Information Search on the Web:
Understanding the Impact of Response Time Delays with Information Foraging Theory

Nolan J. Taylor
Kelley School of Business
Indiana University
Indianapolis, IN 46202
notaylor@iupui.edu
317-274-0185
Fax: 317-274-3312

Alan R. Dennis
Information System Department
Kelley School of Business
Indiana University
Bloomington, IN 47405
ardennis@indiana.edu
812-855-2691
Fax: 812-855-4985

NOLAN J. TAYLOR is an Assistant Professor of Computer Information Systems in the Kelley School of Business at the Indiana University, Indianapolis. He received his Ph.D. in MIS from the Terry College of Business at the University of Georgia in 2001. His research interests include security and computer-aided decision making. His research has appeared in such journals as Journal of Management Information Systems and Information System Research.

ALAN R. DENNIS holds the John T. Chambers Chair of Internet Systems in the Kelley School of Business at Indiana University. His research focuses on the use of computer technologies for decision making, team collaboration, and knowledge management. He is the Publisher for MIS Quarterly Executive and serves on the editorial boards of Journal of Management Information Systems and Journal of the Association for Information Systems.

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ABSTRACT

Delays are among the most frequently cited complaints of Web users. Long delays often cause users to abandon their searches, but do tolerable delays affect information search behavior? Intuitively, we would expect that delays should induce decreased information search. Prior research in non-Web environments shows that as delay increases, decision-makers tend to minimize effort by reducing information search and let decision quality slip. In contrast, information foraging theory suggests that decision makers in multi-page environments such as the Web would react to by searching more *within* each Web page. We conducted two experiments and, consistent with information foraging theory, we found that modest delays induced increased within-page information search but decreased between-page search; that is, tolerable delays increased the depth of search but decreased the breadth of search. In other words, tolerable delays, those that are noticeable but not long enough to cause the abandonment of search, will increase the "stickiness" of Web pages such that users will examine more information on each page before moving to new pages. The net impact of tolerable delays was counter intuitive: tolerable delays had no impact on the total amount of data searched in the first experiment, but induced users to examine more data points in total in the second experiment. Interestingly, there were no impacts on decision time, perceived effort or decision quality.

Subject Areas: *Internet, time, delay, service delays, information search, information foraging, stickiness, decision making.*

INTRODUCTION

The World Wide Web is an important component in many types of information systems. Inside organizations, the growing push for thin-client architecture has increased the importance of the Web as the interface for supporting decision makers both internal and external to the firm. Of particular interest are the external decision makers including sales personnel, traveling staff, telecommuters and the firm's most important decision makers, its customers (Colman 2003; Thibodeau et al. 2004). Despite its popularity, the Web interface is not without problems.

Delays are one of the most highly publicized and highly researched aspects of the Web (Kehoe et al. 1998; Khosrowpour et al. 2000; Lightner et al. 1996). 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 (Sliwa 1999). Long delays also result in fewer pages being viewed at a site (Wonnacott 2000) resulting in low ad revenues. As a result, many sites offer "low bandwidth" or "text-only" versions of their primary sites to reduce the delay in retrieving pages.

While many have suggested that broadband will eliminate delays of this nature, this presupposes that Web delays are all network related. In many cases, delays can be reduced but not completely eliminated because of factors not directly related to the network connection. While some delays are related to bandwidth, delays may also be related to processing necessary on the client and/or server (Galletta et al. 2004; Rose et al. 2001). These processing delays are due to client-side factors such as browser plug-in initialization and HTML table rendering or server side issues such as database operations and their impact similar to those from network delays.

On the network side, high cost and limited availability result in broadband access for a minority of Internet users. Network traffic continues to exceed the upgrades in the network bandwidth leading some to predict that delays will continue to be a concern for many years to come (Sears et al. 2000). Thus, whether due to network delays or processing delays, a site may still consist of several pages with "tolerable" delays in the presentation of information. Theses delays, while noticeable, do not result in the decision maker abandoning the task but may change search behavior.

Several theories have been advanced for explaining changes in search behavior in the face of greater difficulty/effort as is the case with delays. Cost-benefit theory assumes the seeker's motive is to maximize gains (weighted benefits – weighted costs). The theory suggests that in order to maximize gains, 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 (Benbasat et al. 1996; Karim et al. 1998; Smith et al. 1978; Teeni 1990; Vessey 1994).[1] Such effort reduction may impair the decision quality because decision makers may make decisions based on incomplete information (Benbasat et al. 1986; Edland et al. 1993; Hwang 1994). When applying cost-benefit theory to the Web, it is unclear whether this effort reduction will come in the form of reduced number of pages searched or reduced within-page search. These effort reduction strategies can have markedly different impacts on decision quality.

More recently, information foraging theory has been posed as a complementary view of information search behavior (Pirolli et al. 1999). In the "hunt" for information, information sources in the decision maker's environment will vary in terms of value and relevance. Information sources can be viewed as foraging "patches" of varying importance. Rather than effort reduction, "informavores" (i.e., information carnivores) seek to maximize the gains of information per unit

[1] There are however notable exceptions to this effort minimizing maxim. For example, accuracy is the objective when the results of an effort are irreversible (such as a surgeon performing brain surgery). Or similarly, when the task is particularly salient (for example, choosing the name of one's first born child) (Beach, 1978) .

cost (Pirolli et al. 1999, 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, increased delay may actually *increase* search, as the cost of returning to a page increases.

This paper reports the results of two experiments examining the impact of *tolerable* delays on information search and decision making in a Web environment. The impact of intolerable delays, those long enough to cause users to abandon their searches is well known; we know far less about how more modest, tolerable, delays impact users' search behavior, and ultimately, decision making performance. The literature review 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 based on information foraging theory. We then present the methods and results for the first experiment. After discussing these results, we present one additional hypothesis and then the methods and results for the second experiment. The final section discusses the overall pattern of results and draws implications for future research and practice.

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 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, information search, and then examine how delays can affect search behavior by changing the perceptions of the cost and effort required to perform the task.

Basic assumptions on service delays

Delays are unquestionably a key source of customer dissatisfaction across a number of services (Bitner et al. 1990). Research has noted an inverse relationship between performance evaluations and delays in a number of services areas including restaurants (Dube-Rioux et al. 1998), banks (Katz et al. 1991), airlines (Taylor 1995), grocery stores (Tom et al. 1995), fast food service (Davis 1991) and Internet usage (Kehoe et al. 1998; Khosrowpour et al. 2000; Lightner et al. 1996).

Delays may produce a sense of time pressure (Arnold et al. 2000; Payne et al. 1996) and produce a psychological burden termed disutility, stress, or dissatisfaction (Reinhard et al. 1997). For example, traffic delays have been associated with the psychological condition known as road rage. This dissatisfaction may blind the motorist to other positives of the commute – perfect weather, recently completed roadway resurfacing, median beautification projects, etc. Unlike traffic delays where the time can be filled with other activities, delays on the Web are interspersed throughout the task making such filler tasks impractical. As a result, Web delays have been noted as a key source of dissatisfaction. Download times as short as 30 seconds have been associated with negative evaluations (Dellaert et al. 1999). 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 (Nah et al. 2000). More recently, a number of other studies have investigated responses to tolerable waiting time (TWT) on the Web and collectively have confirmed this delay-dissatisfaction link (Galletta et al. 2004; Nah 2004; Palmer 2002; Rose et al. 2003; Rose et al. 2001; Weinberg 2000).

For any specific objective measure of time delay, the subjective interpretation of the delay (whether long or short) will vary from individual to individual and context to context (Katz et al. 1991). The relationship between delays and their subjective interpretation is likely a non-linear step function; miniscule delays (e.g., less than 2 seconds) are often overlooked but once some threshold is reached (e.g., 7-10 seconds), perceptions of delay change and remain constant until another threshold is reached (e.g., 20-30 seconds) when they change again, and so on (Card et al. 1983; Galletta et al. 2004; Nielsen 1997). Delay perceptions can be intensified by task characteristics such as task complexity (Speier et al. 1999) and closeness to completion (Hui et al. 1998). The presence of filler activities such as background music or progress indications (typical of software installation) can be used reduce but not completely eliminate the impacts of delays (Cameron et al. 2003; Taylor 1995). We hypothesize:

H1: Satisfaction will decrease as response delays increase.

Rather that attempt to quantify the boundary of tolerable and intolerable wait periods, our goal is to quantify behavior during delay periods that are deemed tolerable by the user. This class of delays (which we refer to as tolerable delays) are not so long that the decision maker abandons the task but long enough to be noticeable. 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 tolerable delays that can have a significant impact on performance. Thus, the critical question is “how do tolerable delays impact information search behavior?”

Cost-Benefit theory and information search

Different decision makers may choose to search for information in different ways and to devote more effort or less effort into the information search process depending on the situation. One factor that has been shown to influence the breadth and depth of information search is the effort or cost of the information search (Todd et al. 1992).

Delays increase the real and – more importantly – the perceived cost of information search because search takes longer as delays increase. As the cost of information search due to delay increases, decision makers often trade off the amount of effort to be spent with the benefits they expect as a consequence of the effort expenditure (Beach et al. 1978; Todd et al. 1999). Decision makers can react in one of two basic ways (Todd et al. 1992; Todd et al. 1999). At one extreme, 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 (i.e., the amount of data examined) would not differ significantly between modest delayed and non-delayed cases – and thus neither should decision accuracy – but the amount of time taken would increase.

At the other end of the spectrum, 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 tolerable delay and thus decision accuracy could suffer.

Previous research suggests that decision makers often place more value on effort expended than potential benefit received (Einhorn et al. 1981; Kleinmuntz et al. 1993; Schkade et al. 1994). In general, decision makers tend to reduce effort rather than maximize accuracy (Todd et al. 1992; Todd et al. 1999). In the face of increased costs of information search due to tolerable delays, they tend to adopt effort-minimizing strategies that reduce the amount of information examined before making a decision (Benbasat et al. 1986; Benbasat et al. 1996; Edland et al. 1993; Hwang 1994; Smith et al. 1978; Todd et al. 1992). That is, because of effort reduction, decision makers strive to spend a consistent amount of time and effort regardless of whether they are faced with tolerable delays or not. Therefore:

H2: Decision time will not be affected by the magnitude of response delays.

H3: Perceived effort will be not be affected by the magnitude of response delays.

Information foraging theory and information search

Prior research on information search has examined situations in which information is presented in one large pool of information (e.g., Cook 1993; Todd et al. 1992; Todd et al. 1999). That is, the information was presented in a single two-dimensional grid with a large number of intersections, with each intersection representing a unique data point. 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 data points it contains.

In situations in which information is available in one large “pool” organized on a single page grid, 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.

Information foraging theory has been advanced as an explanation of information search choices when the cost to retrieve information is not uniform (Pirolli et al. 1999). Based on optimal foraging theory, information foraging theory draws parallels between the complex behaviors associated with food foraging activities in the wild and information foraging in information environments. In both cases, the goal of the forager is to maximize the utility per unit of effort.

Common to other optimization models, information foraging theory includes an actor and three factors: a strategy set, currency, and constraints (Pirolli et al. 1999; Sandstrom 1994). A strategy set specifies all of the choices or decisions available to an actor at any point in time. Currency includes the net benefit of a decision or activity. Benefits are typically a function of information importance to the decision process as well as the novelty of the information (Sandstrom 1994). That is, the same information will have lower currency when encountered a second time, regardless of its importance level. Costs include the activities associated with the actual expenditures of time and energy. These costs can further be divided into search costs (tracking and location of the prey (i.e., information)) and handling costs (energy expected to capture, process, and consumer the resource). 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, both intrinsic constraints (e.g., strength, skills) and extrinsic constraints (e.g., terrain, weather).

In information search, for example in a digital library, strategy includes how the information will be pursued (newest to oldest, abstracts then the full-text if the abstract is on-target but insufficient, etc.). On the cost side, currency includes the navigation necessary to locate the information and "consumption" of the information. Benefits are what knowledge can be gained from the information source. An older document may be more important (i.e., a "must read") because it is more frequently cited but lower novelty because its information is included in citing works. Constraints refer to limitations in access rights (full text may not be available for a particular source), access ability (certain source formats may not be viewable on a particular machine), and/or personal (the source may be too technical for the reader). Because knowledge of currency and constraints may be gained as a result of the search process, strategies may change over the course of the task as a result.

Rather than assuming the uniform cost of effort suggested by economic theory (Pollay 1970), 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 (Sandstrom 1994, p420). The decision maker then decides on a sequence of pages (strategy) based on varying information value, time constraints, and uncertainty. Though there are a number of decisions the forager must make to achieve this optimal prey mix, the two principle decisions include what to consume (prey choice and diet breadth), and where to hunt (time allocation and patch choice). Inclusion in a forager's diet is informed by the information's "scent" - perceptions of the value and cost of information (Pirolli et al. 1999). With a strong scent, a forager can make the correct decision about whether information should be "consumed". Otherwise, the consumer may choose to ignore it or consume it on the basis of opportunity costs (it might be important so I'd better read it). The information diet model suggests that foragers will favor prey with the highest profitability (benefit – cost). The diet will be narrow when high profitability information is readily available and will be broader (to include lower profitability items) when high profitability information is scarce (Sandstrom 1994).

Where to hunt involves a similar set of decisions. Once in a "patch" a forager must decide whether to continue to hunt within the patch or to seek prey in a different patch. These patch models are concerned with modeling the optimum time allocation (within-patch and between-patch) in order to maximize the currency gained per unit of effort. Strategies range from sampling all patches to determine the most profitable ones (i.e., “matching”) to foraging a single patch until it appears to be more profitable to hunt elsewhere (i.e., “momentary maximization”) (DiClemente et al. 2003).

Information foraging 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)[2]. Delays increase the cost of performing a task by extending the time required to complete it. Because decision makers tend to adopt effort minimizing strategies (Benbasat et al. 1996; Smith et al. 1978; Todd et al. 1992), the increased cost (i.e., time) of accessing Web pages due to tolerable response time delays should induce decision makers to reduce the number of Web pages they search.

H4: The number of pages searched will decrease as response time delays increase.

Under the information foraging theory, decision makers will continue to search within a page of information as long as the marginal benefit of the information they gather exceeds the marginal cost of moving to a new patch to gather more information (Pirolli et al. 1999). Delays increase the

[2] Although caching technologies such as browser caching or proxy server solutions can mitigate delays in successive retrievals of the same page, some pages must be downloaded anew because they have short expiration periods or can not be cached due to security settings or limited memory, especially in handheld mobile devices. Furthermore, caching only addresses delays that are a function of network download rather than the page rendering process.

marginal cost to move among pages. Therefore, in the face of tolerable response time delays, decision makers should gather more information on each page they examine because the cost to move to a new page is higher. 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 with fewer alternative comparisons via backtracking (i.e., revisiting known information) (Saad 1998).

The decision of whether to examine a previously viewed page (i.e. backtrack) is a function of both the cost to backtrack and the value of the information for that particular page (i.e., its importance). As delay increases, information foragers 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). Therefore:

H5: The amount of information examined per page will increase as response time delays increase.

The adoption of effort reducing strategies can have a number of undesirable consequences. Returning to our traffic delay example, the delayed motorist might engage in risky behavior such driving faster and/or parking illegally to reduce the walking distance to the final destination. Such situations can also lead to the need to “decompress” afterwards and thus may also have effects which carry over long past the actual delay. In decision making, delays have been shown to induce decision makers to switch to simpler, noncompensatory decision rules (Payne et al. 1993) and to significantly reduce decision making performance (Ahituv et al. 1998; Durrande-Moreau 1999; Nah 2000). In the present case, we posit that decision time will not vary with delay (H2). The net result is that as the time is “eaten away” by tolerable delays and as fewer pages are searched, decision makers should make poorer decisions. Therefore:

H6: Decision quality will decrease as response delays increase.

EXPERIMENT 1

Subjects

123 students from an introductory information systems class at a large state university participated in this experiment. Males comprised 68% (73) of this sample. As a participation incentive, each subject received extra credit (10 points on a 1000 point scale). As a performance incentive, subjects were instructed that the person arriving at the correct choice in the shortest amount of time in each treatment would receive a $50 prize.

Treatments

Subjects were randomly assigned to one of four between-subject factorial design treatments that imposed different delay times (0, 4, 7, or 11 seconds). The question of what constitutes a “long” delay and a “tolerable” delay has been posed in prior research. This research suggests that the threshold between long and tolerable delays for Web page transitions is in the range of 7-10 seconds. From a cognitive standpoint, 7 seconds represents the upper bound of working memory (Card et al. 1983). Practitioners have suggested 10 seconds (Nielsen 1997) and the oft-quoted “8 second rule” (Sliwa 1999) as the thresholds for long delays. Similarly, Shneiderman (1983) and Davis and Olson (1985) argue that a reasonable upper bound for response time is around 10 seconds. Delays of less than 8-10 seconds in accessing individual pages have typically been interpreted as perceptible but tolerable delays (Newell 1990; Nielsen 1993), although in some cases, even delays of 2 seconds impact behavior (Galletta et al. 2004). The goal in selecting the specific time delays used in this experiment was to have a range of “tolerable” delays.

Task

Subjects were asked to select the best digital camera from a set of 20 cameras for use by a department that had a defined set of selection criteria. In this way, the task resembled both a consumer task involving relatively infrequent, high-value decisions (such as major purchases or vacation planning) as well as a business task where a number of Web sites/online databases need to be consulted in order to select the best alternative from a group of similar choices.

A Web site was designed to present the camera information as well as to record page search data. Several camera ratings sources including Consumer Reports, shopping.com, and epinions.com were consulted in the design of the camera attributes used in this task. We designed the task such that the camera attributes specified as high importance in the task were also those that these sites identified as the important criteria used in the selection of a camera for personal use.

Subjects were provided with information on 16 attributes for each of the 20 fictitious cameras. The task explicitly assigned each of the attributes one of three weighting values reflecting different importance to the decision. Of the 16 attributes, 4 were assigned a high importance weighting value of 70, making them very important to the decision; 8 had a medium weighting value of 25, and the remaining 4 had a low importance value of 5. Appendix 1 provides selected portions of the task materials provided to subjects. From these 16 attributes, 20 alternatives were created based on the actual attribute levels of several popular name brand digital cameras.

The Web site presented the camera information organized by alternative in 20 pages with one page for each camera, labeled camera A, camera B, camera C, etc. The information was organized with a “home page” that linked to the information pages for the 20 cameras. Clicking on the link for a camera presented the user with a page of displaying the values of the attributes for that camera. After returning to the home page, the user could click links to view other camera pages.

For each page examined, subjects were free to use any and all information displayed on that page. Subjects were given a paper worksheet to write down the information that they wanted to use. The worksheet consisted of a single sheet of paper with all of the alternatives listed down the left margin with space on each row for recording attribute information.

Imposed delays (0, 4, 7, or 11 seconds) were implemented via dynamic HMTL (DHTML). In each case, the page title initially appeared. The remainder of the information on each downloaded information page was initially invisible and was made visible at the expiration of scripted timer. The imposed delays were implemented via a script that executed in each information page prior to its display. Thus, the delay only occurred between the transitions *from* the home page to an information page (i.e., one direction only). In the opposite direction (from information page to home page), the home page appeared immediately.

Dependent Measures

Dependent variables included measures in six separate areas: decision time, decision quality satisfaction, perceived effort, number of pages searched, and the amount of information examined per page.

The decision time was the average time subjects spent examining each page (after removing the 4, 7, or 11 second system imposed delay). Decision quality was measured via a single item coded as 1 for a correct solution and 0 for an incorrect solution.

Satisfaction was assessed via a post-session questionnaire using 7-point scale items taken from McKinney, Yoon, and Zahedi (2000). Cronbach's alpha for these four items was .92. Perceived effort was measured via a post-session questionnaire using a modified version of the NASA-TLX (NASA Task Load Index) developed by Fisher and Ackerman (1998). Cronbach's alpha for the six-item construct (7-point scales) was .88. Appendix 2 provides the items for these measures.

Number of pages searched was measured using the number of pages examined as recorded in the computer logs. This figure was calculated by counting all of the information pages accessed, (not counting multiple accesses of the same page); that is, how many of the 20 unique pages did the subject examine (remember that there were 20 pages in total, one for each camera). The amount of information examined per page (the number of data points examined per page) was calculated by counting the number of data points written by each subject on a paper worksheet they received to assist them in performing the task. The total number of points recorded was divided by the number of pages to produce the average number of points examined per page. The validity and reliability of using this paper worksheet to record data point level search are discussed in Appendix 3.

Procedures

Subjects performed the task in groups of up to 16 persons with each group part of the same delay treatment. Within each experimental group, computers were separated by cubicles so that no subject was able to see the progress or the search strategy of other subjects. Subjects signed up for a 90 minute sessions of their choice but were free to go at any time after they completed the post-session questionnaire. All sessions were conducted outside of class time.

Previous research with decision support systems has suggested the importance of training and practice prior to the measurement of performance (Jarvenpaa et al. 1989). Subjects were first trained to use the Web site by completing an apartment selection problem that required them to use the browser in a manner similar to that required for the experimental task. The Web site used in the practice task exhibited the same delay time as the experimental treatment to which the subject was assigned. 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 7-12 minutes).

Once the subjects had completed the practice session, they proceeded with the experimental task. Again, subjects were not informed of any time expectations, but all completed the task in less than 45 minutes.

After recording their decision, subjects completed a questionnaire, were debriefed and released.

Results

As a manipulation check, we asked subjects (on the post-session questionnaire) to estimate the perceived delay. Mean perceived delays for the 0, 4, 7, and 11 second treatments were 1.4 seconds, 3.3 seconds, 7.1 seconds and 7.5 seconds, respectively. An ANOVA analysis of perceived delays found a significant main effect for treatment ($F(3, 119) = 34.1$, $p < .001$). Planned comparisons indicated statistically significant differences between all delay treatment pairs ($p < .05$) except for 7 and 11 seconds ($p=.638$). The results suggest a successful manipulation of delay.

Multiple analysis methods were employed. A multivariate analysis of variance was conducted using all dependent variables (except decision quality, which was a binary dependent variable). Follow-up ANOVAs were used after the MANOVA to identify individual effects. Decision quality was analyzed using cross tabulations (crosstabs). **Error! Reference source not found.** Table 2 presents means and standard deviations.

A MANOVA on the entire group of dependent variables (except for decision quality) found significant effects due to delay (Wilks' $\Lambda=.787$, $F=1.92$, $p=.021$), so follow-up ANOVAs were conducted. Hypothesis H1 posits a decrease in satisfaction as delay increases. An ANOVA found a significant main effect ($F(3,119)=3.23$, $p=.025$) for delay. A Ryan-Einot-Gabriel-Welsch F test found those in the zero-delay treatment to be more satisfied than those in the 11-second delay treatment, but no other differences. H1 is supported.

Hypotheses H2 and H3 argue that that delay will have no effect on decision time and perceived effort. An ANOVA analysis found no significant effects on decision time due to delay

(F(3,119)=1.66, p=0.179). Although the amount of perceived effort appeared to increase with increasing delay, the relationship was not statistically significant (F(3,119)=2.49, p=0.064). As an aside, we note that the power to detect a medium effect size with 30 subjects per treatment was .98. That is, if a relationship exists between delay and the dependent variable, there is a 98% chance that it will be statistically detected. Together hypotheses H2 and H3 results are consistent with an effort minimization perspective as found in prior research.

Hypothesis H4, that the number of pages examined would decrease with increased delay, was supported (F(3,119)=2.90, p=0.038). A Ryan-Einot-Gabriel-Welsch F test found those in the 11-second delay treatment to examine fewer pages than those in the 7-second and those in the zero-delay treatments, but no other differences. H4 is supported.

ANOVA analysis on the number of data points per page examined found a significant difference due to delay (F(3,119)=2.85, p=.040). A Ryan-Einot-Gabriel-Welsch F test found those in the 11-second delay treatment to examine more points per page than those in the other treatments, but no other differences. H5 is supported.

Analysis of decision quality (H6) revealed no statistically significant differences in the mean number of correct solutions per treatment ($\chi^2(3)= 5.16$, p=.161). Thus hypothesis H6 is rejected.

DISCUSSION

The pattern of results in Experiment 1 are generally supportive of information foraging theory, suggesting that it is a useful predictor of Web search behavior in the face of tolerable delays. Subjects did not spend significantly more time or effort as delays increased, instead changing their information search behavior as predicted by information foraging theory. As delays increased, subjects examined fewer pages but more data points per page. Thus while prior research in non-Web environments would suggest a reduction in search efforts in the face of delays, our results, based on information foraging theory, suggests a redistribution of search efforts: *increased* within-page search and *decreased* between-page search. While such increased within-page search may be counter intuitive, it is consistent with information foraging theory. Because the cost to move among pages is higher with greater delays, information foragers search longer within pages.

Our results show a step function in the perception of delays and their impact on behavior. Delays of 4 and 7 seconds reduced satisfaction somewhat similarly compared to the no delay treatment. Delays of 11 seconds further reduced satisfaction and also changed search behavior.

Information foraging on the Web with delays and non-uniform page values

In Experiment 1, each page contained information on a single alternative. In this case, each page essentially had the same potential value because, *a priori*, each camera had an equal likelihood of being the correct choice (on first page visit). However, in many cases on the Web, different pages have different values to the decision. For example, Web search engines typically list results in order of likelihood of matching the user's needs. Thus, links at the top of the page are more "valuable" than links at the bottom. Other common methods include ordering by sales rank (e.g., www.barnesandnoble.com/gateway/bestsellers.asp), number of visits (e.g., www.cnn.com/mostpopular), and customer ratings (e.g., www.imdb.com/chart/top). While Experiment 1 addressed the question of page cost and search, it is unclear how differing page values affect search behavior. Experiment 2 attempts to answer these questions by specifically attaching values to the data pages. We again use information foraging theory to predict the search behavior impacts in the presence of delays.

Like the cost of information, the value of information is also non-uniform. This is analogous to the problem faced by a foraging animal predator in the wild who must select a mix of prey to pursue upon encounter. The academic researcher, a particularly voracious informavore, faces similar choices in the acquisition of information. For example, when conducting a literature search, options range from the more recently published full text HTML or PDF articles to the harder to "catch" but perhaps more highly cited articles which provide abstracts only online so paper copies must be obtained elsewhere. 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 (Pirolli et al. 1999). 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 (Pirolli et al. 1999). This same pattern should be present in Web searches. 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.

H7a: In the face of response time delays, decision makers will examine the same amount of high importance information.

H7b: In the face of response time delays, decision makers will examine a smaller amount of lower importance information.

EXPERIMENT 2

Design

The design of Experiment 2 closely mirrored the design of Experiment 1, with the exception of the manner in which the information was organized and the delay times used. Because no important differences were found between the 4 and 7 second treatments in Experiment 1, the 4 second delay treatment was omitted in this experiment.

138 students at a large state university participated. Males comprised 70% (90) of this sample. As a participation incentive, each subjects received the same extra credit points. As a performance incentive, the subject arriving at the correct choice in the shortest amount of time in each treatment received a $50 prize. Subjects were randomly assigned to one of three imposed delay treatments (0, 7, or 11 seconds) in a between-subject factorial design.

Subjects were instructed to select the best digital camera from the same set of 20 cameras. A Web site similar to that used in Experiment 1 was designed, but differed in the manner in which the information was organized. In Experiment 2, the information pages organized the camera data by the 16 attributes. Each information page contained information on all 20 cameras for that particular attribute. For example, the optical zoom page listed the optical zoom levels for all twenty cameras. The home page listed the 16 attributes grouped by importance level.

The dependent variables in Experiment 2 were identical to those of Experiment 1 (i.e., satisfaction, decision time, perceived effort, number of pages accessed, points considered and decision quality) with the addition of the number of pages in each of the three attribute importance categories. That is, how many of the four high importance pages, eight medium importance pages, and four low importance pages were accessed. Reliabilities for the questionnaire measures (satisfaction and perceived effort) were again adequate (.89 and .90, respectively). Analyses were conducted in a similar manner to Experiment 1. For hypothesis H7, comparison of the number of pages accessed by value was performed using repeated measures ANOVA.

Results

Subjects again were asked to estimate the perceived delay time. Mean delay estimates for the 0, 7, and 11 sec treatments were 1.6 seconds, 5.7 seconds, and 7.0 seconds, respectively. Analysis of the measure of estimated delay revealed a significant main effect for imposed delay ($F(2,137) = 29.2$, $p < .001$). Planned comparisons indicated statistically significant differences between all delay treatment pairs ($p < .05$). The results suggest a successful manipulation of delay.

Error! Reference source not found. Table 3 presents the means and standard deviations. An overall MANOVA found significant effects due to delay (Wilks' Λ=.850, F=2.21, p=.017), so follow-up ANOVAs were conducted. Satisfaction was again found to be related to delay ($F(2,135)=4.78$, $p=.010$); a Ryan-Einot-Gabriel-Welsch F test found those in the zero-delay treatment to be more satisfied than those in the other treatments, but no differences between 7-second and 11-second delay treatments. There were no significant effects on decision time ($F(2,135)=.312$, p=..733) or perceived effort ($F(2,135) =0.81$, $p=.445$). Thus, hypotheses H1, H2 and H3 are supported.

The number of pages accessed was not significantly different in the delayed treatments ($F(2,135)=2.88$, $p=0.060$); H4 is not supported. ANOVA analysis on the number of data points examined per page found a significant difference due to delay ($F(2,135)=3.58$, $p=0.031$). A Ryan-Einot-Gabriel-Welsch F test found those in the 11-second delay treatment to examine more points per page than those in the other treatments, but no differences between the zero-delay and 7-second delay treatments. H5 is supported.

Decision quality was not related to delay ($\chi^2(2)= 3.97$, $p=.138$) leading us to reject H6.

Hypothesis H7 suggests that delays will cause decision makers to reduce their search of lower importance information but will not affect the search of high importance pages. A repeated measures ANOVA found significant effects due to delay ($F(2,135)=4.62$, $p=.011$), due to page importance (whether high, medium or low) ($F(2,405)=38.78$, $p<.001$), and due to an interaction between delay and page importance ($F(4,405)=4.26$, $p=0.002$). These differences were due primarily to a reduction in the number of the lowest value pages searched, although the greatest search reduction was seen for the 7-second delay treatment. Thus, H7 was partially supported.

Under information foraging theory, we would expect decision makers to focus first on the high value pages, then on the medium value pages, and finally on low value pages. There were four high value pages, so we examined the system logs to see if the first four pages searched by each subject were high value pages. We found that of the first four pages read by all subjects, 550 were high value pages and 2 were medium value (these 2 medium value pages were examined by subjects in the 7-second delay treatment). There were 8 medium value pages, so we next examined the first 12 pages examined by all subjects (4 high value + 8 medium value pages)[3], and found that 1473 of these pages were high or medium value pages and 13 were low value (the low value pages were examined by 4 subjects in the zero-delay treatment, 4 subjects in the 7-second delay treatment (who viewed a total of 7 low value pages), and 2 subjects in the 11-second delay treatment). We conclude that subjects were more likely to first search the high value pages, then the medium value pages, and finally the low value pages, and that this pattern was not materially affected by delay.

GENERAL DISCUSSION

Information foraging theory posits that information seekers will modify their information search strategies in the face of increasing search costs in order to maximize their rate of gaining valuable information per unit of search cost. Like its wildlife counterpart, the information forager

[3] Not all subjects examined 12 pages, in which case we examined all the pages they did read.

will tend to engage in "within-patch" foraging until some point where the perceived benefits of moving to and foraging in a new patch of information outweighs the cost of moving between patches. In both of our experiments, subjects changed their search patterns as longer response time delays increased the cost to move between Web pages. As delay increased, subjects searched fewer total Web pages (experiment 1) or fewer lower importance Web pages (experiment 2), but examined *more* information within each page. Table 4 provides a summary of the results

The subjects in our experiments perceived delays fairly accurately, except for the 11-second delay. In both experiments, subjects perceived the delay to be noticeably less than the actual 11 seconds (7.5 seconds and 7.0 seconds). Satisfaction decreased as delay increased, but not drastically; from no delay to an 11-second delay, satisfaction dropped by 20% in Experiment 1 and by 13% in Experiment 2. We conclude that the delays in our experiments were noticeable, but tolerable. This suggests that the conventional wisdom about the length of tolerable delays being about 7-11 seconds is reasonable at least for the tasks and subjects in our studies. While we would all prefer no delays in our Web searches, we tolerate some modest delay with little impact on our satisfaction. Such tolerable delays can, however, induce us to change the way we search.

The time taken to make a decision and the perceived effort expended did not increase as delay increased in either experiment. We interpret this pattern to suggest that tolerable delay did not have material effects on time taken or effect expended for these tasks and subjects.

The pattern of results for information search in Table 4 is consistent across the two studies. We conclude that information foraging theory explains information search behavior on the Web in the face of tolerable delays. When faced with tolerable delays, decision makers tend to act as information foragers; they increase their search within pages and reduce the breadth of their search by examining fewer pages (lower importance pages, if possible) so that they do not spend more time in the search for information. Figure 1 illustrates this pattern. While seemingly counterintuitive, this behavior is frequently encountered. For example, consider the decision whether to read an article online vs. printing the same article. Like our decision Web sites, these articles are multi-page information sources. The greater the need to integrate information located on separate pages (i.e., the need for page transitions), the more beneficial it becomes to print at least some of these pages as a way to reduce the frequency (i.e., cost) of page transitions.

This may also be viewed from a risk perspective. Risk is a function of the probability of occurrence and the consequence of the occurrence (i.e., RISK = Probability x Consequence) (Rainer et al. 1991). Each movement from one page to the next represents a gamble that information not considered on the page you are leaving will not be needed. The *probability* of needing information on a different page is high when the number of pages (and consequently the amount of information not located on the currently viewed page) is large as was the case here. Given that the consequence (*delays* from backtracking and relocating information) cannot be controlled, spending more time examining information on each page is a natural response.

We had also argued that information foragers would attempt to reduce the number of less important pages they examine as delays increased. In Experiment 2, subjects chose to examine all of the high importance pages, but examined fewer lower importance pages as delays increased. As with foragers in nature, certain "dietary elements" may be seen as indispensable to information foragers and thus these elements cannot be ignored.

Tolerable delays affected the nature of information search by increasing the depth of search and decreasing the breadth of search. The net impact of this change was not necessarily an overall decrease in search as found in prior research in non-Web environments (Benbasat et al. 1996; Karim et al. 1998; Smith et al. 1978; Teeni 1990; Vessey 1994). In Experiment 1, subjects in 11 second delay treatment examined more data points in total (167 points vs. 145, 137, and 137 points for the 0, 4, and 7 second delay treatments, respectively), but this difference was not significant ($F(3, 119)= 0.70$, $p= .555$). In Experiment 2, the 11 second delay again induced the greatest total information search (185 points vs. 148 and 137 points for the 0 and 7 second delay treatments, respectively) and the difference was statistically significant ($F(2, 135)= 3.70$, $p= .027$).

Thus, counter to prior research in non-Web environments, our results show that in multi-page Web environments, delay did not reduce information search (experiment 1) and actually increased it (experiment 2). One of the important differences between Experiments 1 and 2 was that in Experiment 2, the relative importance of different Web pages was clear; in Experiment 1, because the pages were organized by alternative not attribute, subjects could not choose to omit lower importance pages. This greater ability to shape the breadth and depth of the information search in Experiment 2 was likely one reason why the differences in total search and the number of pages were differed between treatments in that experiment.

Interestingly, mean decision quality was extremely high for all treatments in both experiments, with no statistically significant differences even though most subjects did not examine all available data. The nature of the tasks allowed for successful use of incomplete decision strategies in which the low value pages were omitted from consideration; however, if subjects omitted the medium value pages, then they were likely to make incorrect choices. It also suggests the tasks proved sufficiently salient to the subjects to induce them to produce high quality decisions. A higher difficulty task (e.g., a higher information load or a 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. A higher information load (and consequently higher perceived effort) would likely result in greater variation in information use (number of pages and points per page) and consequently greater variation in decision time and decision quality. Likewise, a less salient task would also result in greater variation in information use, as less motivated searchers resort to non-compensatory strategies in order to reduce the effort required.

While the results were assumed to be the result of the imposed delays, an alternative explanation is that the intertwined effects of delay and time pressure may have explained the results. That is, the pressures to complete the task before the end of the session (90 minutes) may have created a sense of time pressure. The fact that none of the subjects used the full 90 minutes (most finished in under an hour) suggests that the pressure from the allotted time was not a factor. Similarly, the goal of achieving the lowest completion time to in order to claim the performance prize may have resulted in a sense of time pressure. That is, we cannot rule out with certainty that similar results may have been achieved without delays but by simply manipulating the allotted completion time or the amount of the reward for lowest completion time.

Limitations

Our study suffers from the usual limitations of experimental research. First, the results obtained here are based on a limited number of student subjects and consequently may have failed to capture the full breadth of Web user characteristics such as experience level, socioeconomic status, culture and so on. Business school student subjects may be more or less prone to be “effort minimizers” and/or “information foragers” than either employees in real organizations or actual customers shopping over the Web. Students may be more adept at searching for information on the Web. This higher level of Web-savviness may have muted treatment effects to some degree. Students withstanding, the omission of individual variables did not allow for modeling possible moderation and interaction effects and thus determine under what conditions the results are most applicable. Thus, future research needs to address a broader range of individual and cultural factors.

Task characteristics may have also impacted the obtained results. The task involved a relatively high value product which may have resulted lower sensitivity to the delays imposed. The experimental incentive may have also lessened sensitivity to the delays. This reduced sensitivity may have resulted in reduced treatment effects. In order to increase statistical control, we utilized uniform delays for all information pages where in practice, caching and variations in Internet (network) delays would have resulted in a less consistent pattern. Moreover, subjects were confined to a single Web site where in a real-world case, searchers using a low-performing (i.e., high delay) site may have resulted in task abandonment or at least, the selection of an alternative information source. Finally, in order to amply treatment effects, a relatively large information set (i.e., the number of alternatives x number of attributes) was used.

An additional concern is the particular method used to assess information used. The paper worksheet method was selected in order to minimize potential impacts to search behavior. While providing data about which information was recorded, this method could not be used to determine which information was actually cognitively processed and how that information affected the decision requires more intrusive methods. The current research represents a trade-off between the ability to evaluate actual information search behavior using more intrusive methods (e.g., Karim et al. 1998; Todd et al. 1992) and the ability to assess the actual information search strategies used.

Implications for Future Research and Practice

Notwithstanding the limitations, we believe that this study has several implications for researchers and practitioners. While the tolerable delays in our study had significant but rather modest impacts on satisfaction, they did induce changes in information search behavior. Rather than simply reducing search as previous argued, tolerable delays did not decrease the total amount of information examined and even increased it in the second experiment.

Traditionally, designers have focused on minimizing delay, and as a result, many firms offer "low-bandwidth" versions of their Web site to address the delay issue. However, given the changes in information search behavior that are associated with tolerable delays, this may only address part of the problem with delays. More consideration should be given to the partitioning of information among pages because both within-page and between-page search are affected by delay.

There may also be opportunities to capitalize on delays as means of increasing attention to select areas of a Web site. This increased within page search seen with tolerable delays could potentially be used to improve Web page "stickiness" – as the delay to move to new pages increases, within some tolerable range, users will spend more time reading information within pages, although they will likely decrease the number of pages they visit. This has applications for decision support and Web-based training by increasing the depth of search, at least for *motivated* users. The selective use of delays may also have the potential improving group decision making by reducing the detrimental effects of so-called "hidden profile tasks" (Stasser 1992) in which suboptimal choices are made because information common to all group members is stressed while unique information known only to a subset of subjects is overlooked. By selectively increasing foraging costs, subjects may be more likely to attend to unique information in their search.

While previous research has emphasized cognitive costs, information foraging theory suggests opportunity cost perceptions may also affect foraging behavior both within and between information sources. More research is needed to better understand resource and opportunity cost perceptions, as well as possible interactions between the two in Web-based information searches.

Our data appear to suggest that the impact of delay is non-linear. That is, there is not some gradual and incremental change in behavior as delay slowly increases. Instead, our data would suggest that the impact of delay follows a step function: it has little impact until it reaches some "tipping point," at which point users' perceptions of delays change, triggering a change in search behavior. For the subjects, Web pages, and tasks in these two experiments, behavior changed as delay increased from 7 seconds to 11 seconds, suggesting that the tipping point lies somewhere in the 8-11 second range. This tipping point, of course, only applies for the conditions used in these experiments. It is also quite likely that as delay increases farther, it might reach another tipping point which results in abandoned search (Nah et al. 2000). Future research should investigate the tipping points at which behavior changes for other decision makers, Web pages, and tasks.

In this study, equal delays were present across all pages in order to create the impression of a slowly responding Web site or slower connection to the Internet. In practice, delays are not uniformly distributed because of variations in page size/complexity; some pages experience more delay than others (particularly those with many graphics). Many firms have opted for very complex home pages with animation/video downloads or java initializations that result in appreciable initial delays. Much of the research on home page complexity has been focused almost exclusively on satisfaction (Geissler et al. 2001; Otto et al. 2000). Future research should also address the potential effect that high cost home page downloads may have on subsequent information search on the same site. Additional research is also needed to examine how overall site complexity perceptions affect information search.

The apparent chain of causation – for a given delay and task, variation in delays leads to variations in the number of pages accessed and the amount of data per page examined which in turn may affect decision quality, decision time, perceived effort, and satisfaction suggest several areas for future research. Our tasks provided moderate information load: 16 attributes for 20 cameras and no time pressure. With a higher information load or with time pressure, we believe that subjects would have been more sensitive to delays and would have been more likely to change their search behavior in response to increasing delay. This is an empirical question for future research.

Our tasks provided symmetric information on all alternatives but in practice, decision makers must constantly make decisions with both missing and irrelevant information. Thus, besides the magnitude of the information load, the distribution of the information should be further explored. Future research might also more closely explore information use (i.e., points per page) using more precise research methods (such as eye tracking).

The use of increasingly complex Web content and the growing popularity of lower bandwidth mobile devices promises to make delays an important design concern for some time to come. Based on our results, we believe that information foraging theory is a useful lens for understanding the effects of tolerable delays on Web search behavior. Because delays represent a cost to information search, information foraging theory may also serve as a useful basis for examining other factors affecting Web search, such as complexity which also impose costs on Web search behavior.

Table 1 Digital camera attributes and assigned importance levels

Importance Weight	Attributes	
High Value (70%)	Storage Capacity	
	Versatility	
	Resolution	
	Print Quality	
Medium (20%)	Battery Type	Popularity
	Battery Life	Warranty
	Optical Zoom	Flash Range
	LCD Screen	Price
Low (5%)	Audio Recording and Playback	
	Video Capacity	
	Freeware Photo Editing Software	
	Weight	

Table 2 Dependent variable means (standard deviations) in Experiment 1

	Delay (seconds)							
	0		**4**		**7**		**11**	
H1: Satisfaction	4.99	(1.27)	4.60	(1.44)	4.50	(1.34)	3.98	(1.17)
H2: Decision Time	34.78	(3.56)	42.48	(3.78)	39.56	(4.05)	46.05	(3.85)
H3: Perceived Effort	2.37	(1.00)	2.95	(1.35)	2.88	(1.38)	3.17	(1.25)
H4: Number of Pages	20.00	(0)	19.58	(2.33)	19.96	(0.19)	18.47	(4.05)
H5: Points per Page	7.25	(4.22)	6.84	(4.71)	6.88	(4.39)	11.61	(13.10)
H6: Decision Quality (% correct)	74%		87%		93%		90%	
N (123)	35		31		27		30	

Table 3 Dependent variable means (standard deviations) in Experiment 2

	Delay (seconds)					
	0		**7**		**11**	
H1: Satisfaction	5.15	(1.10)	4.50	(1.03)	4.49	(1.23)
H2: Decision Time	48.18	(3.27)	50.22	(2.92)	51.62	(2.89)
H3: Perceived Effort	2.46	(1.25)	2.62	(1.14)	2.77	(1.04)
H4: Number of Pages	14.67	(1.42)	13.78	(2.64)	14.64	(2.08)
H5: Points per Page	10.02	(6.26)	9.69	(5.48)	12.66	(6.25)
H6: Decision Quality (% correct)	87%		69%		74%	
H7: Relative Page Importance						
Proportion of High value pages searched	1.00	(0.00)	1.00	(0.00)	1.00	(0.00)
Proportion of Med value pages searched	0.98	(0.07)	0.94	(0.19)	0.98	(0.08)
Proportion of Low value pages searched	0.89	(0.29)	0.65	(0.46)	0.82	(0.29)
N (138)	39		49		50	

Table 4 Summary of Results

Hypothesis	Experiment 1 Information Organized by Alternative	Experiment 2 Information Organized by Attribute
H1: Satisfaction will decrease as response delays increase.	**Supported**	**Supported**
H2: Decision time will not be affected by the magnitude of response delays.	**Supported**	**Supported**
H3: Perceived effort will be not be affected by the magnitude of response delays.	**Supported**	**Supported**
H4: The number of pages searched will decrease as response time delays increase.	**Supported**	**Not Supported (See H7a, H7b)**
H5: The amount of information examined per page will increase as response time delays increase.	**Supported**	**Supported**
H6: Decision quality will decrease as response delays increase.	**Not Supported**	**Not Supported**
H7a: In the face of response time delays, decision makers will examine the same amount of high importance information.	Not Tested	**Supported**
H7b: In the face of response time delays, decision makers will examine a smaller amount of lower importance information.	Not Tested	**Supported**

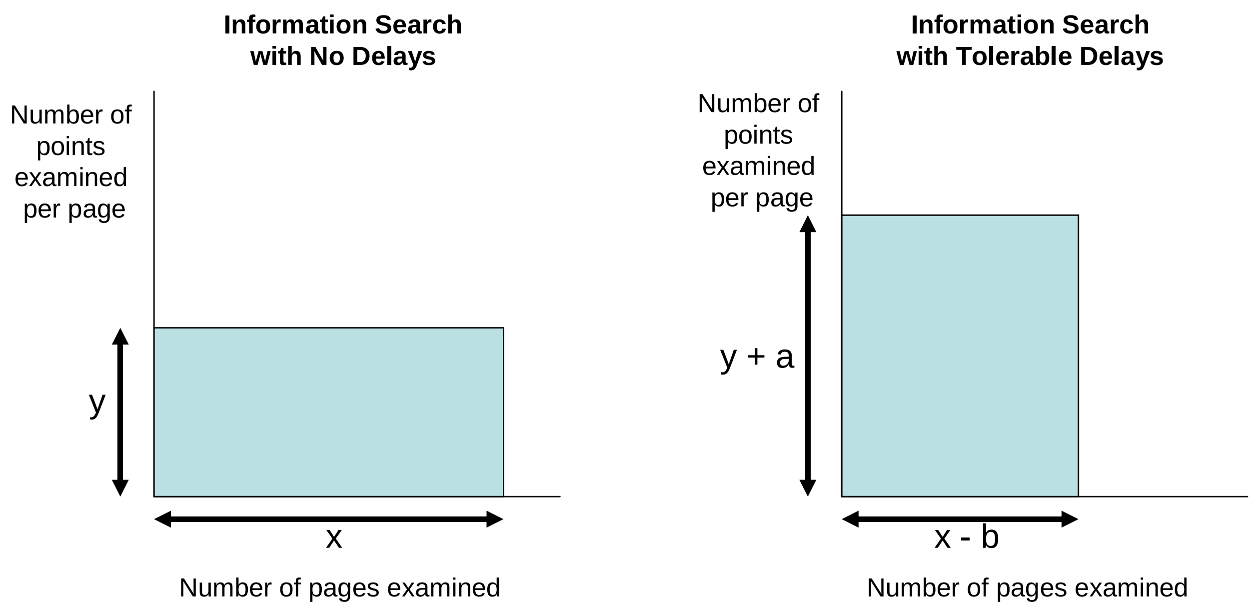

Figure 1: Changing Information Search Patterns

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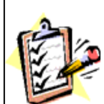
APPENDIX 1: TASK

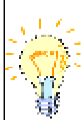
For this problem, you have been asked to select a digital camera for the department. Because the camera will be used to produce content for both the department's Web site and printed media, certain camera features are more important than others. The categories and their relative weighting are as described below.

Critical features (70%):

Because it is the desire of the department to take the best possible pictures, management has identified four factors that are very important selection of the digital camera (the so-called "red factors").

Attribute		Description	Evaluation
	Storage Capacity	This is the amount of memory installed in the camera. The more installed memory, the more photos can be taken before having to delete or upload old photos to make room for new ones.	Higher is better
	Versatility	Flexibility in camera settings rated by a panel of experts on a scale of excellent (highest), very good, good, fair, and poor (lowest). This number includes a wide range of adjustments for best photographs including built-in exposure programs such as night shooting, action, or backlight (to compensate, for example, for the effects of sun behind a subject).	Higher is better
	Resolution	The resolution (expressed in megapixels) is the number of million picture elements (pixels) the image sensor has. The higher the number of megapixels, the greater detail the camera can capture.	Higher is better
	Picture Quality	Reflects the judgments by trained panelists of glossy 8x10 photos made on a high quality inkjet printer. Rated as either excellent (highest), very good, good, fair, or poor (lowest).	Excellent is best

Important features (25%):
In addition, the management has determined that eight additional factors, although not as critical as the four mentioned above, are very important in the selection process. These are:

Attribute		Description	Evaluation
	Battery Type	Batteries can be either rechargeable or non-rechargeable. Because this camera will be used often, rechargeable batteries are the better choice.	Rechargeable is better
	Battery Life	The number of high-resolution photos taken on fully charged battery (or a fresh set of alkaline batteries if the camera uses non-rechargeable batteries). The longer the battery life the lower the chance of missing a good photo opportunity.	Higher is better
	Optical Zoom	Optical zoom is the ability of the camera to increase the size of the resulting photo while maintaining the same distance from the subject. This size increase is expressed in terms of how much larger the maximum size is from the minimum size (e.g., 2X is a factor of 2).	Higher is better
	LCD Screen Size	This is the size (length by width) of the display on the back of the camera. Since the LCD screen is used to preview/review, the larger the LCD screen, the easier the images are to see.	Larger is better
	Popularity	This number is the sales rank based on sales data from the 3 largest digital camera retailers. The relative popularity of the camera is indicated by the number of stars (5 stars maximum).	Higher is better
	Warranty/ Service	This is the length of the factory warranty for the camera in months.	Higher (longer) is better
	Flash Range	Maximum distance from camera (in feet) in low light setting that still results in a high quality photo. Longer flash ranges minimize the chances of taking a too dark photo.	Higher is better
	Price	This is the best price found for the unit including applicable sales tax (and shipping if necessary).	Lower is better

Less important features (5%):
Finally, there are several camera features that are add value to the camera but are not deemed essential (these have been referred to as the "green" features because you have been give the "green light" to purchase a camera without these features). These include:

Attribute		Description	Evaluation
	Audio Recording and Playback	If this feature is available, the camera can capture sound while recording video.	Available is better (than not available)
	Video Capacity	When the camera is used to record video like a camcorder, this is the maximum length of the video (in seconds).	Higher (longer) is better
	Freeware Photo Editing Software	This software allows you to perform so very basic editing (enlarging, cropping, etc.) of your digital photos. This program is public domain and can be downloaded at not cost from the developer’s Web site but is included on CD with some camera models as a convenience to its customers.	Available is better (than not available)
	Weight	This is the weight of the camera including battery and memory card (in ounces).	Lower is better

The department has charged you with the task of evaluating 20 potential digital cameras. Use the links on the Web page to see how the digital cameras scored. When you are ready to make a selection, press the button at the bottom of the page.

APPENDIX 2: MEASURES

Satisfaction

How would you describe your feelings about using the Web site?

- very dissatisfied/very satisfied
- very displeased/very pleased
- frustrated/contented
- disappointed/delighted

Perceived effort

- I felt mentally tired and worn out after using the decision Web site.
- Using the decision Web site was a difficult and complex task.
- The overall mental workload I felt while using the decision Web site was low.
- Using the decision Web site was easy.
- Using the decision Web site required a lot of mental activity.
- I had to work very hard to use the decision Web site.

APPENDIX 3: 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 (Todd et al. 1987). 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 attributes (alternatives) were 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. Using a similar selection task, 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 (Stone et al. 1991)). All pre-test 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.