constraints, and uncertainty.

Information search on the Web in the presence of delays

Delays increase the cost of information search by making it more costly to move from page to page. Each page can be viewed as a "patch" of information that may be more or less important to the decision maker. Delays represent an "entry fee" for each page retrieved. Thus, in the information foraging "patch model", moving from one page to another requires the information forager to pay an additional entry fee. Backtracking to a previously viewed page essentially doubles the entry fee for that particular page (or triples, quadruples, etc. depending upon the number of times the searcher returns to the same page). Because decision makers tend to adopt effort minimizing strategies [7, 48, 55], the increased cost of accessing Web pages due to response time delays should induce decision makers to reduce the number of Web pages they search.

Like the cost of information, the value of information is also non-uniform. This is analogous to the problem faced by a predator who must select a mix of prey to pursue upon encounter. Information foraging "diet selection" models are concerned with determining the information diet such that the rate of gain of relevant information is optimized. This information profitability (the value of information returned per unit of time) drives not only which information is pursued within the patch but also which patches are foraged [41]. By handling less profitable items in the diet one loses the opportunity to go after more profitable items (i.e., pays an opportunity cost).

As in the case of predators in nature, certain "dietary elements" may be indispensable (high profitability) and thus simply substituting a greater number of lower profitability items may not be an option, no matter how abundant the substitute is in the environment [41]. Because delays do not change the actual distribution of indispensable information, the selection of which high value patches (pages) to pursue should be more or less unaffected by between-patch delays. That is, increased delay cost should reduce the total number of pages searched, but pages deemed as essential examined should remain unchanged.

H1a: In the face of response time delays, decision makers will examine fewer pages of less important information relative to the total amount available.

H1b: In the face of response time delays, decision makers will examine the same number of pages of highly important information relative to the total amount available.

Under the information foraging theory, decision makers will continue to search within a page of information until the marginal benefit of the information they gather exceeds the marginal cost of moving to a new patch to gather more information [41]. Delays increase the marginal cost to move among pages. Therefore, in the face of response time delays, decision makers should gather *more* information on each page they examine. While this is counter-intuitive, consider the impact of the potential need to "backtrack" (i.e., to return to a page to view it again). Without delays, backtracking to gather information missed during a previous visit to a page is inexpensive. As delays increase, the cost of backtracking increases. Decision makers trade off the cost to backtrack against the probability of the need to backtrack. As delay increases, they should spend extra time and effort to acquire more information during the first visit (as "insurance" against backtracking) to minimize the possibility of needing to backtrack (Pirolli and Card, (1999) offer a mathematical presentation of this argument).

H2: In the face of response time delays, decision makers will examine more information on each page.

In summary, in the face of delay, decision makers should reduce the number of pages they search, but *increase* their within-page search. The next question is what is the net effect of this change in search behavior on the total amount of information examined? Do decision makers examine more or less information before making a decision? Because decision makers tend to adopt effort minimizing strategies [7, 48, 55], it follows that as delay increases, decision makers will strive to exert less effort. Therefore, they should examine less information in total:

H2b: In the face of response time delays, decision makers will examine less information in total.

The total time taken to make a decision should be driven by the number of pages searched and the amount of information on each page that is used. It may be that countervailing effects of the decreased number of pages searched and the increased amount of information used on each page will cancel each other out. Decision makers usually strive to maintain the total time they invest in a decision in the face of increasing costs [7, 48, 55]. Nonetheless, the increased time and effort associated with response time delays are likely to increase the total time taken to reach a decision, due both to the slower system and to the increased effort the delays impose.

H3: In the face of response time delays, decision makers will spend more time making a decision.

Decision makers will examine fewer pages and less information before making a decision. Therefore, they are more likely to make worse decisions than those who examine more information:

H4: In the face of response time delays, decision makers will make worse decisions.

METHOD

Subjects

The subjects were 31 MBA students drawn from courses at a large state university and were randomly assigned into two treatments: delay and no delay. Cash prizes were awarded to the subjects making the two highest quality decisions in the least time within each treatment because research has shown such incentives affect decision making effort and accuracy [11]. Post-session debriefing indicated this reward structure provided the desired performance inducement.

Task

Users worked to determine the best location for a fast-food restaurant [cf. 27]. The task was taken from Dennis and Carte [17]. This task asked subjects to select one geographic region in which to locate a fast-food restaurant from a set of 26 regions in the city of San Francisco. Subjects were provided with fictitious information on 14 attributes for each of the 26 city regions (e.g., the number of retail stores in the region, schools, hospitals). The task explicitly assigned each attribute a weighting value reflecting different importance to the decision. The data was organized with the "home page" listing the names of the 14 attributes. Clicking on the link for an attribute presented the user with a page of displaying the numeric values of that attribute for all 26 regions. After returning back to the home page, the user could then click the link to another attribute page. Of the 14 pages of attributes, 4 had a weighting value of 10, making them very important to the decision; four had a medium weighting value of 5, while the remaining 8 had a low importance value of 2.

The experimental task approximates one applicable to both Web site customers and remote employees, asking the decision maker to select the best alternative from a group of similar choices based on information gathered from a browser-based search. This is a typical organizational task, and on the consumer side, approximates relatively infrequent, high-value tasks such as vacation planning or college selection. Although such a task might in practice involve searching multiple Web sites, for simplicity the task was constructed as a multiple attribute, multiple page problem within a single site.

Independent Variable

Because service delay was a primary interest of this study, being able to reliably generate consistent delay times was crucial. In order to do this, a customized “browser” was developed. This browser had the ability to display pages in either a non-delayed mode (approximately 1/2 second response time) or an “acceptable” delay mode (7 second response time). The choice of the specific time used for an “acceptable” delay was guided by the literature; we wanted to select a time that would exceed the minimally perceptible delay time [9] but be less what the literature has noted as “not acceptable” [14, 37, 47, 60]. Several delay times (i.e., 3 seconds, 5 seconds, 7 seconds, 10 seconds) were tested in the lab by the first author, a programmer, and a group of doctoral students to see which objective time delay produced a delay that was subjectively noticeable but still “acceptable.” Based on the literature and the perceptions of the test group, seven seconds was selected as a noticeable but “acceptable” delay. This was further evaluated in a pilot test as described in the section below entitled “Worksheet reliability”.

Procedures

Previous research with decision support systems has suggested the importance of training and practice prior to the measurement of performance [26]. Subjects were first trained to use the browser and then worked through a series of five practice questions requiring them to use the browser in a manner similar to that required for the experimental task. A set of pages containing demographic information about the 48 continental states in the U.S. (e.g., population densities, populations by age groups) was used for the practice session. The practice questions included simple information retrieval (e.g., "What states have fewer than 29 people per square mile?") as well as questions requiring more thought (e.g., "Suppose you were going to establish a major business for retired people. In which states would you consider locating?").

All subjects except two completed all five questions; one omitted writing the answer to one question. The duration of the practice session varied between subjects, as subjects were instructed to take as much time as they wished to become comfortable with the system (typically 10-20 minutes).

Once the subjects had completed the practice session, they proceeded with the experimental task. Subjects were not informed of any time expectations, but all completed the task in less than 30 minutes. After recording their decision, subjects completed a short questionnaire, were debriefed and released.

Dependent variables

The dependent variables were: (1) information search behavior; (2) decision time, (3) decision quality, and (4) satisfaction (as a manipulation check to determine that the delay did not affect satisfaction and was therefore “acceptable”). Information search items were the number of pages examined, the number of data points per page examined, and the time per data point. These were measured using computer log files and a lined worksheet that listed each of the 26 regions down the left side of the page. Subjects were instructed to use this worksheet to record all information they used in making their decision. There were a total of 364 data points (14 attributes by 26 regions). The reliability of the worksheet data was assessed in a pre-test using concurrent verbal processing tracing as described in the next section. The number of data points per page was measured by counting the number of data points entered on this worksheet divided by the number of pages beside which data points were written. A computer log file was used to validate the number of pages displayed, as a second measure of information search. Because there were four pages of high importance, four pages of medium importance and eight pages of low importance, we converted the raw number of pages searched within each category to a percentage within that category for analysis.

The total time taken to make the decision was measured in seconds from the time when the subject began working on the task until he/she recorded his/her decision on a decision form. Decision quality has often been measured by the distance of the subject's choice from the correct solution [6, 18]. In this case, decision quality was measured by dividing the score for the region selected by each subject by the score for the correct region and expressing the result as a percent of the optimal decision. Satisfaction was measured using three seven-point Likert scale items that asked subjects' satisfaction with the computer system, with the process by the system was used, and with the decision the subject made (Cronbach alpha=.70); one male subject failed to complete two of the three items in the measure so his response is not included.

Worksheet reliability

While the use of concurrent verbal protocols (i.e., having subjects state aloud what they are doing as they perform the experimental task) have been advocated as a means of identifying the decision process strategies used by subjects, it is possible that concurrent verbal process tracing may distort subject performance [54]. In this study, we chose to use a less intrusive measure of subjects' decision processes, a worksheet on which subjects recorded information. This worksheet was considered less intrusive because all subjects in the pilot tests chose to use one voluntarily. Another technique was the use of computer logs, but this lacked the precision of the worksheets; when the user requested information on a particular attribute, the data for all regions was displayed on a single page, and thus it was only possible to determine from the computer logs which pages were displayed, not which data points on each page were actually examined.

A pre-test was conducted to assess the reliability of using the subject worksheet as a measure of the number of data points. Eight senior undergraduates served as subjects for this pre-test and were randomly assigned into the delay or no-delay treatment. Two measures were used to assess the reliability of the information entered on the worksheet. First, the “browser” software used for the study produced a log that recorded all attribute data pages retrieved by the subjects and thus it was possible to determine which of the 14 attribute pages were examined by each subject. Second, concurrent verbal process tracing was used. After receiving instruction on using the system, subjects worked through a series of five practice questions to become accustomed to it, and then were given the actual experimental task. After subjects had completed half the practice problems, they were instructed to verbally state what information they were using as well as recording it on the worksheet (there is evidence to suggest verbal process tracing is less intrusive after subjects have some practice working with problems without verbal process tracing [51]). All sessions were audio taped.

The information recorded on the worksheet matched the first measure (logs of pages accessed) for six of the eight subjects (75%). In the other two cases, subjects accessed attribute pages for which no information was recorded on the worksheet. An examination of the audio-tapes revealed that in both cases, the subjects stated that there was no "interesting" information on those pages (i.e., subjects accessed the information, but did not use it in their decisions).

The information on the worksheet matched the second measure (verbal process tracing) for six of the eight subjects (75%). In one case, the subject verbally stated four more data points than were recorded on the worksheet, while in the other case; the subject verbally stated one less data point than was recorded on the worksheet. A total of 205 data points were recorded on the worksheets by all eight subjects, indicating there was an overall 98% match (204 out of 208 data points) between the worksheets and results of verbal process tracing. We concluded the use of the worksheets to record the number of data points had sufficient reliability.

We also asked the four participants in the delayed treatment about their subjective impressions of the time delay. They reported it as noticeable but not unacceptable.

RESULTS

The first step was to determine whether subjects perceived the time delays to be "acceptable"; that is, to determine whether or not there were differences in satisfaction between those who participated in the delay and no-delay treatments. No significant difference in satisfaction was observed between the delay and no-delay treatments (means= 4.76, 5.07; $F(1,28)=0.48$, $p=.494$). We conclude the 7-second delay was seen as "acceptable."

The next step in analyzing the results was to assess the reliability of the worksheets versus the computer logs. Similar to the pre-test, the logs matched the worksheets for 23 out of the 31 subjects (74%), with the remaining logs indicating that subjects accessed more data than was recorded on the worksheets. We conclude that the worksheets were reliable.

The next step was to conduct the statistical analyses of the results. Table 1 presents the means and standard deviations. We used a repeated measures ANOVA analysis to examine the percent of pages accessed in each of the three categories of importance. We found no significant overall main effects due to delay ($F(1,29)=0.49$, $p=.488$). There was a significant main effect due to the level of importance ($F(2,28)=43.52$, $p<.001$) as well as the delay by importance interaction term ($F(2,28)=3.51$, $p=.037$). *All* participants examined *all* of the high importance pages, so the significant differences in search behavior occurred in the medium and low importance pages. Overall, decision makers were more likely to examine high and medium importance pages rather than low importance pages, and these differences were more sharply felt in the presence of delay:

decision makers were less likely to search medium importance pages when they experienced a response time delay. H1a and H1b are supported.

Insert Table 1 about here

ANOVA analysis on the number of data points per page examined found a significant difference due to delay (F(1,29)=7.48, p<.001). Decision makers in the delayed treatment examined more points per page than did those in the non-delayed treatment. H2a is supported. There were no significant difference in the total number of data points examined (F(1,29)=3.81, p=.061) although the difference approached significance in the *opposite direction* from that hypothesized: decision makers faced with response time delays did *not* examine less information and may have examined more information. H2b is not supported.

ANOVA analysis found no significant differences in total decision time (F(1,29)=0.34, p=0.567) or decision quality (F(1,29)=1.00, p=.325). Decision time was, however, significantly affected by the percent of medium importance pages searched (F(1,26)=4.22, p=.050) and the percent of low importance pages searched (F(1,26)=4.39, p=.046), but *not* by the percent of high importance pages searched (because all participants searched all pages), the number of points per page examined (F(1,26)=2.98, p=.096) or the effect of delay over and above these factors (F(1,26)=0.42, p=.525). Decision quality was not significantly affected by any of these factors. Thus, H3 and H4 are not supported.

DISCUSSION

Previous research with undergraduate students suggested decision makers are most likely to minimize effort rather than expend additional cost or effort [7, 55]. Under this theoretical perspective, decision makers should reduce the number of pages they search or examine fewer data points per page. There is evidence that “unacceptable” response time delays of 8 seconds or more in retrieving Web pages do indeed induce users to reduce their information search efforts in this manner. However, our study investigated the effects of an "acceptable" delay of 7 seconds, and found such acceptable delays changed information search behavior in what at first appears to be a counter-intuitive way: an acceptable delay did not decrease information search as has been found previously.

Contrary to the cost-effort perspective underlying the effort minimizing predictions, decision makers experiencing response time delays that increased search costs examined more data points per page (but examined the same number of pages). Recall that the browser had 14 pages of data that the subject could choose to view (one for each attribute), with each page showing 26 data points of information. In the delay treatment, no information was displayed until 7 seconds, at which point the entire page loaded almost instantly. Decision makers with and without delays chose to examine the same number of high importance and low importance pages before making their decisions, but those facing delays examined fewer medium importance pages. Nonetheless, those facing delays examined *more* data points on each page they accessed (that is, recorded the values for more regions (alternatives) within each attribute page). There were no differences in the total time taken, although the more pages and the more points per page examined, the greater the time taken to make the decision. In other words, while reducing the breadth of their information search (in terms of the number of medium importance pages examined), decision makers increased the within-page depth of their search.

Information foraging theory posits that information seekers will modify their strategies in order to maximize their rate of gaining valuable information per unit cost. The information environment is composed of various information sources (or "patches") that differ in terms of the amount of valuable information returned per unit cost of processing. In transitioning from one information source to another, the information forager incurs costs. Like its wildlife counterpart, the information forager will tend to engage in "within-patch" foraging until some point where the perceived benefits of foraging in a new patch outweighs the cost of moving between patches. In our case, the delay increased the costs of moving between information patches (Web pages). As a result, decision makers engaged in higher levels of within-patch (i.e., within-page) foraging resulting in a higher average number data points examined per page.

We had argued that information foragers would attempt to reduce the number of less important pages they examine. Our subjects chose to examine the same number of high importance pages, but examined fewer medium importance pages. As with foragers in nature, certain "dietary elements" may be seen as indispensable to information foragers and thus these elements cannot be ignored [41]. In our case, the importance of the data on each page was stated explicitly in the task: 4 of the 14 pages were very important to the decision, another 4 pages were of medium importance and the final 6 pages were of low importance. *All* subjects in both the delayed and no-delay treatments examined the data on the *all* 4 high importance pages, presumably regarding those pages as indispensable, regardless of delay.

We conclude the information foraging theory explains information search behavior in the face of acceptable delays. When faced with acceptable delays, decision makers tend to act as satisficing information foragers; they increase their search within pages and reduce the breadth of their search by examining fewer pages so that they do not spend more time in the search for information.

Limitations

As with any empirical endeavor, limitations must be taken into consideration when interpreting the data. First, the results obtained here are based on a limited number of graduate student participants and consequently may have failed to capture the full breadth of Web user characteristics such as experience level, socioeconomics, culture and so on. Our MBA student subjects, putatively future managers, may be more or less prone to be "satisficing foragers" than the undergraduate students in prior studies or managers in real organizations [41]. Thus, future research needs to address a wide range of individual and cultural differences not explored here.

Second, the task we used may also have impacted results. Mean quality was extremely high for all treatments, with no statistically significant differences between treatments even though most subjects did not examine all available data. This suggests that the nature of the problem allowed for successful use of noncompensatory decision strategies in which some data is omitted from consideration. It also suggests the task proved sufficiently salient to the subjects to induce them to produce high quality decisions. Thus there exists the possibility that a higher difficulty task (i.e., a greater amount of high value information or time limit on reaching a decision) or a less salient task may have produced different results in terms of decision quality and possibly other outcome variables. Future research should consider additional tasks to increase generalizability.

An additional concern is the method used to assess information use. In order to minimally impact search behavior, the worksheet method was used. This method provided data about which information was recorded, but determining which information was actually cognitively processed and how that information affected the decision requires more intrusive methods. While other studies have used more intrusive methods [e.g., 27, 55], the result is an information search experience which differs considerably from that typically encountered on the Web. Thus, the current research represents a trade-off between the ability to evaluate actual information search behavior and the ability to assess the actual information search strategies used.

Implications for practice and future research

The results of this study have several implications for practitioners. While acceptable delays by definition have negligible impact on satisfaction, they did induce changes in information search behavior. Rather than simply reducing search as previous argued, acceptable delays did not decrease the amount of information examined and may even have increased it. Our results, when combined with the results of Nah and Kim [34] and Todd and Benbasat [56], suggest there may be a curvilinear relationship between cost and adoption of compensatory decision strategies: following information foraging theory, information search within a page increases as the cost to access a page (i.e., delay) increases due to the potential cost associated with the need to backtrack and retrieve overlooked information a second time. We believe that search will increase until some point of inflection, at which time information search would decrease as argued by Todd and Benbasat [56] because of increased costs. Thus, designers face two challenges: 1) avoiding designs that produced delays so long as to result in dissatisfaction and reduced search and 2) managing the changes in information search behavior associated with acceptable delays.

In the latter case, rather than simply reduce effort as in response to acceptable costs, these results suggest that Web site visitors redistribute effort in an attempt to maintain value, searching more information on fewer pages. Following a cost perspective has driven a number firms to offer "text only" versions of their Web site to address the delay issue. Taking an information foraging perspective, these firms should consider both costs and value. That is, information should be partitioned among pages based on connection speed to control costs since search within pages is a function of download time but also tailored based on value, since value also affects search. Given that information search increases with acceptable delays, opportunities exist to increase the visit duration or "stickiness" of Web sites. Along with more apparent methods such as how-to sections and product comparisons to increase visit time [12], selective use of acceptable delays and effective partitioning may offer effective means of *increasing* search and Web site visit durations.

The increased within page search with acceptable delays could potentially be used to improve decision making performance. In theory, delays could be used to selectively focus attention at points within in a Web site to the advantage of both the customer and the firm. For individual decision making, selective implementation of delays might aid comprehension in areas such as Web-based training and decision support systems. For example, deliberately imposing an acceptable delay for pages of important information might encourage the user to more thoroughly examine the information it contains. The selective use of delays may also have the potential to reduce detrimental effects of so-called "hidden profile tasks" of group decision making [50] in which suboptimal choices are made because information common to all group members is stressed while unique information known only to a subset of participants is overlooked. By selectively increasing foraging costs, participants may be more likely to attend to unique information in their search.

While our results were assumed to be due to the information costs of delays, determining the true cost of information is a complex endeavor. Previous research has stressed cognitive costs, but cognitive costs alone failed to explain the current results. Information foraging theory suggests opportunity cost perceptions may affect foraging behavior both within and between information sources. Thus, determining the cost of the information search is a complex task, especially on the Web where data are presented in page views. Additional research is needed to better understand the resource and opportunity cost perceptions, as well as any possible interactions between the two in Web-based information searches.

The present research describes a scenario where equal delays were present across all pages of a site. This uniform delay was used to create the impression of a slowly responding Web site or connection to the Web site. In practice, delays are not uniformly distributed because of variations in page size/complexity. Many firms have opted for very complex home pages with video downloads or java initializations that cause acceptable but noticeable delays. Much of the research on home page complexity has been focused almost exclusively on satisfaction [23, 24, 38]. Future research should also address the potential effect that the high cost of home pages may have on subsequent information search. Furthermore, even thought the site's costs may be "front loaded" the site may be perceived as having many high cost pages. Additional research is also needed to examine how overall site complexity perceptions affect information search.

REFERENCES

[1] N. Ahituv, M. Igbaria, A. Sella, The effects of time pressure and completeness of information on decision making, *Journal of Management Information Systems* 15 (2) (1998). 153-172.

[2] V. Arnold, S. G. Sutton, S. C. Hayne, C. Smith, A. P., Group decision making: The impact of opportunity-cost time pressure and group support systems, *Behavioral Research in Accounting* 12 (1) (2000). 69-96.

[3] C. Babcock, A. Ricadela, Taming the beast, *InformationWeek* (943) (2003). 34.

[4] L. Beach, T. R. Mitchell, A contingency model for the selection of decision strategies, *Academy of Management Journal* 3 (3) (1978). 439-449.

[5] H. Ben Zur, S. J. Breznitz, The effect of time pressure on risky choice behavior, *Acta Psychologica* 47 (2) (1981). 89-104.

[6] I. Benbasat, A. S. Dexter, An investigation of the effectiveness of color and graphical information presentation under varying time constraints, *MIS Quarterly* 10 (1) (1986). 59-83.

[7] I. Benbasat, P. Todd, The effects of decision support and task contingencies on model formulation: A cognitive perspective, *Decision Support Systems* 17 (4) (1996). 241-252.

[8] M. J. Bitner, B. H. Booms, M. S. Tetreault, The service encounter: Diagnosing favorable and unfavorable incidents, *Journal of Marketing* 54 (1) (1990). 71-84.

[9] S. K. Card, T. P. Moran, A. Newell, *The psychology of human-computer interaction*. Hillsdale, N.J.: L. Erlbaum Associates, 1983.

[10] G. J. Cook, An empirical investigation of information search strategies with implications for decision support system design, *Decision Sciences* 24 (3) (1993). 683-697.

[11] E. H. Creyer, J. R. Bettman, J. W. Payne, The impact of accuracy and effort feedback and goals on adaptive decision behavior, *Journal of Behavioral Decision Making* 1 (1) (1990). 1-16.

[12] R. O. Crockett, "Keep 'em coming back: Red-hot rivalry has Web execs working hard to make their sites ``sticky''," in *Business Week*, 2000, pp. EB20.

[13] E. C. Cuneo, Web access provides big payoff, *InformationWeek* (938) (2003). 45.

[14] G. B. Davis, M. H. Olson, *Management information systems : conceptual foundations, structure, and development*, 2nd ed. New York: McGraw-Hill, 1985.

[15] M. M. Davis, How long should a customer wait for service?, *Decision Sciences* 22 (2) (1991). 421-434.

[16] B. G. C. Dellaert, B. E. Kahn, How tolerable is delay: Consumer's evaluations of Internet Web sites after waiting, *Journal of Interactive Marketing* 13 (1) (1999). 41-54.

[17] A. R. Dennis, T. A. Carte, "Using geographical information systems for decision making: Extending cognitive fit theory to map-based presentations," in *Information Systems Research*, vol. 9, 1998, pp. 194-203.

[18] G. W. Dickson, G. DeSanctis, D. J. McBride, Understanding the effectiveness of computer graphics for decision support: A cumulative experimental approach, *Communications of the ACM* 29 (1) (1986). 40-47.

[19] L. Dube-Rioux, B. H. Schmitt, F. Leclerc, Consumers' reactions to waiting: when delays affect the perception of service quality, *Advances in Consumer Research* 16 (1998). 59-63.

[20] A. Durrande-Moreau, Waiting for service: ten years of empirical research, *International Journal of Sercive Industry Management* 10 (2) (1999). 171-189.

[21] A. Edland, O. Svensen, Judgment and decision making under time pressure, in: *Time pressure and stress in human judgment and decision making*, O. Svensen,J. A. Maule, Eds. New York: Plenum, 1993, pp. 27-40.

[22] H. J. Einhorn, R. M. Hogarth, J. S. Demski, R. J. Swieringa, Behavioral Decision Theory: Processes of Judgment and Choice/Discussion of Behavioral Decision Theory, *Journal of Accounting Research* 19 (1). 1.

[23] G. Geissler, G. Zinkhan, R. T. Watson, First impressions: Key design considerations for Web home pages to facilitate relationship marketing online, presented at Research conference on relationship marketing, Relationship marketing in the new millennium: Theory, methods and tools., Atlanta, GA, vol, 2000, pp

[24] G. Geissler, G. Zinkhan, R. T. Watson, Web home page complexity and communication effectiveness, *Journal of the Association for Information Systems* 2 (2) (2001). 1-46.

[25] M. I. Hwang, Decision making under time pressure: A model for information systems research, *Information & Management* 27 (4) (1994). 197-203.

[26] S. L. Jarvenpaa, G. W. Dickson, Graphics and managerial decision making: Research based guidelines, *Communications of the ACM* 31 (6) (1989). 764-774.

[27] A. S. Karim, J. C. Hershauer, W. C. Perkins, A simulation of partial information use in decision making: Implications for DSS design, *Decision Sciences* 29 (1) (1998). 53-85.

[28] K. Katz, B. Larson, R. Larson, Prescription for the waiting in line blues: entertain, enlighten and engage, *Sloan Management Review* 32 (2) (1991). 44-53.

[29] C. Kehoe, J. Pitkow, K. Sutton, G. Aggarwal, J. D. Rogers, "GVU's 10th World Wide Web User Survey," vol. 2000: Graphics Visualization and Usability Center, 1998.

[30] M. Khosrowpour, N. Herman, Web-enabled technologies assesment and management: Critical issues, in: *Managing Web-enabled technologies in organizations: A global perspective*, M. Khosrowpour, Ed. Hershey, PA: Idea Group, 2000, pp. 1-22.

[31] D. N. Kleinmuntz, D. A. Schkade, Information Displays and Decision-Processes, *Psychological Science* 4 (4) (1993). 221-227.

[32] N. J. Lightner, I. Bose, G. Salvendy, What is wrong with the World-Wide Web?: a diagnosis of some problems and prescription of some remedies, *Ergonomics* 39 (8) (1996). 995-1004.

[33] F. H. Nah, A study of Web user's waiting time, presented at Information Resources Management International Conference, Anchorage, AK, vol, 2000, pp 146-161.

[34] F. H. Nah, J. Kim, World Wide Wait, in: *Managing Web-enabled technologies in organizations: A global perspective*, M. Khosrowpour, Ed. Hershey, PA: Idea Group, 2000, pp. 146-161.

[35] A. Newell, *Unified theories of cognition*. Cambridge, MA: Harvard University Press, 1990.

[36] J. Nielsen, "Response times: The three importants limits," vol. 2000: Nielsen Norman Group, 1993.

[37] J. Nielsen, "Top ten mistakes in Web design," vol. 2000: Nielsen Norman Group, 1997.

[38] J. R. Otto, M. K. Najdawi, K. M. Caron, Web-user satisfaction: An exploratory study, *Journal of End User Computing* 12 (4) (2000). 3-10.

[39] J. W. Payne, J. R. Bettman, E. J. Johnson, *The adaptive decision maker*. New York: Cambridge University Press, 1993.

[40] J. W. Payne, J. R. Bettman, M. F. Luce, When time is money: Decision behavior under opportunity-cost time pressure, *Organizational Behavior and Human Decision Processes* 66 (2) (1996). 131-152.

[41] P. Pirolli, S. K. Card, Information foraging, *Psychological Review* 106 (4) (1999). 643-675.

[42] R. W. Pollay, The structure of executive decisions and decision times, *Administrative Science Quarterly* 15 (4) (1970). 459-472.

[43] S. Reinhard, H. Heinz, Stress caused by waiting: A theoretical evaluation of a mathematical model, *Journal of Mathematical Psychology* 41 (3) (1997). 280-286.

[44] G. Saad, Information reacquisition in sequential consumer choice, *Advances in Consumer Research* 25 (1998). 233-239.

[45] P. E. Sandstrom, An optimal foraging approach to information seeking and use, *Library Quarterly* 64 (4) (1994). 414-449.

[46] D. A. Schkade, D. N. Kleinmuntz, Information Displays and Choice Processes - Differential- Effects of Organization, Form, and Sequence, *Organizational Behavior and Human Decision Processes* 57 (3) (1994). 319-337.

[47] B. Shneiderman, Direct manipulation: A step beyond programming languages, *Computer* 16 (8) (1983). 57-69.

[48] J. F. Smith, T. R. Mitchell, L. R. Beach, A cost-benefit mechanism for selecting problem-solving strategies - some extensions and empirical tests, *Organizational Behavior and Human Performance* 29 (3) (1978). 370-396.

[49] C. Speier, J. S. Valacich, I. Vessey, The influence of task interruption on individual decision making: An information overload perspective, *Decision Sciences* 30 (2) (1999). 337-360.

[50] G. Stasser, Information salience and the discovery of hidden profiles by decision-making groups: A 'thought experiment', *Organizational Behavior and Human Decision Processes* 52 (1) (1992). 156-181.

[51] D. N. Stone, D. A. Schkade, Numeric and linguistic information representation in multiattribute choice, *Organizational Behavior and Human Decision Processes* 49 (1) (1991). 22-41.

[52] S. Taylor, The effects of filled waiting time and service provider control over the delay on evaluations of service, *Journal of Academy of Marketing Science* 23 (1995). 38-48.

[53] D. Teeni, Perceived Costs and Benefits As Determinants of User Behavior - an Experiment With Matchmaking, *Behaviour & Information Technology* 9 (1) (1990). 31-45.

[54] P. Todd, I. Benbasat, Process tracing methods in decision support systems research - exploring the black-box, *MIS Quarterly* 11 (4) (1987). 493-512.

[55] P. Todd, I. Benbasat, The use of information in decision-making: An experimental investigation of the impact of computer-based decision aids, *MIS Quarterly* 16 (3) (1992). 373-393.

[56] P. A. Todd, I. Benbasat, Evaluating the Impact of DSS, Cognitive Effort, and Incentives on Strategy Selection, *Information Systems Research* 10 (4) (1999). 357-377.

[57] G. Tom, S. Lucey, Waiting time delays and customer satisfaction in supermarkets, *Journal of Services Marketing* 9 (5) (1995). 20-29.

[58] I. Vessey, The effect of information presentation on decision making: A cost-benefit analysis, *Information & Management* 27 (2) (1994). 103-117.

[59] J. Vijayan, Best in class: Application framework allows easy portal access, *Computerworld* 37 (8) (2003). 51.

[60] Zona Research, "Estimated $4.35 billion in ecommerce sales at risk each year," vol. 2000: Zona Research, 1999.

Table 1 Means and Standard Deviations

	No Delay		Delay	
	Mean	Std	Mean	Std
Information Search				
Percent of High Importance pages examined	100%	0%	100%	0%
Percent of Medium Importance pages examined	86.7%	35.2%	56.3%	51.2%
Percent of Low Importance pages examined	20.0%	41.4%	31.3%	47.9%
Number of data points examined per page	6.54	3.63	12.18	7.15
Total number of data points examined	67.13	39.90	95.06	39.77
Time				
Total decision time	621.93	371.51	765.69	383.78
Decision Quality				
Percent of optimum solution	99.26%	1.25	98.46%	2.91

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