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PERFORMANCE AND SATISFACTION IN ADAPTIVE WEBSITES: AN EXPERIMENT ON SEARCHES WITHIN A TASK-ADAPTED WEBSITE

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Abstract

Finding information within websites is becoming an increasing challenge as the size and the complexity of websites soar. One possible solution is to adapt the view of the site to the task in hand. Although such a procedure is technically feasible, the effectiveness of such designs is yet to be tested. Assuming user scenarios that involve searches by browsing rather than structured queries, we build on models of searching in text to formulate a task representation of searches within websites. This task representation is used to model the effects of adapted websites on performance and satisfaction.

We have, therefore, two main aims: (1) to propose a task representation of website searches, and (2) to use it to explore the effect of adaptive designs on performance and satisfaction.

In an experiment with a simulated adaptive website, the impact of an adapted site is compared with that of a non-adapted site in terms of time, accuracy, and perceived complexity of completing a search task and satisfaction with the human-computer interaction. The results indicate that adapted sites improve performance but not overall satisfaction. A breakdown of the components of satisfaction reveals that users are unhappy with the changing menus. Part of the explanation may be their perceptions that adaptive sites are less consistent and, therefore, more complex.

Keywords: Adaptive websites, human-computer interaction, search, consistency, complexity, experiment

I. INTRODUCTION

In order to design effective and attractive websites, designers must understand how people use and perceive the site they visit. Moreover, use and perceptions may vary considerably among different types of websites and different types of tasks, so that our understanding of these phenomena should begin with specific contexts before we can generalize across contexts. This paper concentrates on search tasks within adaptive websites, i.e., websites that can adapt to the task at hand. Such searches are characterized by goal-directed browsing, an activity that is rapidly becoming popular with millions of users. We consider this environment to be non-structured in comparison to, say, database queries. We are, therefore, concerned with the needs to increase control and to reduce complexity, which are particularly relevant to non-structured environments.

This study starts from the premise that adaptive websites are technically feasible, and it tests empirically whether, and to what extent, adaptive views can increase users' performance and satisfaction when looking for information (e.g., precision of the search results and time spent on the search). To this end, a cognitive framework of search in a website is presented, and this becomes the basis for building a user’s task representation. A specification of the user's task representation makes it possible to characterize an adapted view of a website as one that corresponds with the task representation. Thus, the study’s contribution is twofold: it offers a cognitive framework of search behavior within a website and provides an analysis of the impact of adaptive websites on performance and satisfaction.

We set the stage for this study by first discussing adaptive websites, secondly, defining search by browsing, and finally combining search and adaptive websites into a framework. We then develop several hypotheses and test them in a controlled experiment that compares adaptive and non-adaptive websites. The final sections report the results and discuss their implications.

ADAPTIVE WEBSITES: PERFORMANCE AND SATISFACTION

Finding information on the World Wide Web has become a challenging and urgent problem (Pitkow and Kehoe 1996). The vast number of websites makes it hard, or indeed impossible, to find the site required (Lawrence et al. 1999). Similarly, the growing size and complexity of individual websites makes it very difficult to locate information within a website. This problem of finding information in a site has become an important area of research, with several solutions currently being pursued. One is to offer powerful search engines that can often take into account the user's profile. A second method is to design the site for a particular type of user, for example, children in the **Disney site**. A third direction is to design the site according to a prevalent task. For example, locating a specific software package for Windows95 in the tailored **Windows95 site** was so successful that users fought the company's decision to redesign it. A fourth solution is to adapt the user's view of the site dynamically, according to the task at hand. The user's view is adapted so that a more relevant subset of the information in the site may be presented to the user, by means of appropriately tailored screens in a way that is commensurate with the task as seen by the user.

Our study examines the effectiveness of adapting the user's view to the task. This fourth solution to the problem of finding information can be seen as part of a growing trend toward adaptive sites, which dynamically improve their organization and presentation by capitalizing on the user's expected access pattern (see *PageGather* in Perkowitz and Etzioni 1998; and *SiteIf* in Stefani and Strapparava 1998). Intuition suggests that an adaptive site should fare better than one that is not adaptive. However, although this trend seems promising in the academic arena, it has not yet penetrated commercial websites. In fact, despite apparent difficulties of users working with major commercial sites, these vendors are, as yet, unlikely to have invested in adaptive sites. This may be because they do not consider such an investment to be economically beneficial, in which case the question of the effectiveness of adaptation would be a major practical consideration. It may also be the case that designers prefer stable interfaces, giving consistency greater importance than flexibility. The issue of adaptive sites is, therefore, akin to the issue of consistency versus flexibility across applications (e.g., Satzinger and Olfman 1998). If indeed this is the case, there appear to be two forces at play: one is toward higher control through consistency and the other is toward higher compatibility through flexibility.

Although the model developed here focuses on cognition and performance, user satisfaction is also of importance. In order for the study to lead to practical implications, user performance should not be studied in isolation from user satisfaction. While it is not yet clear what attracts people to visit websites the first time, what keeps them engaged in the site, and what attracts them back the site, it is clear that user satisfaction plays a role in the decision to revisit (Hoffman and Novak 1996). With the huge proliferation of websites, it is also clear that, for any given purpose, people have a vast selection of services from which to choose. Moreover, the relatively similar navigational tools (the common browsers) used for this vast selection of websites dramatically reduces the switch over cost from one website to another, in contrast to the relatively high switch over costs from one traditional system to another, e.g., from one library system to another (Bakos 1997). It follows, therefore, that customers, in selecting their service, may be more sensitive to poor designs than in the past, especially in the initial interactions with the systems (Davern et al. 2000). The examination of adaptive sites must, therefore, include user satisfaction as well as performance.

Satisfaction builds on perceptions of the system attributes and of the work with the system, e.g., perceptions of ease of use. The possibly conflicting effects of lower consistency and higher flexibility in adaptive websites may affect not only actual performance but also perceptions of performance, and in particular the perceived complexity of working with such systems. It seems intuitively right that the more effective and less complex a website seems to users, the higher their satisfaction with the website. Again, however, there is no systematic evidence to support this intuition in the context of adaptive websites.

SEARCH BY BROWSING

Several recent classifications of user activities consistently suggest a duality of browsing and querying when searching for information in a website (Byrne et al. 1999; Choo et al. 2000). Indeed, this work is motivated by a strong belief that current models of user behavior developed for online queries are inadequate for describing how people search websites. They are likely to be inadequate on two levels: the search activity and the web environment. Searching information in online catalogues of databases is more parameterized or structured than searching and browsing a website (Marchionini 1995; Miles et al. 2000). For example, the search strategies used in query-based searches are different from those used in link-based searches (Golovchinsky 1997). Secondly, users seem to experience interaction with the Web and the Internet in ways that differ from the traditional use of computer systems (Chen et al. 1999). If, for example, there is a blurred line of demarcation between the Web as a tool for work and the Web as recreation, then it may be difficult to use measures of satisfaction that concentrate on work related utility and ignore more general sensations such as engagement (Csikszentmihalyi 1990). It is, therefore, entirely unclear whether the tools with which we commonly model and measure search behavior, systems utilization, and satisfaction are also appropriate for use with websites.

Of special interest here is the level of structure of retrieving information from a website, which is lower than that of retrieving information from a database but higher than that of browsing a website. In general, a search activity is more structured the lower the uncertainty (or degrees of freedom) in deciding how to begin searching, how to proceed from one stage to another, and how to end the search activity. In retrieving information from a database, the user must first define a target, specify the domain and conditions using some query language, and end the search once the set of results is satisfactory. Browsing is “an activity in which one gathers information while scanning an information space without an explicit objective” (Toms 2000, p. 424). Browsing is, therefore, hardly constrained because a user may start browsing with or without a goal, may move, in any moderate size website, to many different locations, and will stop browsing for a variety of reasons such as boredom or time constraints.

Retrieving information from a website often involves browsing with a target in mind (Hertzum and Frokjaer 1996). The user may have only a rough goal to pursue but one that is sufficient so that the desired result is recognized once it is reached. Clearly, this activity is less structured than the database query and yet more structured than browsing without a goal. Moreover, this search activity will probably require different abilities and skills than querying a database, e.g., the ability to recognize what you want and the ability to scan large quantities of text. It is, therefore, important to learn more about such searches and examine how they can be supported by appropriate website designs.

The older context of database retrieval has obviously been studied more extensively than the relatively younger context of Web browsing. The main design (independent) variables of the human-computer interaction for a retrieval task are the level of abstraction for formulating the query, the flexibility of the query language, and the difficulty inherent in the query. Chan et al. (1999) have recently reconfirmed that performance is higher for higher levels of abstraction, higher flexibility, and lower difficulty. These variables are determined at the outset of the query and, therefore, it is not clear how readily they can be transferred to the context of Web browsing, which is more of an evolving activity and less predefined. The inherent difficulty of the query may be translated to the difficulty of the search goal, assuming that one can be articulated. The flexibility of the query language is difficult to apply to the context of browsing, which is by definition very flexible. In fact, the notion of non-adaptive versus adaptive websites may reflect, respectively, high and very high flexibility of a search language. Finally, the query level of abstraction, which is determined when the query is issued cannot be transferred to the context of browsing. On the contrary, the user of a website is expected to fluctuate between levels of abstraction throughout the process, much like a user who engages in the unstructured process of data modeling (Srinivassan and Te’eni 1995).

The main measures of performance in the context of database queries have been query accuracy and query time, and these may be transferred directly to the context of browsing, although they may need to be augmented with others such as satisfaction. Interestingly, Hertzum and Frokjaer found that browsing was faster and more accurate than conventional querying.

II. A FRAMEWORK FOR SEARCH IN ADAPTIVE WEBSITES

The general argument advanced in this section is that adaptive sites can be designed to be more compatible with the user's representation of the search task. Accordingly, the first subsection formulates a task representation and the second subsection examines how websites can be made more compatible with the representation.

THE REPRESENTATION OF SEARCH TASKS IN WEBSITES

As noted above, there has been little theoretical research into search behavior within a website, in comparison to the extensive body of research about online search behavior in other contexts. For example, Marchionini (1995) characterizes information seeking as a process that includes the following sub-processes: define problem, select source, formulate query, execute query, examine results, extract information, reflect, and stop. Marchionini suggests, however, that browsing must be characterized differently because it is usually a mix of scanning, observing, navigating, and monitoring. An interesting parallel to a search within a website is the location of information within a book chapter (Dreher and Guthrie 1990), which has also been used to understand searches within online documents (Guthrie et al. 1991). The location of text can be subdivided into the following cognitive processes: (1) goal formation, (2) category selection, (3) information extraction, (4) integration, and (5) recycling (which we re-label as control, as explained below).

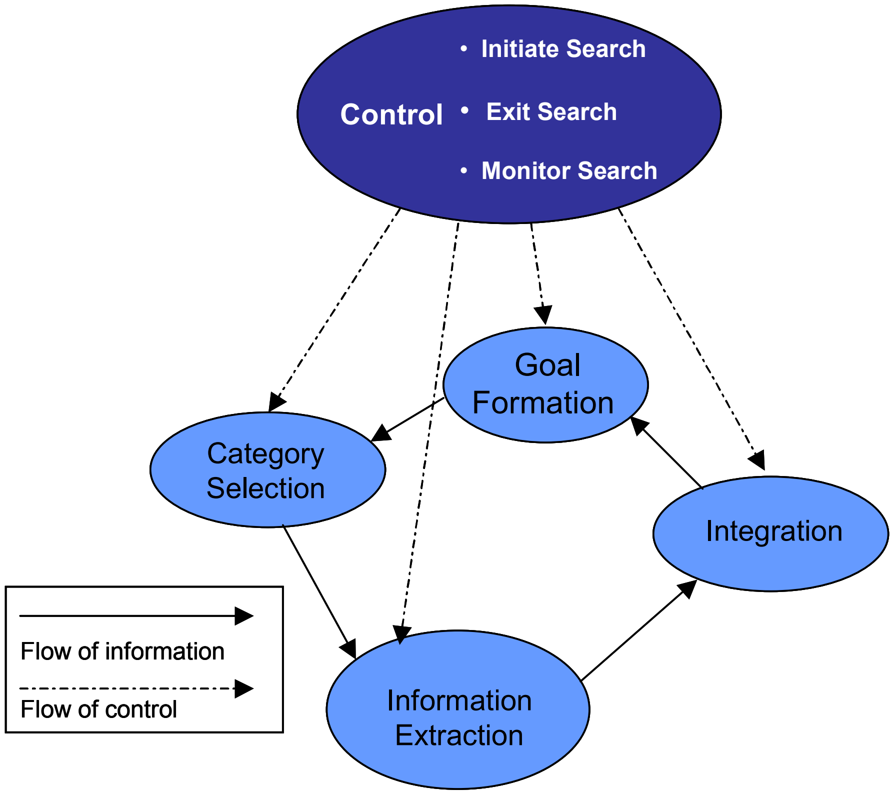

Figure 1. A Cognitive Framework for Search Behavior Within a Website

This can be demonstrated by considering a hypothetical instance of a part-time university student, first year in the program, using the school website. She is looking for information to construct her course schedule for the coming semester. Her first objective might well be to limit herself to courses on Tuesdays and Fridays. Goal formation is the process of clarifying the goal as "find all introductory classes given on Tuesday or Friday." Once the goal has been formed, the student needs to select appropriate categories of information in which to search. One category may be those classes organized alphabetically according to day of the week. Another category may be detailed descriptions of classes, including description of type of class (e.g., introductory, advanced, integrative) and its prerequisites. Once categories have been selected, the student proceeds to extract the relevant information from each category, e.g., filtering out all items that are not about Tuesday or Friday. After completing the stage of information extraction, the student needs to determine whether the goal has been met or whether it is necessary to repeat part of the search (e.g., have the required classes been found or is it necessary to include another day of the week). The label “control” implies a more general cognitive process than that of “recycling” and is, therefore, adopted here to denote all executive decisions in the search process of when to start and stop searching, when and what to repeat, and when and what to accept or discard. As shown in Figure 1, control can be seen as a meta-process that oversees the other cognitive processes (Srinivassan and Te’eni 1995). Typical control functions are initiation, process monitoring and exit.

The framework of Figure 1 can be seen as the basis for building a task representation for search tasks in a website that relies on the five cognitive processes shown in the figure. Furthermore, websites can be designed to support each of these cognitive processes, as will be seen in the conclusion of the paper. However, in the experimental setting described below, we focus on how to align the view of the website to category selection, given a specific search task. This focus, too, is in line with the findings on text location, in which higher performance was attributed predominantly to improved category selection rather than improved information extraction, and moreover, documents that are designed to emphasize categories improve category selection (Guthrie et al. 1991).

SITE ADAPTATION FOR HIGHER COMPATIBILITY

Systems should be designed for higher compatibility between the user’s representation of the task requirements and the system’s representation of the information needed to satisfy these requirements. Of course, this is a general guideline that should be sensitive to the possibility of user errors or misrepresentation. In other words, the user’s view of the system should fit the user’s view of the task at hand, assuming the latter is not counter-productive. Low compatibility induces a translation of the information presented by the system before it can be used and thereby increases the demands on the user’s resources and increases the probability of error (Barber 1988; Norman 1990). Designs with higher compatibility should, therefore, be more effective than those with low compatibility.

It follows that a site that adapts to a particular user representation by attaining a higher compatibility should prove to be more effective than one that does not. In the context of information search, compatibility is defined by a correspondence between the expected information categories needed to accomplish the search task and those presented by the system. In other words, the user's representation of a search task is assumed to be composed of a set of information categories. The more accurately the system can determine and present this set, the higher the fit. Thus, a higher compatibility should reduce the effort needed in the cognitive process of category selection.

***Hypothesis 1*:** Users perform better in adaptive sites than in non-adaptive sites.
- 1a: users perform faster in adaptive sites.
- 1b: users perform more accurately in adaptive sites.

Nevertheless, the effect of site adaptation on the cognitive process of control is unclear. On the one hand, the difficulty of category selection in the adapted site is reduced, and assuming that the other processes of Figure 1 remain unaffected, the need and complexity of control will be seen as likely to decrease. On the other hand, the non-adapted site provides a consistent, familiar meta-structure to the information, which is an important part of control in non-structured environments. The lack of meta-structure may hinder control and result in disorientation when browsing. This sense of loss of control should be reflected in a more general sense of higher perceived complexity. Thus, the higher the need for structure, the higher the probability that perceived complexity will arise through such adaptation. For example, less knowledgeable users have a higher need for meta-structure than knowledgeable users so as to avoid disorientation (McDonald and Stevenson 1998). Similarly, more difficult tasks may rely on meta-structure to a greater degree. In general, the difficulty of search tasks in an organized information repository is contingent upon the number of categories, their size and the distinction between categories (e.g., Payne et al. 1988).

In sum, adaptation may be counter-productive in cases where the lack of consistent interface impedes control, and in such cases we can expect a higher level of perceived complexity.

Hypothesis 2 (exploratory): Users perceive adaptive sites to be more complex than non-adaptive sites, particularly when working on difficult rather than easy tasks.

The effects of task difficulty and site adaptation with regard to *satisfaction* are not clear. There is no theoretical basis to assume higher satisfaction with adaptive sites, although intuitively they may be perceived as more considerate of the user's perspective. Moreover, even if adaptive sites improve performance, there is little evidence to suggest that improved performance will be associated with increased satisfaction (Frokjaer et al. 2000; but see also claims of a positive relationship in Goodhue and Thompson 1995; Karahanna and Straub 1999). It may be that the relationship between satisfaction and performance is contingent on user expectations (Szajna and Scamell 1993). If, for example, users have come to expect multi-media features in websites, they will be disappointed not to see them, regardless of how easy it is to use the site. However, the evidence on the relationship between performance and satisfaction is usually collected at the level of a job rather than a specific task and refers to perceptions of performance rather than actual performance. In any event, it would seem that the user's experience with the Web may affect satisfaction independently of the task difficulty and task performance. Overall, the impact on satisfaction is, therefore, unclear and explored as a tentative hypothesis.

Hypothesis 3 (exploratory): Users are more satisfied with adaptive sites than non-adaptive sites.

III. METHOD

EXPERIMENTAL PROCEDURE AND DESIGN

Setting

The experiment was conducted online, in groups of up to 20 subjects. Each subject sat in front of a PC for the entire session, and the experimenter, who was present throughout the session, first lectured from a podium to the entire group and then walked around the room to solve individual problems. All subjects used the same web browser (Netscape), with which they were all familiar.

The experimenter provided the group with general instructions and an online demonstration. The subjects then worked individually on either an adapted or non-adapted site. First, the subjects were given four search tasks (in random order to reduce the change of order effects) and they proceeded to solve them at their own pace. At the end of each task, the system recorded time and accuracy and presented the subject with a three-item questionnaire to assess perceived complexity. Once the four tasks were completed, a final questionnaire was given to assess overall satisfaction with the site. (The corresponding variables are summarized in Table 1 and later described in more detail.)

Table 1. Variables and Their Measurement

Variable	Measurement	Variable Type: Measurement Type
Type of site	Adapted vs. non-adapted site	Independent: Pre-defined
Difficulty of task	Number of categories required and possible selections	Independent: Pre-defined
Performance—time	Minutes to complete task	Dependent: Automatic record
Performance—accuracy	Correct or incorrect answer	Dependent: Recorded answer
Perceived complexity	Perception of complexity in working with the system on the search task	Dependent: Three-item questionnaire
Satisfaction with site	Satisfaction with the site overall, screen organization, and information content	Dependent: Ten-item questionnaire

Subjects

Originally, 140 subjects signed up for the experiment but 44 did not complete the experiment for various reasons. The 96 subjects who completed all stages of the experiment were students in social sciences, of which 50 were male and 46 female. The subjects were assigned at random to work with either the non-adapted site (40 subjects) or the adapted site (56 subjects).

There was no formal incentive given to the subjects and yet all of the subjects who completed the experiment invested time and effort (as evident from the automatic time-stamped traces) and appeared to be seriously involved (as evident by the relatively high accuracy of the search results).

Experimental Tasks

Each subject performed, in random order, the following four tasks:

1. What is the name of the professor who conducts research on “Industrial Relations” and has an office in the school’s main building?
2. What is the name of the professor who teaches the “Finance seminar” this semester, and who has office hours on Sunday afternoon?
3. A faculty member published in 1995 the article “Teaching human-computer interaction: the design of windows.” What, if anything, does this faculty member teach on Fridays this semester?

4. A student wants to take all the mandatory courses in Information Systems given by an external faculty member who has a personal web site. List these courses by name. You can find personal websites in the faculty sites within the school website.

Website

A business school website was used for this experiment. Two versions were constructed, one being a simulation of an adaptive site and the other a standard (non-adaptive) site. The two versions were identical in all other respects. Figure 2 shows the structure of the entire website as a map (the subjects saw only text-based menus, not the map). To explain this structure efficiently, we mapped the structure with numbered nodes (each corresponds to a physical HTML page) and the accompanying index has the title of each page. The map shows a three level hierarchy in which node 1 is the first-level (main) menu, with nodes 2, 3, 4, and 5 as its options. Each one of these four nodes is a second-level menu, with the third-level elements as its options. Node 2 has five elements (nodes 21 through 25), node 3 has only one (node 31), and node 4 has nine (nodes 41 through 49). All together, there are 20 pages in the website. The subjects who were given the non-adapted site saw the appropriate elements from the index in Figure 2. For example, the second-level menu for "Curriculum" was the list of elements corresponding to nodes 41 through 49.

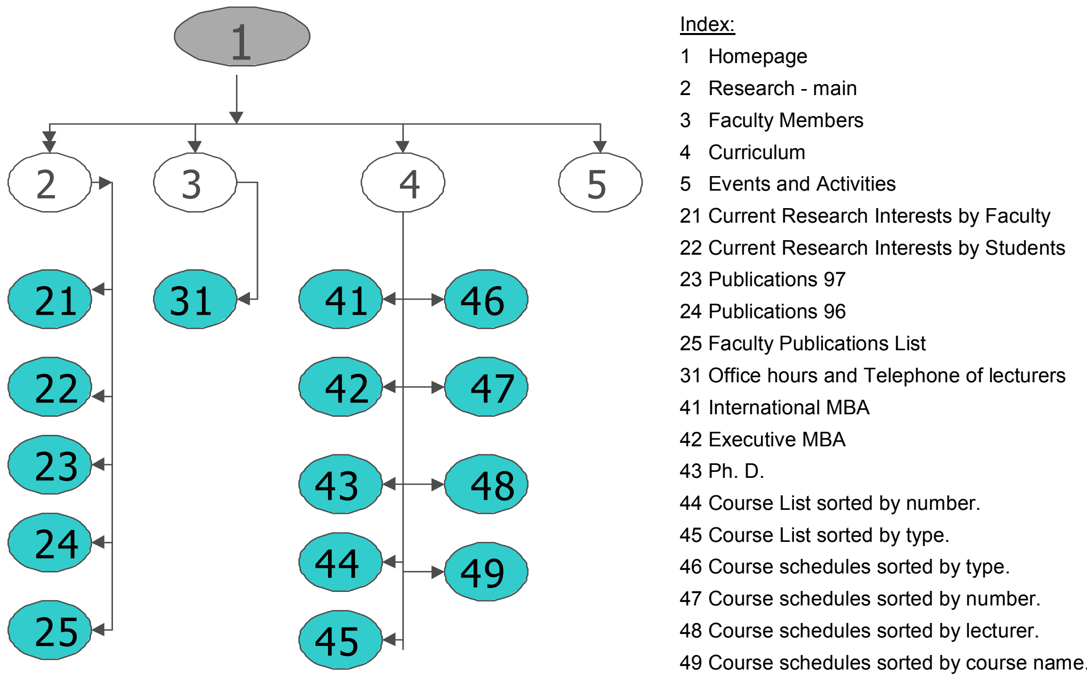

Figure 2. Structure of School Website
(The non-adapted view of the site, which remains the same for all tasks, includes the entire structure.)

The algorithm for simulating an adapted site is as follows: the question to be answered is parsed to detect the appropriate information categories present in the website (where every category is assumed to be a titled page). A list of these categories is presented to the user. As explained above, this adaptation is designed to reduce the difficulty of category selection but hardly affect the other cognitive processes of search (see Figure 1). We assume that it does not affect information extraction within a category and also assume that it does not affect integration (this assumption may be wrong when unnecessary categories are scanned).

Figure 3 shows the screen presented as a menu for task 4 in the adapted site. The corresponding site map (not shown to the user) is depicted in Figure 4. For the other tasks, similarly tailored menus will appear in the adapted sites, but in the non-adapted site, the same menu appears consistently for all tasks.

The following are the relevant categories of information for this search:

1. Faculty members.
2. Codes for types of courses.
3. Course schedules sorted by lecturer.
4. Course schedules sorted by type of course.

Click *Next* when done.

Figure 3. Screen of Adapted Website for Task 4

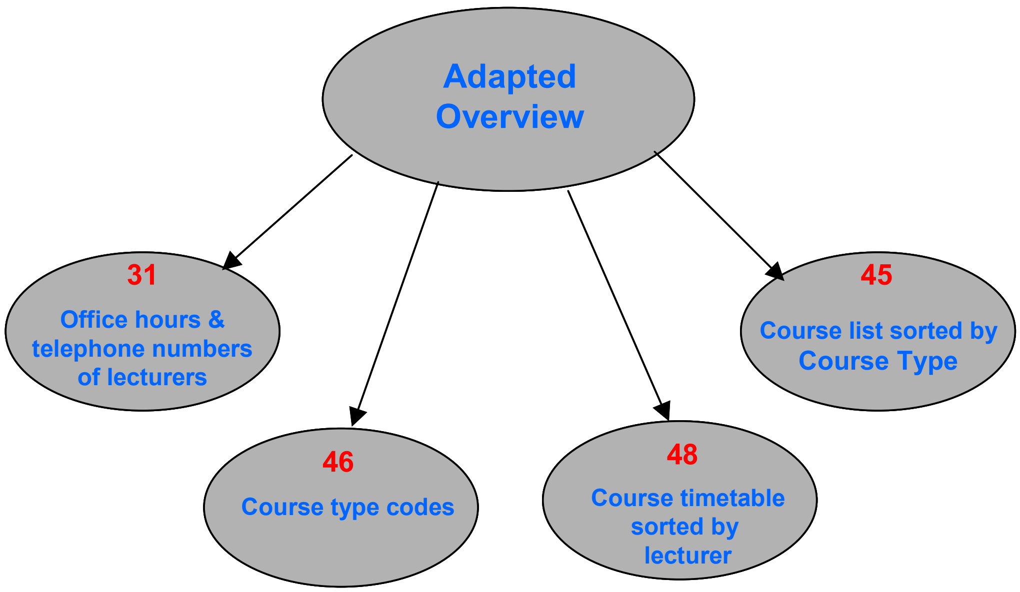

Figure 4. Site Map of Adapted Website for Task 4 (Numbered nodes represent information categories on separate pages.)

The website (IIS version 4.0) was built on an NT server with FrontPage 98. Additional programs (written in Java) established a controlled dialog throughout the experiment. This system ensured that the user would proceed through all stages of the experiment. It also built a log of the user's actions. The log files were then processed in Excel and exported for further statistical analyses in SPSS.

Task difficulty was predefined by the experimenter. Of the four tasks, only two were analyzed to detect effects of task difficulty: task 1 (the least difficult) and task 4 (the most difficult). Table 2 describes these two tasks in both the non-adapted and the adapted site. For task 1, the subject had to find a faculty member with a given research interest. In the non-adapted site, the answer would be in the category of “Current research interests sorted by faculty” (node 21). Looking at Figure 2, node 21 is selected from nine possible categories in two stages, which correspond to two levels in the menu hierarchy. First, node 2 is selected out of four options on the main menu (nodes 2 through 5) and then node 21 is selected out of five options on the second-level menu (nodes 21 through 25). Each of the faculty members selected must be matched to a given specification of office (i.e., office location), which is located in the category of “Office hours and lecturer phone numbers” (node 31). Node 3 is selected from the first-level menu and then node 31 is found as the only category within node 3. This search is continued for every faculty member that researches “Industrial relations.” The two searches for node 21 and then node 31 are, therefore, interdependent.

By comparison, the same task in an adapted site requires the same categories but the selections are easier because a list of only two categories is presented to the searcher, namely, node 21 and node 31. Furthermore, in the adapted site the two-stage process of searching for node 21 disappears because node 21 is accessed directly, bypassing the need for the upper level menu.

The second row of Table 2 similarly describes task 4, which requires four categories (as opposed to two in task 1) that also are interdependent. Clearly, task 4 is more difficult than task 1.

Table 2. Tasks Characterized by Sources of Difficulty in Non-Adapted and Adapted Sites (Refer to Figures 2 and 4)

Task	Non-Adapted Site	Adapted Site
1	Select “21" from 4 at level I and 5 at level II, “31" from 4 at level I and 1 at level II.	Select “21" from 2, “31" from 2.
4	Select “31" from 4 at level I and 1 at level II; “46" from 4 at level I and 9 at level II; and “48" from 4 at level I and 9 at level II.	Select “31" from 4, “46" from 4, “48" from 4.

DEPENDENT MEASURES

Having discussed the measurement of site (adapted or non-adapted) and task difficulty, we describe in detail the dependent measures shown in Table 1. Performance and perceived complexity were measured after each task (i.e., four times for each subject), while site satisfaction was measured only once for each subject.

Task performance includes two factors. *Time* is defined as the time taken to reach a solution. *Accuracy* is defined as whether or not the solution is correct.

Site satisfaction was measured by using a short version of a user satisfaction questionnaire (Chin et al. 1988). At the time of this experiment, there were no established questionnaires dedicated to the website context. Therefore, we used a general questionnaire of interactive systems. Ten questions address (1) the *general* experience of working with the system, (2) the organization and presentation of the information between and within *screens*, and (3) the information *content* the site provides. Cronbach's alpha reliability coefficient for the questionnaire with 10 items was 0.807 (alpha values of 0.70 or above are acceptable according to Nunnally [1978]).

Perceived complexity consisted of a set of three questions that referred to the overall difficulty of the search task. The following are the questions presented on five point Likert scales.

1. It was easy to find the answer;
2. The task was difficult;
3. I knew how to proceed solving the task.

The alpha reliability coefficient for the questionnaire with three items was 0.729 (which is acceptable, as noted above).

IV. RESULTS

DESCRIPTIVE STATISTICS

Overall, the time to complete a task was between four and 44 minutes with an average of 9.55 minutes per task (standard deviation was 0.198 with a 95% confidence interval ranging from 9.2 to 9.9). The distribution of time had three outliers (20, 27, and 44), which had no statistical effect on the tests reported below. About 68% of the task solutions were accurate (standard deviation was 0.031 with a 95% confidence interval ranging from 62% to 75%). Table 3 reports the means and standard deviations for the dependent variables across the type of site, i.e., non-adapted or adapted. These include time and accuracy as measures of performance, perceived complexity, and satisfaction with the web site. Satisfaction, which was measured between-subjects, is also broken down into its three subconstructs: satisfaction in general, satisfaction with the screens and satisfaction with the information content presented. The statistics for performance and perceived complexity, which were measured within-subjects, are averaged over the four tasks.

Table 3. Descriptive Statistics Across Site Type

Variable	Non-Adapted Site		Adapted Site	
	Mean	s.d.	Mean	s.d.
Performance—time	11.00	0.30	8.09	0.26
Performance—accuracy	0.61	0.05	0.75	0.04
Perceived complexity	3.13	0.11	3.45	0.09
Site satisfaction (total)	10.06	2.16	10.14	2.01
Satisfaction—general	3.14	0.82	3.31	0.68
Satisfaction—screen	3.59	0.83	3.30	0.85
Satisfaction—content	3.35	0.90	3.54	0.85

The basis for analyzing performance and perceived complexity as a function of task difficulty is a comparison between the least and most difficult tasks. Hence, Table 4 reports the means of the within-subjects measures across type of site and level of task difficulty. As a manipulation check for task difficulty, we compare the levels of perceived complexity of low and high levels of difficulty (concentrating on the extreme values of task difficulty and ignoring the intermediate values simplifies the analysis.) The difference between means is significant at 0.01, demonstrating the effect of manipulating task difficulty on perceptions of difficulty. However, while adapted sites increase performance for both low and high levels of task difficulty, their impact on perceived complexity interacts with task difficulty. When the task is easy, the adapted site reduces perceived complexity, but when the task is difficult, the adapted site increases perceived complexity.

Table 4. Descriptive Statistics Across Site Type and Levels of Task Difficulty

Variables: Site	Non-Adapted Site		Adapted Site	
Task Difficulty	Low	High	Low	High
Performance—time	13.71	11.01	10.83	7.55
Performance—accuracy	0.58	0.77	0.70	0.86
Perceived complexity	2.72	3.22	2.52	3.96

TESTS OF HYPOTHESES

To test Hypotheses 1 and 2, predicting that adapted and non-adapted sites will differentially affect performance and perceived complexity, we conducted a two-way, repeated-measures multivariate analysis of variance (MANOVA), with type of site as a between-subjects factor and task difficulty as a within-subjects factor for performance and perceived complexity. The results of the MANOVA demonstrate a significant effect for task difficulty (Wilks' lambda $F_{9,86} = 33.924$, $p < .001$) and also for the interaction between type of site and task difficulty (Wilks' lambda $F_{9,86} = 2.273$, $p < .025$).

Having found these significant effects, we conducted two ANOVAs to test Hypotheses 1a (on time) and 1b (on accuracy). Both effects appeared to be in the expected direction and statistically significant: time ($F_{1,94} = 54.168$, $p < .001$) and accuracy ($F_{1,94} = 5.323$, $p < .023$). To test Hypothesis 2, the effect on perceived complexity, we look at both the effect of type of site, which was in the anticipated direction but not significantly so ($F_{1,94} = 3.205$, $p < .077$), and the interaction with task difficulty, which was significant ($F_{1,94} = 15.344$, $p < .001$).

Testing Hypothesis 3 on the difference in satisfaction between adapted and non-adapted sites resulted in practically no difference in overall satisfaction. Interestingly, though, the breakdown of the overall satisfaction revealed conflicting trends, where satisfaction with screens decreases while general and content satisfaction increases in adapted sites (see Table 3). However, none of these effects were statistically significant at the .05 level.

V. DISCUSSION

In brief, this study examined the impact on performance and satisfaction of sites that adapt the user's view of the system to the search task at hand. To this end, we began with a framework of searching by browsing, which is the basis for representing the user's view of the task. We then used the user's view of the task to adapt the user's view of the system so that the two views are more compatible. A laboratory experiment showed that, indeed, users performed better in terms of time and accuracy in the adapted site (assumed to be more compatible). The experiment also showed that the perceived complexity of the adapted site was higher than the non-adapted, although the higher perceived complexity of the adapted site was due entirely to the considerable increase in its perceived complexity when working on the difficult task but not when working on the easier task. This interaction between type of site and task difficulty is in line with the argument that control is needed most when complexity is high and that the perception of low control due to inconsistency is higher when complexity is higher.

Surprising was the result that the adapted site was not more satisfying than the non-adapted site, as you may expect from a system that appears to be tailored toward your needs. Part of the explanation may lie in the breakdown of satisfaction into its components: general, screens, and content. Satisfaction with the adapted site was higher with general and content aspects but lower with aspects of the screens, although these effects were not statistically significant. This may very well suggest that users prefer consistent appearances, even though they value the adapted functionality.

Our discussion is organized around the two contributions of the study: a framework for representing search behavior within websites and the tentative results on the effects of adapted websites on performance and satisfaction. We begin, however, with several limitations of this study.

LIMITATIONS

One general limitation of this study, noted in the introduction, is that the website is seen as nothing more than a repository of knowledge. Finding information is only one of several functions (Miles et al. 2000; O'Keefe and McEachern 1998). Any recommended design, such as adaptive views, must consider the interaction between all functions of the system. In the present research, we concentrate on only the process of finding information. Moreover, the adaptation of views to the task at hand was considered, rather than to user characteristics (Lin and Chan 1999; Stefani and Strapparava 1998). We do, however, attempt to provide a conceptual analysis that goes beyond the experimental setting in order to potentially direct future research into other aspects of user-interface design. Furthermore, this study concentrated on one mode of searching information, namely browsing. However, users most likely use different modes of search and, moreover, may shift between different search goals and strategies during a search (Xie 2000).

Another limitation is the use of students as surrogates for users in general (Briggs et al. 1995; Hughes and Gibson 1991). In this experiment the subjects were social sciences students and the website was a school site. Any generalization must be restricted to rather young and sophisticated users engaged in searches on a website of some interest. As opposed to any attempt to generalize to a very special type of worker, such as managers, we think it may be possible to generalize our results to typical users searching, say, a technology support center or an entertainment center. Clearly, however, users outside an experimental environment may behave differently.

While our experiment only manipulated task difficulty, other sources of complexity, such as lack of experience, may also result in higher perceived complexity of adapted sites. Moreover, although the simulated adaptation was transparent to the subjects, i.e., they could not know that the solutions were predefined unless they created their own new queries, the entire experiment should be conducted with a much broader set of queries.

COGNITIVE FRAMEWORK FOR WEBSITE SEARCH BEHAVIOR

The cognitive framework of search behavior is adapted to the context of searching a website from a more static context, that is, the location of text in an online book. Websites are more proactive than the traditional book, and will probably become even more so in the future. The case of adaptive websites is a good example. The appropriateness of this framework to the dynamic context must be investigated in depth. One possible direction may be to look at the relative importance of each of the five cognitive processes exhibited in Figure 1 and their susceptibility to error. We focused here on the selection of information categories and addressed only briefly the effects of other processes. Clearly, these other cognitive processes need to be studied. In particular, the notion of control needs to be developed more thoroughly, given the more dynamic world of interactive websites. The clear increase in perceived complexity, particularly as the task becomes more difficult, implies that researchers, and later designers, will have to pay more attention to supporting control for browsing within websites.

Moreover, the mapping of cognitive strategies required in search tasks needs to be validated by more direct observation. Ideally, precise protocols of user activity should be captured on the following two dimensions: (1) the transition from one cognitive process to another, and (2) the transition paths from one node to another in the website. In retrospect, it might have been possible to create logs that captured these paths but the necessity to program the system from scratch precluded the addition of this feature. Current logging software is now available to do so.

Assuming that the framework of Figure 1 represents at least part of the processes involved in searching a website, it has an important practical implication: it can serve as a checklist for functionality to support searches. Following the tradition of decision support systems, Table 5 demonstrates some of the functionality that websites can offer for each cognitive process. Consider the following examples. Intelligent systems can represent the user's goal in reference to the website structure (Cockburn and Jones 1996). Websites may not only filter the information presented but also recommend where to start extracting information and in what direction to proceed. Finally, systems can supply information about search and navigation maps to enhance control paths (Campbell and Maglio 1999).

Table 5. Examples of Support Functions in Websites

Cognitive Process	Support Function for Search Within Sites
Goal formation	Intelligent parsing and rephrasing of intentions
Category selection	Adaptive views
Information extraction	Filtering, guided extraction
Integration	Integrative view of goal versus results
Control	Navigation maps, feedback on progress, link anchors

PERFORMANCE AND SATISFACTION IN ADAPTIVE SITES

The most direct and practical implication of this study concerns adaptive sites. From our limited experiment, we can conclude that the notion of fitting the website dynamically to the task has been shown to be effective, albeit not necessarily satisfying. Adaptive views of the website content can meaningfully reduce the effort needed for category selection, which appears to be one of the more demanding cognitive processes in website searches. However, user satisfaction may depend on additional factors that go beyond the ease and accuracy of searches. It may be useful to look at the research on the perceptions of usefulness of information technology to job performance. Perceived usefulness such as higher accuracy and perceived ease of use such as time spent or perceived complexity have been the major determinants of users' intention to use the technology (Davis 1989). Although we expect user satisfaction to influence the user's intention to revisit a website (Hoffman and Novak 1996), it seems that our results on performance and perceived complexity cannot explain the user's attitude in the way perceived performance and perceived ease of use explain users' intention to use. While the adapted website improved accuracy and time, it was not rated more satisfying. At least two explanations are possible: the need to consider additional factors and the need to consider the contingent nature of performance-satisfaction on the level of perceived complexity.

First, the lack of consistent menus may affect satisfaction, not only by objectively making it more difficult to control navigation but, more importantly, by reducing the user's sense of control due to the shift of control from the user to the system. Research into the notion of flow of work shows that such a reduction in perceived control will reduce satisfaction (Webster et al. 1993). Therefore, it may be important, despite the limitations of this study, to call for a reevaluation of the user satisfaction construct in the context of the Web. It would also strengthen the calls of many practitioners for more engaging and enjoyable website designs that go beyond task-related content and usability. For example, the notion of flow in the web experience involves an enjoyable sense of involvement and purpose beyond the task (Chen et. al. 1999; Hoffman and Novak 1996).

If future research finds that users' attitudes toward websites cannot be modeled only by task related costs and benefits (i.e., usefulness and ease of use), the methods for tapping attitudes should also be revised for the Web context. Again, such a conclusion would be in line with recent calls for developing new measures of satisfaction with websites (Katerattanakul and Siau 1999). In particular, such measures should consider user expectations of websites (e.g., many young users may expect from websites not only support for certain tasks but also entertainment). The work cited above on flow may also be included in development of satisfaction measures. There would also be practical implications. For example, the above-mentioned solution of a dynamic map to boost control may not necessarily solve the problem of lower satisfaction with adaptive sites. Although, a familiar site map may increase the perceived control over the task, there remains a possibility that the user senses the system is taking over control (in deciding what to present to the user). This would violate a basic principle of design in which the user maintain a sense of control (Shneiderman 1987). One idea may be to gauge the user's search goal, interpret it in light of the website categories of information, and then present it as a recommended view to be confirmed by the user.

A second, and perhaps complementary, explanation to the lack of relationship between improved performance and satisfaction centers on the tradeoff between compatibility and consistency. Decomposing satisfaction into its three components revealed that users were dissatisfied with inconsistent screens. In conjunction with the finding that perceived complexity increased in the adapted site when working with more difficult tasks, the dissatisfaction with inconsistent screens suggests that users prefer consistency over compatibility when things get rough. Moreover, users want a consistent appearance but at the same time appreciate compatible functionality (e.g., appropriate information categories). This is in line with recent findings on the utility of consistency across applications at the level of visual appearance but not at the level of action specification (Satzinger and Olfman 1998).

Indeed, this study can be positioned in the larger context of benefits of consistency versus flexibility. Although, primarily an issue of perception, consistency has been accepted as a major design guideline in human-computer interaction (Nielsen 1989; this view has been challenged Grudin 1989). We show here that there is a tradeoff between flexibility (which leads to compatibility) and consistency (which leads to a higher level of control and sense of control). This finding has important implications on the design of adaptive systems because users of inconsistent designs may change their behavior to compensate for the higher complexity by looking for alternative means of control, such as check points throughout the interaction (Te'eni 2001). Further research into the feasibility of using perceived complexity to indicate a sense of poor control or even disorientation may prove to be useful. If proven valid, it could serve to measure, for example, effects of inconsistency before the user's action (rather than measure performance after the fact) so that, in time, the system could adjust accordingly.

VI. ACKNOWLEDGMENTS

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[1]Editor's Note: The following reference list contains hyperlinks to World Wide Web pages. Readers with the ability to access the Web directly or are reading the paper on the Web can gain direct access to these linked references. Readers are warned, however, that

1. these links existed as of the date of publication but are not guaranteed to be working thereafter.
2. the contents of Web pages may change over time. Where version information is provided in the References, different versions may not contain the information or the conclusions referenced.
3. the author(s) of the Web pages, not AIS, is (are) responsible for the accuracy of their content.
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