In Proceedings of the Human Factors and Ergonomics Society 45th Annual Meeting, Minneapolis/St. Paul, October 8-12, 2001.

THE EFFECTS OF SEARCH ENVIRONMENT AND TASK REALISM ON SEARCH BEHAVIOR

Xioyan Niu and Ann M. Bisantz
Department of Industrial Engineering
University at Buffalo, The State University of New York, Amherst, NY

This paper presents a study which compared user search behavior across an open search environment (the World Wide Web) and a closed search environment (an on-line library card catalog). Users performed a structured search task, where they were given topics to search for, and a self-directed search task, where they could choose their own topics. Search tasks were defined based on a qualitative, three-stage model of search behavior. Results showed that overall, search behavior tended to be very similar across search environments, indicating that empirical results and models of search behavior could generalize across these two environments.. Differences were due primarily to characteristics of the particular search environments chosen (e.g., the Internet vs. a library catalog) and the searching mechanisms and interfaces available for searching these environments. Additionally, behavior was also similar across the structured vs. self defined search tasks, suggesting that aspects of search engines and user search behavior can be tested in a controlled setting and that the results can be applied to less controlled, more natural search tasks.

INTRODUCTION

This paper presents a study which compared user search behavior in two different conditions: an open search space, and a closed search space. Theoretically, one could consider an open search space to be one in which there are an infinite number of nodes or items to be searched, while a closed search space is one with a finite number of nodes. A more operational definition is that an open search space is one in which the number of cataloged or available items is large enough to be considered practically infinite, while a closed search space is one in which there is a boundary on the number of cataloged or available items. A typical example of a closed search space is a library card catalog (e.g., a database listing the finite contents of a physical building or set of buildings), while an example of an open search space is the World Wide Web.

User search behavior may be affected by the limits of the search environment, and their perception of those limits. For instance, users in an open environment might continue searching for information longer than in a closed environment, since they may continue to believe that there are other, or additional items which better suit their search criteria. Alternatively, users in an open search environment may stop searching prematurely because they are overwhelmed with the size of the search space, and do not believe that additional searching for some reasonable amount of time will produce results that are any better than those currently in hand. Users in a open environment may be more satisfied with their search results because they believed the environment was more comprehensive, or less satisfied, because they did not succeed in searching the entirety of the space.

There has been extensive research on user search behavior (e.g., Leckie and Pettigrew 1996; Wilson, 1996; Allen, 1996; Hsieh-Yee, 1998; Tang, and Solomon, 1998; Tauscher and Greenberg 1997). Some prior research has described qualitatively different search stages (Kuhlthau, 1993; Kennedy, Cole and Carter, 1997). For instance, Kennedy et al. (1997) describe three stages of search behavior: a pre-focus stage, in which someone determines topics of interest, a semi-focus stage, in which further information regarding the topics is identified, and a post-focus stage, in which specific pieces of information are identified and retrieved. However, the applicability of such stage models, as well as user search strategies and preferences between open and closed search spaces have not been directly compared.

Additionally, users in previous studies of search behavior are often given topics to search for. An important methodological question is how results from such studies with experimentally controlled search topics apply to realistic search experiences, when users have control over, and are perhaps more interested in the search they are pursuing. Without experimental control over search topics in the studies, however, it is difficult to compare results across individuals or conditions.

METHOD

To address these questions, a multi-phase experiment was conducted. In the first phase, 127 university students completed a questionnaire requesting information about their use of the World Wide Web, and their use of the University at Buffalo Libraries on-line card catalog to search for information on two broad topics, education and entertainment, in order to develop realistic search tasks for the next experimental phase (the topics were selected based on prior research indicating these as popular topics for WWW search). Survey results indicated that students had not used the card

Table 1. Significance values for ANOVA tests.

		Search Time	Search Steps	Checked Items	Ease of Use	Satisfaction
Structured	Open vs. Closed	p<.000	p=.034	n.s.	p=.002	p =.033
	Stage	p<.000	p=.003	p<.000	p<.000	p<.000
	Interaction	n.s.	p=.004	p<.038	n.s.	n.s.
Self-Directed	Open vs. Closed	p=.003	n.s.	n.s.	n.s.	n.s.
	Stage	p<.000	n.s.	p<.000	p=.024	p =.014
	Interaction	n.s.	n.s.	p<.047	n.s.	n.s.

catalog to search for entertainment related information; therefore education-related search tasks were designed for the next experimental phases.

Two additional phases were conducted: a structured task phase, and a self-directed task phase. In the structured task phase, participants were given a predefined search task to complete. The task had three stages, corresponding to the three stage search model described by Kennedy et al., (1997). Participants first were asked to use the WWW or library catalog to find identify a topic for a term paper for a given course on media and society (the first stage), then search for specific information they would need to write the paper (the second stage), then find specific books or journal articles using the search engines (the third stage; authors and titles were given). In the self directed task phase, participants were again asked to search for information, but the topic of their search was self determined. Again, the task had three search stages. In the first stage, participants were asked to find information on a topic they were interested in, in the second stage, they were asked to search for more information on the specific item identified in the first stage, and in the third stage, to identify two items of interest relevant to the topic.

A within-subjects design was used. Twenty participants were assigned to either the open or closed search space condition, performed the structured search task, and then returned a week later and completed the structured search task in the opposite search space condition. Participants then returned a week later, were again randomly assigned to the open or closed search space condition, and performed the self directed task. Finally, they returned a week later and performed the self directed task in the opposite search space condition. Thus, each participant performed four searches: two structured searches and two self directed searches, under both the open and closed search space condition.

Dependent measures were collected by video-taping the computer screens during the search tasks, and by administering questionnaires to the participants. Dependent measures included search time, number of search steps, number of items returned that were checked or examined (by clicking or selecting), search strategies (as categorized by the experimenter), participants' reasons for stopping the search and subjective ratings of ease of use and satisfaction.

RESULTS AND DISCUSSION

Results of significance tests from the structured search and self directed search phases are summarized in the tables below. A two factor, within-subjects ANOVA with search stage and search environment as factors was used to analyze search time, number of search steps, number of items examined, and ratings of ease of use and satisfaction. Results of significance tests are given in Table 1. Contingency table analyses were performed on the categorical measures of search strategy and stopping reason to assess the effects of search stage and search space on these measures. Because search strategies were categorized differently based on whether the search was using the WWW or the library card catalog (i.e., possible search strategies depended on software functionality), the two conditions were not directly compared for that measure.

Results are graphically displayed in Figures 1 and 2. Of interest are the similarities between results from the structured search task and the self directed search task Additionally, there are relatively small differences between the closed search environment (the UB Library catalog) and the open search environment (the Internet search). More specifically, ANOVA results for the structured search task showed that there were significant effects of search environment and search stage on search time, number of search steps, ratings ease of use, and ratings of satisfaction. There was also a significant effect of search stage on the number of checked items. There were significant environment by stage interactions for the number of search steps and number of checked items. For the self-directed search task, there was a significant effect of search environment on search time, and a significant effect of search stage on search time, the number of items checked, ratings of ease of use, and ratings of satisfaction. There was a significant environment by stage interaction for the number of checked items. Contingency table analyses indicated a significant dependence

of the stopping rule selected on the search stage for the structured task (χ_6 =23.4,p=.001), but not for the self directed search task. There was no dependence of stopping rule on the open vs. closed nature of the search space, for either task. Additionally, there was a significant dependence of the search strategy selected on search stage in the open environment, for both the structured (χ_{26} =21.4, p=.002) and self directed (χ_{26} =12.2, p=.056) search tasks.

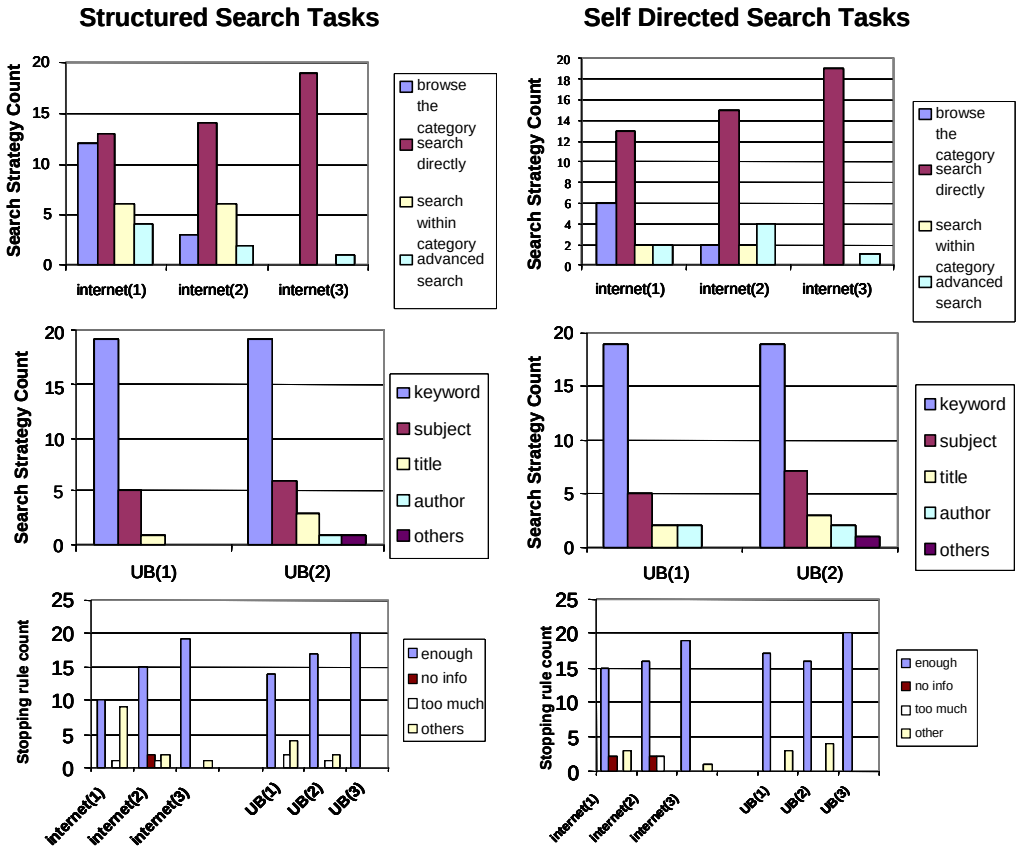

Figure 2. Illustration of results by search stage and type of task. The figures on the left correspond to the structured search task. The figures on the right correspond to the self directed search task. Figures in the same row represent the same dependent measure.

Effects of Search Stage

As expected, results from both the designed experiment and the validation study showed differences across the three search stages. Differences in search behavior were expected due to the different characteristics of the search stages hypothesized by Kuhlthau (1993). For example, we had expected that participants would change their search strategies for different search stages because of different information needs. For example, we had expected they would spend the longest time and check the most items in stage 1, due to the exploratory nature of that stage. As indicated by the three-stage model of search, search behavior did change across search stage. Across search environments and both the structured and self directed search tasks, participants generally took longer to search in stage 2 than stage 1, and spent the least time searching in stage 3. The number of search steps tended to decrease somewhat across the three search stages; however, the number of checked items was greatest in stage 2, less in stage 1, and least in stage 3. Participants seemed to do the most in-depth search in the second stage, after they had narrowed the search space through a broader stage 1 search, and then go directly to items of interest in stage 3.

These conclusions as supported by the categorizations of stopping reasons and strategies shown in Figure 2. As the search became more focused from stage 1 to stage 3, more participants stopped searching because they had found enough information, more participants in the internet environment used direct search strategies, and opinions regarding ease of use, and search satisfaction, tended to increase.

Search strategies also tended to differ across search stages for the open (Internet) search environment. Participants used a combination of category browsing, direct search, category search, and advanced searched methods, with more emphasis on category browsing and direct search. Category browsing declined in the second stage, and by the third stage,

almost all participants relied on a direct search for the item of interest, indicating a more focused search approach across the three stages. In the closed environment, participants in both the first and second search stages relied primarily on keyword search, with some use of subject searching and other methods (participants were given a title and author in the third stage, so strategies for that stage were not included in the analysis). This lack of differentiation may indicate that the search mechanisms provided by the closed search environment were not comprehensive enough to allow changes in search strategy.

Effects of Search Environment

Due to the closed vs. open nature of the two search environments, we anticipated some differences in search behavior. For instance, we expected participants to spend longer, take more steps, and investigate more options in the Internet vs. the library search, since the search space itself was larger. Stopping rules might also be different: those in the more open environment may have stopped searching because they were overwhelmed with information, or alternatively been more likely to stop because they found relevant information, rather than stopping because they did not find any relevant information. However, overall, search behavior tended to be very similar across search environments. Differences were due primarily to characteristics of the particular search environments chosen (e.g., the Internet vs. a library catalog) and the searching mechanisms and interfaces available for searching these environments. One limitation of this comparison lies in the different mechanisms available for searching the two different environments. For instance, the library had specific search mechanisms for subject, author, and title searches, while the internet search engine did not. Future work on this topic could make the comparison more directly by utilizing a subset of web pages (e.g., perhaps those hosted by a single university) rather than a library catalog as the closed search space, thus allowing the same search engine to be used in the closed and open search spaces.

Effects of Type of Search Task

An important methodological question investigated in this study was whether or not participants' search behavior and search evaluations would be similar in an experimentally defined search task, and one in which they controlled the topic they searched for. The self directed search topic was assumed to be a more natural search experience, and one that is more similar to real world search behavior. It may be that experimentally controlled search topics cause participants to use different stopping rules, or investigate fewer options, because they are less interested in and motivated to continue the search. Thus, a comparison of behavior across the two types of tasks, which has not to our knowledge been previously investigated in a similar study, has implications for the generalizability of the results described here, as well as those presented in other studies.

Results indicated that participants had a somewhat lower search time for stages 1 and 2 on the self directed search tasks than the structured search task. However, differences were not extreme (on the order of 10 minutes) and patterns across search environments, and search stages, were similar for both the self directed and structured search tasks. Similarly, the number of items checked was slightly lower for stages 1 and 2 of the validation study than the designed experiment, but again, the patterns across search environments and search stages were similar. The number of search steps was also on a similar scale between search tasks. Search strategies, and stopping rules, used by participants were also similar across tasks. Finally, subjective measures of ease of use, and satisfaction, were similar in value across the structured and self directed search tasks.

Thus, this study showed few differences in search behaviors across the two types of search tasks. This is an important methodological finding, since it suggests that aspects of search engines, and user search behavior, can be tested in a controlled setting, and that the results can be applied to less controlled, and more natural, search tasks. Had the results been very different, it would be difficult to support the application of results from tests or studies where users are given specific search tasks to the natural search tasks in which users are typically engaged. Testing users through self directed search tasks can make it difficult to perform accurate comparisons across search tools or environments. In contrast, these results support the evaluation of search tools, or the comparison of several search tools, through more controlled, experimenter designed tests.

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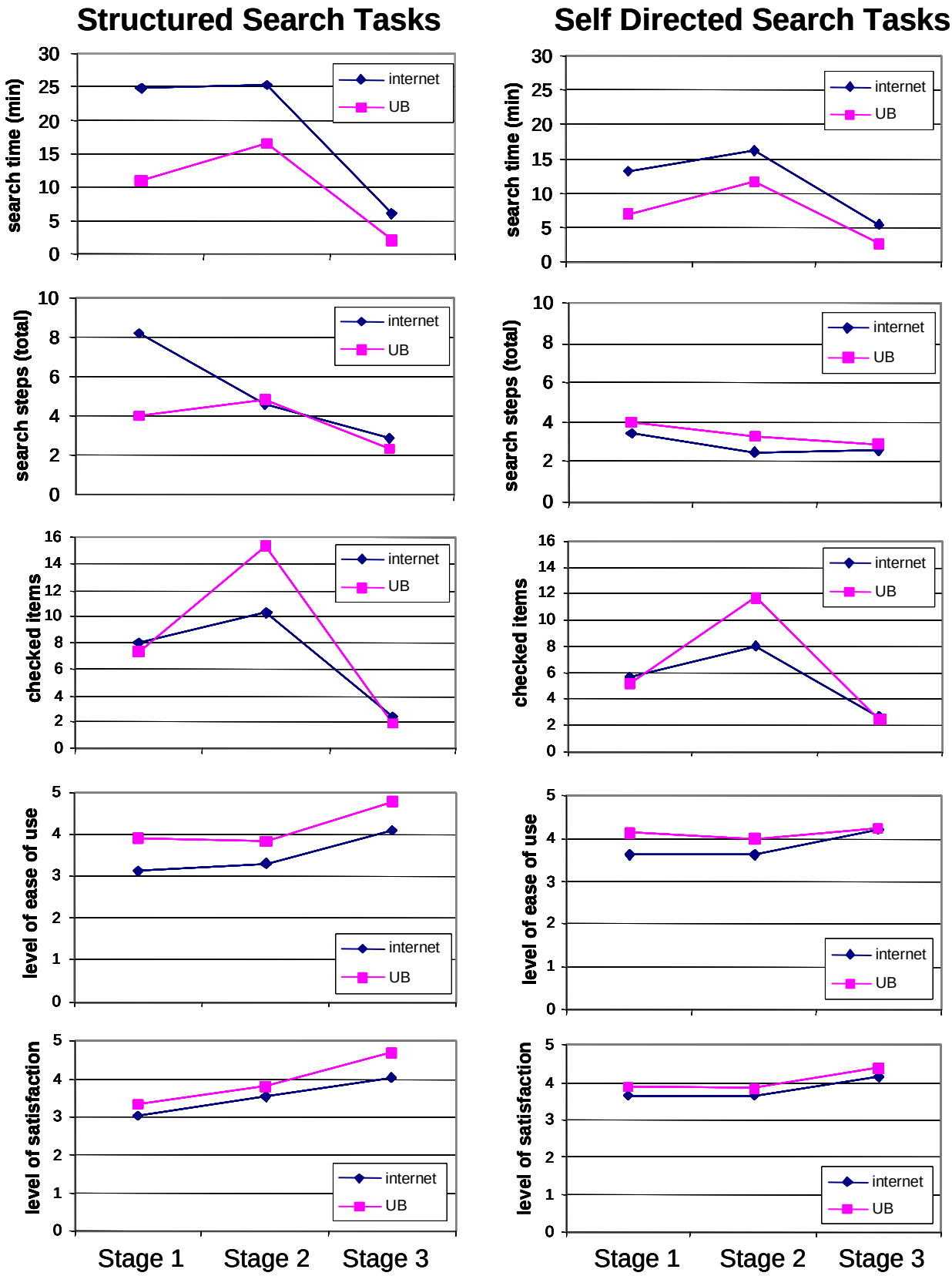

Figure 1.Illustration of results by search stages and type of task. The figures on the left correspond to the structured search task. The figures on the right correspond to the self directed search task. Figures in the same row represent the same dependent measure. Within each figure, results from the three search stages are shown.