Information seeking on the Web: Effects of user and task variables

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Abstract

This study investigates how cognitive style (field dependence vs. field independence), online database search experience (novice vs. experienced searchers), and task type (known-item vs. subject search tasks) influence users’ search behavior on the Web. Forty-eight undergraduate students participated in this study. The participants were divided into four groups according to cognitive style and online database search experience. Each participant searched for information on a university Web site to complete two differing search tasks. The time spent and the number of nodes visited in retrieving information were used to measure users’ search performance. The choice of navigation tools was examined to determine users’ search and navigational style. It was found that online search experience and cognitive style interacted and influenced search performance, as well as navigational style. Online search experience also interacted with task type to influence navigational style and the number of nodes visited. The article concludes with suggestions for improving Web interfaces and Web-user training programs. © 2001 Elsevier Science Inc. All rights reserved.

We live in an era of information explosion. With the development of a wide variety of technologies, the amount of information available to people is growing rapidly. Furthermore, through different channels, the same information is diffused in various forms; this accelerates the speed of information growth.

As computer technology advances, information systems have been designed and have evolved for improving the retrieval of information. The advance in technologies has also contributed to the improvement of the interface in most information systems. Hypermedia, characterized as a nonlinear multimedia system that allows interaction with users, is a
relatively new information technology and has been adapted as an information system for a variety of purposes. Because of its novel characteristics and perceived ease of use, hypermedia has attracted many end-users, although it also has been condemned for imposing unusual burdens on the user due to its nonlinearity.

The World Wide Web (Web), is a hypermedia-based information system combined with telecommunication technologies. The Web has become one of the most widely used information systems, allowing flexible presentation of, and seemingly limitless access to, information. The popularity of the Web is made even more dramatic by the degree to which it enables the creation and dissemination of primary information sources. The Web has engendered a fervish rush for adoption among different individuals with different needs. Regardless of their backgrounds, characteristics, and information needs, an increasing number of individuals have become frequent Web users.

Unlike traditional information systems with confined access by a rather homogeneous group of users, the Web is used by a “new” population of users, far more heterogeneous in terms of their backgrounds, skills, and needs. The shift in the user population results in a new challenge in the system interface design, as well as system user training (Borgman, 1986). In response to the challenge, there has been a paradigm shift from “system-centered” to “user-centered” approaches in designing user studies (Dervin & Nilan, 1986; Hewins, 1990; Sugar, 1995). Although there exists a great body of research focused on system performance characteristics and effective practice of search intermediaries, an increasing number of studies have been conducted to understand end-users with different backgrounds and needs, who are usually novice searches.

A number of user-centered studies have shown that users and tasks are the factors with strong impact on the use of information systems (Marchionini, 1995; Nielsen, 1993). An analysis of existing studies on hypermedia systems also confirms that the users’ individual characteristics and their tasks are the most important issues for usability of hypermedia (Nielsen, 1989).

This study investigates how some of the user and task variables influence information-seeking behavior on the Web. Factors such as task type, users’ cognitive style, and users’ online search experience are considered, together with the relationships and effects these factors exert on search performance and navigational behavior. The research questions posed are as follows: (a) What are the effects of task type, and the user’s cognitive style and online database search experience, on the search performance and (b) what are the effects of task type, and the user’s cognitive style and online database search experience, on the search and navigational style? The study aims at improving the understanding of Web users’ information-seeking behavior and provides guidelines for Web user training and for the design of Web search and navigation tools.

1. Background

This section provides a review of research on the effects of task and user variables on information behavior. More specifically, studies on information search tasks and those on users’ cognitive style and online search experience are examined.

1.1. Cognitive style

Cognitive styles, generally defined in terms of consistent patterns of “organizing and processing information,” influence the manner in which individuals prefer to learn and receive instructions (Messick, 1976). Among different attempts to identify cognitive styles, field dependence (FD) versus field independence (FI) is one of the most widely researched approaches. FD versus FI refers primarily to a global versus an analytical way of perceiving things. FD individuals are more likely to be dominated or influenced by the prevailing field, and tend to be diffuse in their responses. On the other hand, FI individuals are adept at overcoming the influences of the field or embedded context, and experience items as separate and discrete from their backgrounds (Witkin, 1973; Witkin, Moore, Goodenough, & Cox, 1977).

In a hypermedia system where information is presented in multimedia formats with a flexible structure, the FD/FI cognitive style is likely to have an impact on the user’s information-seeking behavior. Korthauer and Koubek (1994) evaluated the effect of individuals’ cognitive style in conjunction with the nature of the hypertext task. The study revealed that cognitive style had a significant effect on learning in a hypertext environment. The FD individuals, in general, performed at less accurate levels than FI participants. Liu and Reed’s (1994) study, which focused on vocabulary learning with a hypermedia-based learning system, found that students with different cognitive styles explored the system differently. The FDs navigated the hypermedia system in a linear mode, whereas the FIs freely jumped around within the system. Ellis, Ford, and Wood (1993), who also investigated the effect of the user’s cognitive style on the learning outcomes in a hypertext-based system, found that the FI individuals tried a higher number of access attempts to information nodes than did the FDs. In addition, FIs were more successful in producing correct answers than the FDs.

1.2. Information search experience

Another factor that affects search behavior is experience or expertise in information searches. Fenichel’s (1981) study, which compared search performance on an online database system, found that users’ search experience influenced their search performance. Novice searchers retrieved information more slowly and made more errors than experienced searchers. Not only were novice searchers slower and more prone to error but another study (Pennebaker, 1975) found a significant difference between novice and experienced searchers in their search patterns as well.

Using a hypertext-based information system, Marchionini, Lin, and Dwiggins (1990) compared effects of the user’s search experience and subject expertise on the information search process and outcomes. They found that both groups of experts (search and subject experts) outperformed the novices. Although no difference between the two expert groups was detected on their success rate, their search styles differed. Subject experts tended to spend more time reading the retrieved information, whereas search experts spent more time on search-preparation and modification work. Hsieh-Yee (1993) examined and
compared effects of the user's search experience and subject expertise on the use of online database systems. She concluded that in online searches, users' search experience affected their use of search strategies and played a more important role than subject expertise. Qiu (1993b) examined users' information search patterns on a hypertext system. She discovered that experienced searchers tended to navigate the hypertext system in a nonlinear mode. Novice searchers, on the other hand, explored the system applying a more linear browsing approach.

1.3. Information search task

Ingwersen (1992) pointed out that effective information retrieval must be based on understanding of a user's task or problem. Information needs and information-seeking processes depend on the task of the user, because the task imposes information requirements that must be met if the task is to be completed (Wersig, 1975).

In a series of studies on users' behavior and needs on online catalogs (Drabenstott, 1984; Matthews, Lawrence, & Ferguson, 1983), the existence of two major types of search tasks was reaffirmed: "known-item search" and "subject search." In research on other information systems, such as online database and hypertext information systems, search tasks similar to the known-item and subject search tasks have frequently been used to compare the impact of tasks on the user's information search behavior.

Marchionini (1989) investigated elementary students' information search behavior in a full-text online system, using "closed" and "open" tasks. The closed task, used in his study, shared the cognitive characteristics of the known-item search. Indeed, Marchionini himself used "known-item search" and "closed task" interchangeably. He also used "fact retrieval" to refer to the closed task. Similarly, his open task is comparable to the subject task. In a subject search task, the user has a general and abstract idea about a subject to be searched. Because the target information is unknown and its boundary is fuzzy, the formulation of a query is often difficult. Furthermore, the number of pieces of information to be retrieved is not determined in the subject search. The open task in Marchionini's study shares these characteristics with the subject search task. Marchionini found that depending on tasks to complete, students' information behavior differed. That is, students needed to spend more time for the open task than for the closed task. In addition, the open task seemed to require a higher number of moves and look-ups.

Qiu (1993a) conducted a study to investigate the effect of task type on search strategies in a hypertext information system. She used two types of tasks: "general" and "specific." For the general search task, users searched for general information about a broad topic. For the specific search task, users sought more specific information that was known to exist. The general and specific search tasks are closely related to subject and known-item searches, respectively. Qiu found that the types of search tasks influenced the user's search strategies. The general task led to the frequent use of browsing, whereas the specific task led to the frequent use of analytical search strategies.

2. Method

2.1. Participants

Forty-eight individuals participated in this study. All of the participants were undergraduate students of the University of Texas at Austin. They were recruited through ads posted in buildings throughout the campus. All participants were offered monetary compensation for their participation. The participants were from all grade levels, although almost half of them were seniors: 12.5% (n = 6) were freshmen, 14.5% (n = 7) were sophomores, 25% (n = 12) were juniors, and 48% (n = 23) were seniors. The participants' academic backgrounds were as follows: 54.2% (n = 26) were majoring in the soft sciences (arts, humanities, and social sciences) and 45.8% (n = 22) were majoring in the hard sciences (engineering and natural sciences). There were equal numbers of men and women. Their ages ranged from 17 to 43 years (M = 21.9, SD = 4.4).

2.2. System

A Pentium personal computer (PC), equipped with two speakers that permitted the delivery of audio information to the user, was used for the study. The PC also had the standard keyboard and mouse required for input from the user. Netscape Navigator 4.0 was used as a Web browser. Lotus ScreenCam was used to record the participants' search behavior on the Web. All screen displays were recorded in the real time order in which the user consulted Web sites and pages. The ScreenCam allowed an easy and unobtrusive recording of search sessions.

Participants were encouraged to carry out their search tasks within the boundary of their university Web site. The main purpose of setting the limit on the search environment was to prevent the study from being influenced by any unwanted, intervening variables from the system. First, this limitation could lessen the chance of undesirable, extremely long delays caused by contacting remote Web servers. Second, the university Web site could provide a stable search environment, relatively immune to any unexpected, drastic changes that could contaminate the study results. In addition, it seemed probable that, because it was their own university's site, the participants would feel more comfortable with, and could relate more easily to, the Web site. It was assumed that participants were more likely to be motivated to search on their university's Web site than on other sites with which they might have no connections at all.

2.3. Independent variables

There were three independent variables in this study, each defined dichotomously: (a) cognitive style, (b) search experience, and (c) type of information search task. The first two user variables were between-subjects independent variables, whereas the last task variable was a within-subject variable, used for the repeated measure.
2.3.1. Cognitive style

The participant's cognitive style was determined by the Group Embedded Figures Test (GEFT) (Olzman, Raskin, & Witkin, 1971). The test is a standardized paper-and-pencil test consisting of 18 questions. The test taker's job is to find a simple figure that is embedded in a complex figure in a way that obscures the simple figure. Individuals who are successful at disembedding the hidden figures are field independent (FI), whereas those unsuccessful at such disembedding are field dependent (FD). The score of the test can range from 0 to 18. High scores indicate high FI, while low scores reflect high FD. The reliability of the test is .82 for both men and women undergraduates. Its validity varies depending on tests used as a criterion measure: -.34 with the portable apparatus of the Rod-and-Frame Test and .82 with the individual Embedded Figures Test.

On the basis of the GEFT score, participants were classified as either FD or FI. Decisions were made according to the national norm provided in A Manual for the Embedded Figures Tests (Witkin, Olzman, Raskin, & Karp, 1971). Half of the participants (n = 24) were FDs (M = 8.25, SD = 2.63), and the other half were FIrs (M = 15.96, SD = 1.99).

2.3.2. Search experience

Information concerning the participants' experience with online databases was collected through a questionnaire. Four questions were used to collect information on the participant's online search experience in particular: (a) Have you ever used any online databases (indexes, abstracts, or full-text databases) available in the university libraries or any other places; (b) how long have you been using online databases; (c) how often do you use online databases; and (d) could you name any of the online databases that you have used before? Participants who answered "no" to the first question received a score of "0" and were classified as "novice." For those who answered "yes" to the first question, their answers to the second and third questions were rated and averaged to determine their level of experience with online databases. Those who reported using online databases frequently and for a long period of time received a higher weighted score (up to 4 points). The fourth question determined whether the participants understood what was meant by "online databases," and if they had been using the databases frequently enough to remember some of the names. Participants who answered that they had used online databases but failed to name any of them were briefly interviewed by the researcher, to assess the participants' level of experience more accurately. Half of the participants were categorized as "novice" (M = 0.92, SD = .95) and the other half were "experienced" (M = 2.96, SD = .46).

2.3.3. Search task

Two different kinds of search tasks were used: a known-item search task and a subject search task. The operational definition of a known-item search is a task requiring the searcher to find a piece of information known to exist. The search scope is so narrowly focused and specific that every searcher should have the same criteria in evaluating the relevance of the retrieved information. For this known-item task, there was a piece of target information that all searchers were expected to retrieve. The known-item task was presented as follows:

Your graduation is coming closer. You are thinking of several options for your future, and one of them is to pursue further studies in the UT [University of Texas] graduate school. First, you decide to learn more about the requirements for the admission. Find information on requirements for admission, for U.S. graduates applying for UT graduate programs. When you locate the Web page listing the requirements, make a bookmark of it.

A subject search, on the other hand, is defined as a task requiring the searcher to retrieve information that is related to the given subject or topic regarded as useful to the searcher. The subject task was presented as follows:

Before your graduation, you decide to collect information on your future job and career. Find any information that you think useful to prepare for your future career. For example, you might want to search for information on questions like: What kinds of jobs are available and/or suitable for a person with a background like yours? Where can you find information on the jobs? Is there any career service available on campus? Is there any job fair on campus? What are you supposed to do for interviews—before, during, and after interviews? How should you prepare your resume (curriculum vitae) and/or other documents? Are there any people who are currently employed and want to share their experience, and many others. When you locate a useful resource, make a bookmark of it, and go on to the next. Find three to five Web resources that you think useful and bookmark them.

The scope of this search is so broad that each searcher could have different criteria for evaluating the relevance of the retrieved information. It is well known that individuals can hardly reach a consensus when evaluating the relevance of information. Thus, for the subject task used in this study, the usefulness of the retrieved information, judged by each searcher, was adopted as the criteria. Because the participant was asked to bookmark Web pages on which he or she found useful information related to the given subject, all the Web pages bookmarked by the searcher were regarded as relevant.

2.4. Dependent variables

The dependent variables were chosen to reflect individuals' search behavior. Two groups of dependent measures were adopted: one for search performance and the other for navigational style.

2.4.1. Search performance

Dependent variables used for measuring the search performance included (1) time spent in retrieving information and (2) number of nodes visited in retrieving information.

1. Time spent in retrieving a piece of information: In general, the length of time spent for completing a search task may vary depending on the task. Differences in task completion time could be explained in at least two different ways. One is by the qualitative difference between search tasks: Each task requires unique search strategies and actions that result in differences in terms of the task completion time. The other is by the quantitative difference,
That is, although search tasks are similar in nature and require the same kind of search strategies, one of the tasks requires the searcher to retrieve more pieces of information than the other. To reflect only the qualitative difference between search tasks, eliminating any quantitative differences, the total length of time spent for completing a search task was divided by the total number of pieces of information retrieved (reflected in the number of Web pages bookmarked) in each search task.

In the known-item search task, for example, participants were asked to find the specific target information located in a Web page and bookmark it. This search task consisted of one subtask (i.e., finding a piece of target information). In the subject search task, participants were asked to find more than one piece of information located on different Web pages and bookmark each page. The subject search task consisted of more than one subtask. Had they been compared as given, differences in the completion time would have reflected not only the task differences in nature but also the difference in the number of subtasks. To make a fair comparison of the two search tasks with different numbers of subtasks, the average length of time that a participant spent in retrieving a piece of information was calculated for each task (known-item and subject searches) and labeled as TIME.

\[
\text{TIME} = \frac{\text{total length of time spent for the completion of a task}}{\text{total number of bookmarks made}}
\]

2. Number of nodes visited in retrieving a piece of information: As mentioned previously, the requirement for each search task differed in terms of the amount of information to be retrieved. This difference could influence not only the length of time spent but also the number of nodes visited for the completion of a task. To retrieve more pieces of information, the searcher would need to visit more nodes. To make a fair comparison of the two search tasks, the average number of nodes that a participant visited in retrieving a piece of information was calculated for each task and labeled as NODE.

\[
\text{NODE} = \frac{\text{total number of nodes visited for the completion of a task}}{\text{total number of bookmarks made}}
\]

2.4.2. Navigational style

In addition to the search performance, navigational style was also investigated. For this, the number of times that a participant used a particular navigation tool or search option for completing a search task was counted. Then, this number was divided by the number of bookmarks made by the participant, yielding the average number of times that a participant used a tool in retrieving a piece of information.

The search and navigational tools of interest included the following: (a) embedded links; (b) Back button; (c) Home button; (d) jump options, such as Go, and History; and (e) keyword searches.

2.5. Procedure

First, a brief introduction to this study was given to the prospective participants. Then, the GEFT and questionnaire, individuals with characteristics needed for this study were selected and asked to have an individual lab session with the researcher. This selection process was necessary to ensure a balanced 2x2 factorial design: (a) FD-novice, (b) FD-experienced, (c) FI-novice, and (d) FI-experienced.

The lab session started with a brief review of the Web basics, explaining how to navigate the Web using Netscape 4.0, and how to formulate simple search queries using the AltaVista search engine, available on the university Web site. The review was designed to ensure that every participant was aware of the availability of different tools and menu options in the Web browser, as well as some basic search tools and features. Depending on the level of a participant’s Web experience, the review took 5 to 10 minutes.

Once the review was completed, two search tasks were given to the participant by means of printed instructions for each search task. The researcher also read the directions to the participant. For the subject task, the participant was asked to bookmark the Web pages that he or she found relevant to the given topic. To complete the task, the participant was encouraged to make three to five bookmarks. After making more than two bookmarks, the participant could stop searching. Those who made fewer than three bookmarks were asked to stop searching when the search took longer than 15 minutes. The time limit needed to be set, because recording a lengthy search session using Lotus ScreenCam could take up a lot of memory and result in freezing the computer screen. For the known-item task, the participant was asked to bookmark the Web page containing the target information. The participant had to continue searching until he or she found the target information. All participants were able to locate the target information within 15 minutes.

After the directions were given, the participant was asked if he or she had understood what to do for each task. More explanations were provided when necessary. When the participant felt ready to start searching, he or she asked the researcher to start recording the search session. After the first task, the participant had a short break to read the directions for the second search task. When the participant was ready, the recording started in the same manner as the first search session. The recording of each search session ended when the searcher indicated completion.

The order of tasks alternated to minimize any possible “order effect.” As a result, half of the participants started their search sessions with the known-item search task and the other half with the subject search task. For each individual’s search session, all the screen displays consulted and keyboard/mouse inputs were recorded using the Lotus ScreenCam software. All the recorded search sessions were viewed; search activities were coded by the researcher, with a code-recode consistency ratio of .98.

3. Results

Analysis of variance (ANOVA) was used to analyze the collected data. Results of the search performance are reported first, followed by the results of navigational style.
3.1. Search performance

To find out if and how search tasks and the user’s cognitive style and online search experience influenced the user’s information search performance, an ANOVA was performed, with the cognitive style and the online search experience as the between-subjects variables and the task type as the within-subject independent variable. Dependent variables used for measuring the search performance included the length of time spent in retrieving information and the number of nodes visited in retrieving information. It was hypothesized that differences in each independent variable (cognitive style, online search experience, and task) would be associated with different levels of search performance reflected in search time and the number of nodes visited. It was also hypothesized that different combinations of any two or three independent variables would be associated with different levels of search performance.

3.1.1. Time spent in retrieving information (TIME)

As indicated in Table 1, a significant two-way interaction was found between cognitive style and online experience, $F(1, 44) = 5.791, p < .03$. Figure 1 illustrates how the participants' cognitive style and online search experience interacted and influenced TIME. For the novice, the cognitive style had a great impact. That is, the FD spent significantly more time than did the FI to find information: $M_{FD, NOVICE} = 190.04$ seconds, $M_{FI, NOVICE} = 90.24$ seconds. For the experienced participants, on the other hand, the cognitive style did not seem to have any impact on TIME. In the experienced group, both FDs and FIs spent almost the same amount of time to find information: $M_{FD, EXPERIENCED} = 90.49$ seconds, $M_{FI, EXPERIENCED} = 88.07$ seconds. Overall, the FD-novice group spent a significantly longer time than the rest to retrieve a piece of information.

A significant main effect of cognitive style was also found, $F(1, 44) = 6.382, p < .02$. That is, the FD in general spent more time than did the FI: $M_{FD} = 140.27$ seconds, $M_{FI} = 89.15$ seconds. A significant main effect was also found on online search experience, $F(1, 44) = 6.318, p < .02$. In general, the novice participants spent more time than the experienced participants: $M_{NOVICE} = 140.14$ seconds, $M_{EXPERIENCED} = 89.28$ seconds. For the task variable, neither its main effect nor its interaction with other user variables (cognitive styles and online experience) was found to be significant.

3.1.2. Number of nodes visited in retrieving information (NODE)

As shown in Table 2, there were two significant two-way interactions: one between cognitive style and online search experience and the other between task and online search experience.

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<tr>
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* p < .05.

Table 2

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* p < .05.
The interaction between cognitive style and online experience was significant, $F(1, 44) = 4.21, p < .05$. As shown in Figure 2, among the novices, the FI tended to visit fewer nodes than did the FD: $M_{FI, NOVICE} = 7.43$ nodes, $M_{FD, NOVICE} = 13.13$ nodes. In the experienced group, however, little difference was found between the FI and the FD: $M_{FI, EXPERIENCED} = 7.4$ nodes visited, $M_{FD, EXPERIENCED} = 7.53$ nodes visited. Overall, the effect of cognitive style was significant in the novice group but exerted almost no effect in the experienced group.

Another significant interaction was found between task and online experience, $F(1, 44) = 4.098, p < .05$. As shown in Figure 3, for the known-item task, the novice participants tended to visit more nodes than did the experienced participants: $M_{NOVICE} = 11.5$ nodes, $M_{EXPERIENCED} = 5.96$ nodes; $t(46) = 2.344, p < .03$. For the subject search, however, the novice and the experienced groups visited almost the same number of nodes in retrieving a piece of information: $M_{NOVICE} = 9.07$ nodes, $M_{EXPERIENCED} = 8.98$ nodes.

As indicated in Table 2, no significant main effect was found. That is, there was no statistically significant difference between any of the two groups with different cognitive styles, different levels of search experience, or different types of search tasks.

### 3.2. Navigational style

To investigate the effects of task and users' cognitive style and online search experience on the navigational style, ANOVA was performed for each of the following dependent variables: the average number of times embedded links, the Back button, jump options, the Home button, and keyword searches were used in retrieving information.

It was hypothesized that differences in each independent variable would be associated with different levels of search/navigational activities reflected in the number of times different navigation tools were used. It was also hypothesized that different combinations of any two or three independent variables would be associated with different levels of search/navigational activities. In this section, only the results with statistically significant effects are presented.

#### 3.2.1. Number of times an embedded link was used (LINK)

As indicated in Table 3, three significant main effects were found: main effects of cognitive style, online experience, and task. Because significant two-way interactions were also found, these main effects should be interpreted in light of the interactions.

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<td>5.052</td>
<td>.030*</td>
</tr>
<tr>
<td>$T \times C$</td>
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<td>.181</td>
</tr>
<tr>
<td>$T \times O$</td>
<td>1</td>
<td>6.162</td>
<td>.017*</td>
</tr>
<tr>
<td>$T \times C \times O$</td>
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<td>.440</td>
</tr>
<tr>
<td>Error</td>
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<td></td>
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</tr>
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</table>

* $p < .05$. 

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Fig. 2. NODE: Interaction between cognitive style and online search experience. FD, field dependent; FI, field independent.

Fig. 3. NODE: Interaction between task and online search experience.
Apart from the interaction between cognitive style and online search experience, there was another significant interaction. The interaction between task and online search experience was significant, $F(1, 44) = 6.162, p < .02$. That is, effects of online experience on the LINK varied depending on the task type. Figure 5 illustrates how the two variables interacted with each other. In the known-item task, the novice participants used a greater number of embedded links than did the experienced participants: $M_{\text{NOVICE}} = 7.42$ links used, $M_{\text{EXPERIENCED}} = 4.25$ links used; $t(46) = 3.09, p < .01$. In the subject task, however, the difference between the novice and the experienced groups was minimal: $M_{\text{NOVICE}} = 4.64$ links used, $M_{\text{EXPERIENCED}} = 4.39$ links used.

3.2.2. Number of times the home button was used (HOME)

The ANOVA results revealed no significant main or interaction effects, except the interaction between cognitive style and online experience, $F(1, 44) = 4.543, p < .04$ (see Table 4). It was apparent that the effect of cognitive style on HOME varied depending on the participant’s online search experience. As shown in Figure 6, in the novice group, the FD used the Home button more frequently than did the FI: $M_{\text{FD-NOVICE}} = 0.25$, $M_{\text{FI-NOVICE}} = 0.03$.

It should be noted that the Home button was one of the navigational tools used rather infrequently, compared with the use of embedded links by all participants. The total number of times the Home button was used by a participant (before averaged by the number of bookmarks made) ranged from 0 to 3. Only 29.2% of participants used the Home button, and the number of times the Home button was used was 0.44, on average.

3.2.3. Number of times jump options were used (JUMP)

JUMP is the average number of times that a participant used tools for jumping, such as Go, History, and Location window, in retrieving a piece of information. Table 5 summarizes the ANOVA result. The two-way interaction between task type and online search experience was significant, $F(1, 44) = 9.715, p < .01$. As shown in Figure 7, jump options were rarely used, except by experienced searchers carrying out the subject search task. Similar to the case of Home button, jump options were not used as frequently as embedded links. The total number of times jump options were used by a participant ranged from 0 to 6. Only 22.9% of participants chose to use jump tools; the number of times jump options were used was 0.48, on average.

4. Discussion

The first research question was “What are the effects of task type, and the user’s cognitive style and online database search experience, on the search performance?” When the average length of time spent in retrieving information (TIME) was used for measuring the search performance, both of the user variables (cognitive style and online experience) had significant impacts. The FD individuals needed longer time than the FI individuals. Similarly, novice participants needed more time than the experienced online searchers.
Unlike other traditional “linear” information systems, hypermedia systems, such as the Web, can offer many different navigational options and attractive features. In the hypermedia systems, contents can also be presented by means of various media, including texts, images, audio, and video. In addition, a number of hyperlinks are available to help users jump to different places. The FDs, whose perception is easily influenced by outstanding cues that are not necessarily pertinent to the given task, may face difficulties in concentrating on whatever they need to choose as a next step on hypermedia systems. Because of this tendency, the FDs are more likely to spend extra time following unnecessary links and redirecting their attention from stimuli that are more attractive yet unnecessarily lead away from the desired goal. This may explain why the FDs needed more time to find information than did the FIs. When the effect of online search experience was considered, the novice participants usually needed more time than did the experienced individuals in retrieving information. This finding is comparable to what Fenichel (1981) found in her study on the use of a linear online information system.

Apart from these findings, this study also revealed a significant interaction between search experience and cognitive style in TIME. That is, among the experienced individuals, both the FDs and the FIs spent almost the same length of time, whereas among the novices, the FDs needed more time than the FIs. It seems that the FDs, who can be easily distracted and thus are expected to need more time to find target information, could complete a search task as quickly as the FIs when the FDs were equipped with substantial amount of online search experience. This implies that having online search experience may help the FDs improve their search performance on the Web. Surprisingly, among the FIs, little impact of online search experience was found. The FIs who can easily focus on what they need, and who have an analytical mind, seem to have an advantage over the FDs when using hypermedia systems. The FIs retrieved...
information fairly quickly regardless of the levels of their online experience. The results on TIME imply that experience with the use of online databases can help users shorten their search time, and that this is especially true for the FD group. From a user-trainer's point of view, it can be seen that a training program for Web users should include teaching how to search online databases. Such training programs should aim at the FDs in particular.

It was somewhat unexpected to find no task effects on TIME, because the subject task, similar to Marchionini's (1989) open task, was thought to require more time for completion, as in his study on an online information system. However, the difference in Marchionini's findings and this study's can easily be explained by differences in approaches to measuring the search time rather than by differences in characteristics of the systems or tasks used. Marchionini measured the total search time for completing a task regardless of the amount of information retrieved for each task, whereas this study used the normalized search time (the total search time divided by the number of pieces of information retrieved). When the total search time is used, this study leads to the same findings as Marchionini's. That is, users spend more time in the subject search than in the known-item search: $M_{SUBJECT} = 411.25$ seconds, $M_{KNOWN-ITEM} = 120.75$ seconds; $t(47) = -11.79, p < .001$. Because the participants had to find more than one piece of information for the subject search task, it took them longer time than in the known-item search task, for which they needed to find only one piece of information.

Here, we need to think about these two different approaches: the use of "raw" versus "normalized" measures. Which measure would accurately reflect characteristic differences in search tasks? Search tasks used in this study (i.e., known-item and subject) may be dissimilar in their characteristics, but at the same time, they also differ in terms of the amount of information to be retrieved. That is, known-item tasks require only one item, whereas subject tasks require more than one piece of information. To compare these tasks fairly, the normalized measure (averaged by the amount of information retrieved) would be the better one to use, because it reflects only qualitative, but not quantitative, differences in search tasks.

When the average number of nodes visited in retrieving information (NODE) was considered as an indicator of the search performance, 2 two-way interactions were found significant: one between cognitive style and online experience and the other between task and online experience. The interaction between cognitive style and online experience had the same impact on NODE as it did on TIME: the effect of cognitive style was significant in the novice group, although it was minimal in the experienced group. That is, the FD-novice participants needed to visit more nodes than the rest.

Another significant interaction that did not exist in TIME was found in NODE: an interaction between search task and online experience. For the known-item task, the novice group needed to visit a greater number of nodes than did the experienced participants to find a piece of information. This was as expected, because the novice participants, who have not had enough opportunities to develop search skills as have those with more experience, are more likely to follow unnecessary steps in addition to essential ones. Surprisingly, in the subject task, the novice participants visited almost the same number of nodes as did the experienced participants in retrieving information. This result should be interpreted with caution, however, because the search performance for the subject may have been influenced by other variables. In this study, the subject task required participants to find information on a topic that was general enough for them to focus on subtopic areas of their interest. Consequently, the retrieved information in the subject task varied depending upon the participants' area of interest.

From this result, it could be inferred that when individuals have an option to search for information in the areas in which they are interested and familiar, or both, they can find the information by taking fairly few steps, no matter how little online experience they have. This might be because of their familiarity with the subtopics they selected (subject expertise), or simply their high motivation toward the search on the subtopics they chose. For example, if an individual majoring in computer engineering searches for information related to his career, he is more likely to carry out successful searches. It could be because he knows about the discipline and related issues (e.g., organizations that may have job openings and associations that may offer career services for computer engineers) or because he is interested (and motivated) in the search topic that is directly related to his major. Whatever the reason, it seems that this particular situation in which participants could choose search questions provided a positive impact, although it would be difficult to objectively measure and assume the relevance of search results. Further research is needed to investigate the effects of subject and search expertise, as well as the effects of motivation, on search performance on the Web.

The second research question was "What are the effects of task type, and the user's cognitive style and online database search experience, on navigational style?" In this study, it was assumed that navigational style is reflected in the use of search/navigation tools, such as embedded links, jump tools (using history list, bookmark, Back, Go option, or the URL location box in order to jump), keyword search, and the Home button. The use of links can indicate whether an individual tends to navigate the Web in a linear mode. The more frequently links are used, the more the navigational mode approximates a linear structure. In contrast, the more frequently jump tools are used, the more the navigational mode approximates a nonlinear structure. As in other studies (Marchionini, 1995; Qiu, 1993b), it can be assumed that the frequent use of the keyword search indicates the preference toward analytical search. Finally, the frequent use of the Home button implies that the searcher has gotten lost in the process of the search and needs to return to the starting point to get his or her bearings.

For the use of embedded links, the interaction between two user variables was significant. That is, the FDs used links more frequently than the Fi's in the novice group, whereas both of the FDs and the Fi's used links almost the same number of times in the experienced group. This finding implies that the FDs have a tendency to navigate the Web in a linear mode when searching, which coincides with findings of previous research (Liu & Reed, 1994). It also suggests that with more search experience with online databases, the FDs are less likely to navigate the Web in a linear mode. Online search experience seems to help the FDs depend less on the structure that others (such as Web authors) impose, and take advantage of the nonlinearity of the hypermedia system.

In addition, a significant interaction between task type and online experience was also found. In the known-item task, the novice participants used embedded links more frequently than did the experienced searchers. In the subject task, however, little or no difference was found between the novice and the experienced groups, although it was anticipated that the
novice participants would use the links more frequently than would the experienced participants, as in the known-item search. It is not clear why this tendency disappeared in the subject task. It could be because of the different conditions established by different types of tasks. As in the case of the use of nodes, subject expertise or motivation of searchers, or both, may have played a role in reducing the tendency of linear browsing. Further research is needed to clarify why this kind of interaction effect existed.

Interestingly, a significant effect of task type revealed that embedded links were more frequently used in the known-item than in the subject task. This finding conflicts with Gary and Shasha's (1989) remarks that embedded links would be more useful for a general exploratory search. When the total number of times that embedded links were used for completing a search task was calculated, regardless of differences in the number of pieces of information retrieved for each task, the findings of this study support Gary and Shasha's speculation. That is, a greater number of links used was observed in subject than in known-item searches: $M_{subject} = 17.58$ links used, $M_{known-item} = 5.83$ links used; $t(47) = -10.04, p < .001$. Again, the decision on whether a raw or normalized measure should be used may depend on whether the difference in the amount of information retrieved for each task should be viewed as part of task characteristics. In this study, normalized measure was adopted to gauge effects exerted by tasks' qualitative differences.

For the use of the Home button, the interaction between cognitive style and online experience was found again. In the novice group, the FDs used the Home button more frequently than the did the FIs. In the experienced group, on the other hand, both the FD and the FI groups rarely used the Home button. It seemed that the FDs tended to get disoriented and got lost easily, which was probably why Home was used more often by the FD-novice participants. With more online experience, however, the FDs seemed to overcome the problem of "getting lost." Interestingly, the FIs did not seem to have this kind of problem, no matter how little online experience they had. The FIs, who tend to be focused and goal oriented, are less likely to experience the problem of disorientation.

When the use of Jump tools was considered, an interaction between task type and online experience existed. The experienced group used Jump tools more frequently in subject than in known-item searches. It may be assumed that the way in which the experienced group searched for information would be the "better" way, because they always managed to find information by following a shorter path, and thus in a shorter period of time than the novice participants. Then, a question emerges: Why would the subject task require the use of more Jump tools than the known-item task? A possible answer is that, in contrast to the known-item search, which requires only one piece of information, the subject search requires the searcher to find more than one piece of information on a topic—pieces that are not necessarily located in Web sites linked to one another. Thus, it seems natural that Jump tools would be more frequently used in the subject task. Although the Home button and Jump tools were used as frequently as others, such as embedded links or the Back button, they still seem to be useful to a certain group of users and to those carrying out certain tasks.

It should be pointed out that, in this study, only one question was used for each type of task. The findings on task type could be attributed either to characteristics of the known-item and the subject tasks in general, or to characteristics of the tasks used in this particular study.

The findings of the study can be generalized only after they are confirmed by a study in which a number of different questions are used for both the known-item and subject search tasks.

5. Conclusion

In general, online database search experience seems to be a user variable with a strong impact on both search performance and navigational style. Individuals with online database search experience are able to use the Web efficiently. They usually find information quickly, by following a short path. A simple regression result showed that the online search experience variable could predict the Web search performance better than other kinds of experience variables, such as computer or Web experience (Palmaquist & Kim, 2000). Although the Web, a hypermedia-based information system, has characteristics different from those of other linear online database systems, it is apparent that the Web requires search strategies useful for searching online databases. An alternative explanation is that many Web sites are still being developed on the basis of the principles applied to linear online database systems, even though the characteristics and capacities of the two systems differ. Whichever is the right explanation, this finding implies that training for the effective use of online databases can help users with the Web as well.

Obviously, cognitive style also influences the user's information-seeking behavior, but it matters most for those with little or no online search experience. Although there is a general tendency for the FIs to outperform the FDs, this difference can be minimized, and both groups of individuals can perform equally well when the FDs are equipped with substantial online search experience. Training the FDs to use online databases effectively might improve their search performance on the Web. In addition, Web designers and developers might need to pay close attention to the characteristics that the FIs tend to face (such as the dependency on navigational and disorientation problems). They should experiment with different layouts and structures of Web pages to help the FDs search and navigate the Web in a more efficient way. As suggested by others, providing a site map (Nielsen, 1995; Thuring, Hanneman, & Haake, 1995) or an improved history list (Ayers & Stasko, 1995; Cockburn & Jones, 1996) may mitigate disorientation problems that the FDs often face in using hypermedia systems such as the Web.

Overall, the use of search or navigational tools is likely to change as the user gains more experience, especially for the FDs. It is also affected by tasks. From a Web interface designer's perspective, this finding could be used to justify the decision to make different options (such as embedded links, Home button, and jump tools) available to everyone. If a Web site is for users with certain levels of search experience and characteristics, or for certain types of tasks, it will need to be designed in such a way as to facilitate the users' information seeking for certain tasks.

It is interesting to note that all results with different measures revealed no interaction between cognitive style and task type, although each variable's main effect and its interaction with the search experience variable were often observed. Further study is needed to focus on possible relationships between cognitive and task characteristics.
Online search experience seems to play a critically important role in improving search performance and developing effective search/navigational tactics, although cognitive style also affects the search performance and behavior. Task variable does not seem to have a great impact on search performance, but do influence search and navigational styles. To further investigate the effect of task types on search behavior, more research on users' information seeking in different contexts (such as different situations with different tasks) is called for. Studies on the taxonomy of information tasks and those on measures accurately reflecting task differences are also needed. Web user-trainers and Web developers may find the study findings useful. Web user-trainers will need to design educational programs to support individuals who are likely to have difficulties in using the Web, such as the FDI's with little search experience. Web developers will need to take the findings into consideration when designing Web pages, so that all users will be enabled to carry out their tasks equally well.

References


