Implications of User Characteristics in Information Seeking on the World Wide Web

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The study described in this article investigated how differences in cognitive style and online search experience influence the search performance and navigational pattern of individuals utilizing a university World Wide Web (WWW) site. Forty-eight undergraduate students with diverse academic backgrounds participated in the study. On the basis of cognitive style and prior experience with online database search, the participants were assigned to 1 of the following groups: (a) field-dependent (FD) with little or no online search experience, (b) FD with substantial online search experience, (c) field-independent (FI) with little or no online search experience, and (d) FI with substantial online search experience. It was found that cognitive style influenced search time, whereas online search experience affected navigational style, such as jumps and layer traversal. Cognitive style and online search experience also interacted to influence search performance and navigational style. FDs with little or no online search experience navigated the WWW in a fairly linear mode, using embedded links frequently. They also tended to visit more nodes and used "Home" more frequently than the rest. The results imply that as FD searchers gain more online search experience, their navigational style and search performance change and become comparable to that of FIs. Based on these findings, some suggestions are made to improve the WWW interface and WWW user training programs.

1. INTRODUCTION

As computer technology advances, different systems have been developed for improving the learning and retrieval of information. Hypermedia is one of the newer technologies, equipped with attractive interface and flexibility. It is capable of integrating large bodies of information in alternative representation formats and providing it in different organizational structures to accommodate the user's interest and needs. Today, hypermedia has come to include remote databases and online resources accessible by way of the World Wide Web (WWW) and other networks.

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(Ayersman, 1996). With its appealing features and flexibility inherited from the hypermedia technology, and its capacity of providing access to a variety of different resources, the WWW has become one of the most popular information systems widely used all over the globe.

In contrast to more traditional information systems, hypermedia is intentionally nonlinear (Nielsen, 1995). It presents a new information environment with which the user may not be familiar; it permits the user to have considerable flexibility in choosing the sequence with which to access information, rather than forcing the user to access information in a fairly linear sequence. Such linear sequencing has long been prescribed by the authors of books and is the one with which most users are familiar. As most users have not fully developed skills of information-gathering in a nonlinear environment, they often report discomfort and experience difficulties in using hypermedia. The most predominant problems reported are "cognitive overload" and "disorientation" (Conklin, 1987; Nielsen, 1995).

Despite these problems, previous studies have revealed that using hypermedia systems positively influences students' learning (Chen, 1993; Liu & Reed, 1994; Toro, 1995). In these studies, it was found that students learned better when hypermedia-based instruction was used. Obviously, there also exist other studies reporting no gains for hypermedia-based instruction over others (Leonard, 1992; McCoy, 1994). However, a recently conducted meta-analysis of existing studies on hypermedia-based instruction revealed that the effect of using hypermedia in instruction is, in general, positive over nonhypermedia instruction (Liao, 1999). According to Liao, the varied effects of hypermedia systems found in existing studies might have resulted from other variables in addition to the hypermedia technology, such as differences in instructional methods, contents, students, and so on.

A similar speculation may also be valid for research on the effectiveness of hypermedia as an information retrieval system. Like those on the hypermedia system for learning, studies on hypermedia for information retrieval have engendered inconsistent findings. Several studies found that using a hypermedia system resulted in better search performance than using other nonlinear information systems (Egan, Remde, Landauer, Lockbaum & Gomez, 1989; Gary & Shasha, 1989; Leventhal, Teasley, Instone, Rohlman, & Farhat, 1993), whereas others found the opposite (Marchionini & Shneiderman, 1988; McKnight, Dillon, & Richardson, 1990). This inconsistency in findings might have been due to variables other than the hypermedia technology, such as differences in users, tasks, and so on. Research investigating variables related to the effective use of hypermedia has suggested that differences in users' individual characteristics (e.g., cognitive style, gender, search experience) may be one of the most influential factors affecting search behavior on a hypermedia system (Ford, Wood, & Walsh, 1994; Qiu, 1993a). This is confirmed by a finding from an analysis of existing hypertext studies, indicating that individual differences among users are responsible for 4 of the 10 largest factors affecting hypertext usability (Nielsen, 1989).

Among different kinds of individual differences, cognitive style, particularly field-dependence/field-independence (FD/FI), is one of the most frequently studied factors in the research of learning through hypermedia systems. FD/FI is a perceptual dependence and independence on the structure of the prevailing visual
field (Witkin, 1973). This tendency is believed to be transferred to and affect the individual's cognitive and personality orientations as well. FDs, who tend to be dominated by salient cues, make less effective use of mediational process, adopt a passive role in learning, and are more sociable. On the other hand, FIs, who are less dominated by the most obvious or salient cues, tend to make a great use of mediational process activities such as analyzing and structuring; adopt an active, hypotheses-testing role in learning; and operate more from their intrinsic motivation and goals, which leads them to be more independent and less sociable than FDs (Witkin, Moore, Goodenough, & Cox, 1977).

Hypermedia systems provide an environment where information units are presented through different media and in a loose structure, which may not be favorable for FDs to find information efficiently. An interaction between the variety of environments that hypermedia provides and the cognitive style (FD/FI) of users is highly probable. In fact, a number of studies have shown that FI individuals generally perform better than FDs on hypermedia information systems (Ellis, Ford, & Wood, 1993; Ford et al., 1994).

Expertise/experience is another individual difference that may have a strong effect on the information-seeking process. Computer experience and expertise in online searching and subject areas have been found effective in the choice of search strategies and the search performances on hypermedia. The more computer experience individuals have, the more analytical searching strategies they use (Campagnoni & Ehrlich, 1989). Expertise in subject areas and expertise in online searching are found to have similarly positive effects on the search performance (Marchionini, Lin, & Dwiggins, 1990). A number of studies have shown, however, that among different kinds of experiences and expertise, search experience plays the major role in determining the effective use of systems (Fenichel, 1981; Hsieh-Yee, 1993).

This study investigates some of the seemingly important factors affecting the information-seeking behavior of users on a hypermedia-based system, using the WWW as a current popular information-intense choice. Factors such as users' cognitive style and online search experience are considered together with the relations and effects these factors exert on the information search behavior. In this study, two research questions are addressed: (a) What are the effects of a user's cognitive style (FD/FI) and online search experience (Novice/Experienced) on the user's information search performance? and (b) What are the effects of a user's cognitive style and online search experience on their navigational style? Answers to these questions are sought by evaluating users' search performance as well as by analyzing search and navigational styles reflected in tool usage and layer traversal. Based on these findings, suggestions are made to improve the WWW interface and WWW user training.

2. USER DIFFERENCES AND THE HYPERMEDIA

2.1. Cognitive Style

Cognitive styles, generally defined in terms of consistent patterns of "organizing and processing information," have been known to influence the manner in which
individuals prefer to learn and receive instructions (Messick, 1976). For this reason, terms like cognitive styles and learning styles are often used interchangeably, although they are measured with different measuring approaches (Jonassen & Grabowski, 1993). According to Goldstein and Blackman (1978), there exist a number of different approaches to identifying cognitive style, each of which has resulted in an abundance of various types of cognitive styles. "Holism-serialism" (Pask, 1976), "field-dependence–independence" (Witkin et al., 1977), and "reflective-impulsive" (Kagan, Rosman, Day, Albert, & Phillips, 1964) are some of the cognitive styles identified.

Among different attempts to measure cognitive styles, FD/FI is one of the most widely researched approaches. FD versus FI refers primarily to a global versus an analytical way of perceiving. FD individuals are more likely to be dominated or influenced by the prevailing field and tend to be diffuse in their responses. FI individuals are adept at overcoming the influences of the field or embedded context and are able to experience items as separate and discrete from their backgrounds (Witkin, 1973). It is known that this cognitive style is relatively stable: Individuals tend to hold the same position relative to their age peers on the FD dimension over the life span (Witkin, Olman, Raskin, & Karp, 1971).

In hypermedia systems where information units are presented in various formats and media and in a loose structure, FD individuals are likely to have difficulties because of their limited differentiating ability. A number of studies have revealed that FI individuals, less likely to be dominated by salient cues, tend to find information more correctly and efficiently and arrive at desired goals more quickly than FDs (Ellis et al., 1993; Ford et al., 1994; Korthauer & Koubek, 1994). Studies focused on learning rather than information retrieval, however, have discovered that FD and FI individuals can learn equally well on hypermedia-based instructional systems (Fitzgerald & Semrau, 1998; Liu & Reed, 1994). In spite of the apparent discrepancies in their research foci and results, these studies seem to have a common finding: FD and FI individuals interact differently with hypermedia systems. For example, Liu and Reed found a difference between FDs and FIs on their navigational style. In their study, FDs explored a hypermedia system in a linear mode, by following the sequence encouraged by the system. In contrast, FIs preferred a nonlinear navigational style. They freely jumped around within the system by utilizing index tools frequently. Fitzgerald and Semrau also discovered that FDs and FIs interacted differently with a hypermedia system, although both achieved comparable levels of learning. A relation between cognitive style and the use of hypermedia was found in other studies as well. Leader and Klein's (1996) study discovered that FIs took advantage of certain tools, such as index/find and map, that can facilitate a nonlinear navigation, and found information more efficiently, whereas FDs did not.

It seems that with its exceptional flexibility, hypermedia can accommodate users' different preferences and needs. Hypermedia allows individuals to use and interact with a system in diverse ways depending on their needs. Naturally, users are likely to demonstrate different ways of using and navigating the system while searching for information. Despite or thanks to these differences, however, users often achieve comparable levels of learning.
2.2. Online Search Experience

Users' expertise in online searches has been found to influence search performance and choice of search strategies. The more search experience individuals have, the more accurate their search outcomes become. Furthermore, experienced searchers usually find information more quickly than novice searchers (Fenichel, 1981).

Using a hypertext-based information system, Marchionini and his colleagues (Marchionini, Lin, & Dwigginis, 1990) compared the effects of a user's search experience and subject expertise on information search outcomes. No difference between two expert groups was found in terms of their success rate, although both expert groups' search performance was far better than a novice searcher group's. In a study investigating search behavior in a hypermedia-based information system, Qiu (1993a) discovered that experienced searchers tended to adopt an analytical search strategy (e.g., keyword search), whereas novices applied a more linear browsing approach. It seems that the user's experience with systems to use, tasks to carry out, and subject areas to search affect his or her search performance and style. Among the different kinds of experiences, which one would be the most influential remains to be discovered, although a study on a nonhypermedia online system revealed that search experience had a stronger impact than subject expertise on search behavior (Hsieh-Yee, 1993).

Based on previous studies, the following hypotheses are established:

1. FDs who tend to perceive information with a low level of differentiation would spend more time and visit more nodes than FLs to complete a search task.
2. FDs would navigate the WWW following the structures and sequences WWW authors prescribed and use embedded links more often than FLs.
3. FDs would be easily disoriented and use the Home button more frequently than FLs.
4. FLs would initiate jumps whenever necessary and use jump tools more frequently than FDs.
5. Novices would spend more time and visit more nodes than experienced searchers.
6. Different combinations of searchers' cognitive style and online search experience would be associated with different levels of search performance and navigational activities.

3. METHODS

3.1. Participants

The participants were 48 undergraduate students recruited from a public university. Half of the participants (n = 24) were male, and the remaining half were female. With regard to their academic orientation, 54% (n = 26) of the participants were majoring in soft sciences (including arts and humanities, social science), and the rest
(46%) were in hard sciences (including natural science and engineering). Their participation was voluntary, and compensated financially.

3.2. Apparatus

To identify participants' cognitive styles, the Group Embedded Figures Test (GEFT; Oltman, Raskin, & Witkin, 1971) was used. The test is a standardized paper-and-pencil test, with 18 questions. In each question, a simple figure is embedded in a complex figure and presented in a way that obscures the simple figure. Individuals who successfully disembed the hidden figures are FI, and those who cannot are FD. High scores indicate high FI, whereas low scores reflect high FD. The national norm provided in the GEFT manual (Witkin et al., 1971) was used to determine whether a participant is FD or FI.

A questionnaire, developed by the researcher, was used for estimating the level of participants' online search experience and also for collecting participants' demographic information. Among 18 questions included in the questionnaire, 4 questions were used to determine how long and how frequently each individual used online databases. The resulting scores from these questions ranged from 0 to 4, where a score of 4 indicated the highest level of online search experience. Individuals with the average scores of 0 to 2 were considered to be novice online searchers (Novice), whereas those with scores higher than 2 were experienced online searchers (Experienced).

3.3. Tasks

Two different kinds of search tasks were assigned to each participant: a known-item search task and a subject search task. They were typical types of information search tasks used in different studies (Marchionini, 1989; Qiu, 1993a, 1993b). For a known-item search task, there was a piece of target information that all participants were expected to retrieve. A subject search task, on the other hand, required the participant to retrieve information that was related to the given topic and that was regarded as useful to the participant. Both questions were designed to be related to the participants' study and career, to ensure that (a) participants would be motivated to find the information required and (b) no participant would be disadvantaged because of lack of previous knowledge on search topics.

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 your University's graduate school. First, you decide to learn more about the requirements for admission. Find information on requirements for admission, for US graduates applying for your University's graduate programs. When you locate the Web page listing the requirements, make a bookmark of it.
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. When you locate a useful resource, make a bookmark of it, and go on to the next. Find 3–5 Web resources that you think useful and bookmark them.

3.4. Procedure

For each participant, an individual lab session was arranged. The lab session started with a brief review of WWW basics. The review was designed to ensure that every participant was aware of different navigation tools and menu options available in the WWW browser and also some of the search tools and their features. In this study, Netscape Navigator 4.0 was used as the WWW browser. After the review, the two search tasks were assigned to the participant. Each search task required the participant to find pertinent information on their university WWW site. The participant was asked to make bookmarks of the WWW pages on which information relevant to the given search task was found. During the search session, all the screen displays were consulted and keyboard and mouse inputs were recorded using LOTUS ScreenCam, a commercially available software program. The recording of the search session started when the participant was ready and ended when the participant indicated the completion of the task. No time limit for completing search tasks was imposed, and all participants could successfully complete them. After the completion of tasks, the participant was asked to evaluate his or her own searches and to provide tips for WWW search and navigation, by means of a short questionnaire.

3.5. Experimental Design

This was an experimental study with two independent variables: cognitive style and online search experience. To ensure a “balanced” $2 \times 2$ factorial design resulting in the same number of participants in each category (see Table 1), participants were selected from a pool of volunteers, on the basis of their cognitive style and online search experience.

<table>
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<th>Table 1: Design of the Study</th>
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<td>Cognitive Style</td>
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<td>Online search experience</td>
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<td>Novice</td>
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*Note. FD = field dependence; FI = field independence.*
Independent Variables

Cognitive style. GEFT (Oltman et al., 1971) was used to determine an individual's cognitive style. Half of the participants ($n = 24$) were FDs (GEFT score: $M = 8.25, SD = 2.63$), and the remaining half were FIs (GEFT score: $M = 15.96, SD = 1.99$).

Online search experience. A questionnaire was used to collect information on the level of online search experience. The selection of participants was made with half of the participants ($n = 24$) assigned as Novice ($M = .92, SD = .95$) and the other half as Experienced searchers ($M = 2.96, SD = .46$).

Dependent Variables

In the study, two different groups of dependent variables were used. The first group of variables was adopted to evaluate search performance and consisted of two dependent variables: (a) the average length of time spent for retrieving information and (b) the average number of nodes visited for retrieving information. To complete the search tasks assigned, participants had to make bookmarks of the WWW pages where they found information relevant to the tasks given. The two dependent variables used here were calculated by dividing either (a) the total length of time spent or (b) the total number of nodes visited for completing a search task by the total number of bookmarks made.

To examine the participant's navigational style, the second group of dependent variables was used. Dependent variables adopted included (a) the average number of times a navigation or search tool was chosen for retrieving information and (b) the average number of layers consecutively traversed. The average number of times a tool was used for retrieving information was calculated for each navigation or search tool (e.g., embedded links, Back button, Forward button, Home button, jump tools) as follows: the total number of times a tool was used for completing a search task divided by the total number of bookmarks made. For measuring the use of jump tools, the number of times any jump tools (including History list, Go option, Location window, used for user-initiated jumps) were used for completing a task was counted and averaged by the number of bookmarks made. The average number of layers traversed was computed by dividing the total number of layers consecutively traversed from a WWW page reached through something other than embedded links with the total number of consecutive layer traversals.

3.6 Data Analysis

The log data collected were coded and then analyzed using an analysis of variance (ANOVA). For measuring the effect of cognitive style and online search experience on search performance, a two-way ANOVA, with cognitive style and online search experience as the independent variables, was run for each of the following as the dependent variable: (a) the average length of time spent for retrieving information and (b) the average number of nodes visited for retrieving information.
To examine the effect of the independent variables on navigational style, two-way ANOVAs were carried out with different dependent variables. Those used as the dependent variables include the average number of times each of the following navigation or search tools was used for retrieving information: (a) embedded links, (b) Back button, (c) Forward button, (d) Home button, (e) search engines, and (f) jump tools (e.g., Go, History, typed URL, etc., used for jumping). A two-way ANOVA was also conducted with the average number of layers consecutively traversed as the dependent variable.

4. RESULTS

4.1. Search Performance

Two dependent variables were used for evaluating the search performance of the participants: (a) the average length of time spent for retrieving information and (b) the average number of nodes visited for retrieving information.

**The Average Length of Time Spent for Retrieving Information**

As shown in Table 2, the ANOVA revealed a significant main effect of cognitive style, $F(1, 44) = 5.271$, $p < .03$. FDs spent significantly more time than FIIs for finding information: $M_{FD} = 130.3$ sec ($SD = 81.4$), $M_{FI} = 89.9$ sec ($SD = 41.4$). No other significant main or interaction effects were found.

Although it is not significant at $p < .05$, it is worth noting the interaction between cognitive style and online search experience, $F(1, 44) = 3.859$, $p < .06$. Among FIIs, online search experience had no impact on the time spent for retrieving information: $M_{FI- Novice} = 89.5$ ($SD = 42.7$), $M_{FI- Experienced} = 90.3$ ($SD = 41.9$). For FDs, on the other hand, online experience played an important role in reducing the amount of time spent for retrieving information. FDs with little or no online search experience spent 71% more time than FD-Experienced searchers did: $M_{FD- Novice} = 164.6$ ($SD = 86.7$), $M_{FD- Experienced} = 96.1$ ($SD = 61.4$). Although the online search experience had no impact among FIIs, it seems to have contributed to decreasing the amount of search time needed to find information among FDs. However, the power of this statistical test was .49.

**The Average Number of Nodes Visited for Retrieving Information**

ANOVA results revealed no significant main or interaction effects (see Table 3). However, the interaction between cognitive style and online experience is worthy

| Table 2: Analysis of Variance on the Average Time Spent |
|-------------|--------|--------|
|             | df    | $F$    | $p$      |
| Cognitive style (C) | 1    | 5.271  | .027    |
| Online experience (O) | 1    | 3.690  | .061    |
| C x O       | 1    | 3.859  | .056    |
| Within groups | 44  |        |         |
of note, $F(1, 44) = 3.57, p < .07$. The pattern of the interaction is similar to the one found with the average time spent for retrieving information. FDs with little or no online search experience tended to visit 50% more nodes than those with substantial online search experience: $M_{FD-Novice} = 11.7 (SD = 6.1)$, $M_{FD-Experienced} = 7.8 (SD = 5.0)$. In the FI group, on the other hand, little difference was found between the Novice and the Experienced searchers: $M_{FI-Novice} = 7.3 (SD = 3.0)$, $M_{FI-Experienced} = 8.5 (SD = 3.3)$. Here again, the power of this analysis was only .46, and a replication of the study with a bigger sample would be needed to confirm this finding.

4.2. Navigational Style

To examine how users’ cognitive style and their online search experience influenced the participants’ navigational style, two groups of dependent variables were adopted: (a) the average number of times a search or navigation tool (e.g., embedded links, Back button, Home button, jump tools) was used for retrieving information and (b) the average number of layers consecutively traversed.

The Average Number of Times a Search or Navigation Tool Was Chosen

**Embedded links.** The analysis revealed a significant interaction between cognitive style and online experience, $F(1, 44) = 5.595, p < .03$ (see Table 4). The online search experience seemed to affect FDs, but not FIs, when their usage of embedded links was considered. FDs with little or no online search experience chose to use embedded links 67% more frequently than those with substantial online experience: $M_{FD-Novice} = 6.5 (SD = 3.2)$, $M_{FD-Experienced} = 3.9 (SD = 2.5)$. In the FI group, however, both the Novice and the Experienced used embedded links rather infrequently: $M_{FI-Novice} = 4.0 (SD = 1.4)$, $M_{FI-Experienced} = 4.5 (SD = 1.8)$. The pattern of this interaction resembles the interactions found for search performance variables (search time and the number of nodes visited).

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<th>Table 3: Analysis of Variance on the Average Number of Nodes Visited</th>
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<td>Cognitive style (C)</td>
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<td>Online experience (O)</td>
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<td>C x O</td>
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<td>Within groups</td>
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<th>Table 4: Analysis of Variance on the Average Number of Times Embedded Links Were Used</th>
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<td>Cognitive style (C)</td>
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<td>Online experience (O)</td>
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<td>C x O</td>
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<td>Within groups</td>
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Jump tools. When the total number of times a tool was used (not averaged by the amount of information retrieved) was counted, jump options were far less frequently used ($M = .48$) than others such as embedded links ($M = 23.4$) or the Back button ($M = 12.4$). It is interesting to note that several participants ($n = 11$) chose to use jump tools up to six times. With regard to the average number of times jump tools were used for retrieving a piece of information, ANOVA results showed no interaction effect but a significant main effect of online search experience, $F(1, 44) = 6.421, p < .02$ (see Table 5). A comparison of means between the Novice and Experienced groups revealed that the Experienced group tended to use jump tools more frequently than the Novice group: $M_{\text{Experienced}} = .17, M_{\text{Novice}} = .01$.

Home button. When the total number of times a tool was used was counted, it was found that the Home button was another infrequently used tool ($M = .43$). Similar to jump tools, however, a number of participants ($n = 14$) used the Home button up to three times. With regard to the average number of times the Home button was used for retrieving a piece of information, ANOVA results revealed no significant effects at $p < .05$. However, the interaction between cognitive style and online search experience is worthy of note, $F(1, 44) = 3.728, p < .07$ (see Table 6). There seems to be a tendency that FD–Novice searchers used the Home button more frequently than the rest, although the power of the analysis was only .47.

The Average Number of Layers Consecutively Traversed

ANOVA results revealed a significant main effect of online search experience, $F(1, 44) = 4.063, p < .05$ (see Table 7). That is, the Novice searchers traversed a higher number of layers consecutively than the Experienced searchers: $M_{\text{Novice}} = 2.2$ ($SD = .87$), $M_{\text{Experienced}} = 1.7$ ($SD = .39$).

| Table 5: Analysis of Variance on the Average Number of Times Jump Tools Were Used |
|---------------------------------|--------|--------|
| df                | F     | p      |
| Cognitive style (C)  | 1     | 0.310  | .580 |
| Online experience (O) | 1     | 6.421  | .015 |
| $C \times O$       | 1     | 0.013  | .910 |
| Within groups      | 44    |        |      |

| Table 6: Analysis of Variance on the Average Number of Times Home Button Was Used |
|---------------------------------|--------|--------|
| df                | F     | p      |
| Cognitive style (C)  | 1     | 0.549  | .463 |
| Online experience (O) | 1     | 1.460  | .233 |
| $C \times O$       | 1     | 3.728  | .060 |
| Within groups      | 44    |        |      |
Table 7: Analysis of Variance on the Average Number of Layers Consecutively Traversed

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<tr>
<th></th>
<th>df</th>
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<tbody>
<tr>
<td>Cognitive style (C)</td>
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<td>.515</td>
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<tr>
<td>Online experience (O)</td>
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<td>C x O</td>
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<td>Within groups</td>
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5. DISCUSSION

The first research question was “What are the effects of cognitive style and online search experience on the search performance?” Two different indicators were used for measuring the search performance: the average length of time spent for retrieving information and the average number of nodes visited for retrieving information. With regard to the average length of time spent for retrieving information, the FD individuals needed 44.9% more time than the FI individuals to complete search tasks.

The effect of cognitive style found here can be explained in light of the unique characteristics of hypermedia. Different from other traditional “linear” information systems, hypermedia systems can offer many different navigational options and attractive features. In hypermedia systems, the content can 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 within a seemingly large number of choices. FDs who perceive information with a low level of differentiation are likely to have difficulties disembedding and concentrating on whatever they need to choose as a next step on hypermedia systems. Thus, FDs are expected to spend extra time following links that are attention-grabbing but not necessarily useful for the given task and also to spend more time assessing a wider variety of stimuli that are attractive, to find those leading toward, not away from, the desired goal. This trend was found with FDs in this study.

This study also revealed an interaction between cognitive style and online search experience (p < .06). The effect of cognitive style was negligible in the Experienced group, whereas it was significant in the Novice group. More specifically, in the Experienced searcher group, both FDs and FIs spent almost the same amount of time, which was shorter than the time spent by the Novice group in general. In the Novice group, on the other hand, FDs needed much longer search time (about 71% more) than FIs. It is interesting to note that FDs, expected to need more time than their counterpart (i.e., FIs), completed a search task as quickly as FIs when FDs were equipped with online search experience. This implies that having online search experience may help FDs overcome difficulties that they have in using hypermedia systems. Interactions between cognitive style and search experience, found on the use of navigation tools, suggest that FDs may learn and adopt seemingly efficient navigational strategies as they gain more online search experiences.

Another interaction effect of similar kind was found for the average number of nodes visited for retrieving information (p < .07). That is, to find information on the
WWW, the FD–Novice needed to visit more nodes than the FD–Experienced and FIs. Apparently, the FD–Novice group was the one that always needed extra time and steps to find information. Then, a question arises: Why would an individual need extra time and steps that the others do not need? There are at least two different explanations for the need for extra time and steps. One is that the person lacks an ability to differentiate pertinent elements from others—the ability necessary for efficiently carrying out WWW search tasks. Due to this propensity, the person would have difficulties in locating and focusing on useful cues among other attractive ones, which also may lead to the visit of unnecessary nodes. As a result, the person would need more time than others to find information on the WWW. Another possible explanation is that the WWW site used in this study is simply a badly designed one. This, however, cannot explain why only the FD–Novice, but not others, needed extra time and steps to complete the same search tasks. Hence, the latter explanation can be ruled out.

When we assume the former interpretation, findings related to the search performance suggest that FD–Novice individuals are the ones who are less likely to differentiate pertinent cues from others successfully while searching the WWW. This is interesting because the tendency of little differentiation is expected from FDs in general. Apparently, having search experience with online databases helped FDs recognize useful tools and strategies and use them to improve their performance in a WWW search situation. Further research would be worthwhile to find out whether simply FDs’ search strategies change or their cognitive style also changes (toward FI) as the FDs gain more experience with online searches.

The second research question was “What are the effects of cognitive style and online search experience on navigational style?” Two kinds of indicators were adopted for evaluating navigational style: (a) the average number of times a search or navigation tool was used for retrieving information and (b) the average number of layers consecutively traversed. The findings on the use of embedded links indicated the existence of an interaction effect between cognitive style and online search experience. That is, in the Novice searcher group, FDs used embedded links 50% more frequently than FIs, whereas both of FDs and FIs in the Experienced searcher group used embedded links rather infrequently. As embedded links are prescribed by WWW authors, following embedded links is considered linear navigation, compared to nonlinear navigation characterized by jumps initiated by searchers. The finding on the use of embedded links implies that FDs have a tendency of navigating the WWW in a fairly linear mode. However, FDs’ navigational style changes from linear to nonlinear as they gain more search experience with online databases. It seems that online search experience helps FDs initiate intentional jumps and take advantage of the nonlinearity of the hypermedia technology. A further analysis of FDs’ jump tool usage also supported this. The FD–Experienced individuals used jump tools more frequently than the FD–Novice individuals, \( t(22) = -2.464, p < .03 \). This result partly supports the findings of Liu and Reed (1994). In a study on the hypermedia-assisted instruction of English as a second language, Liu and Reed found that FD students explored a hypermedia system in a linear mode, by following links the author prescribed.
In this study, Experienced searchers used the jump mode more frequently than Novice searchers. The more online search experience individuals have, the more often they jump around within a hypermedia system—navigating the system in a nonlinear mode. This result coincides with findings of previous research. In a study investigating the navigational pattern on a hypermedia system, Qiu (1993b) discovered that Experienced searchers navigated the system in a nonlinear mode, whereas Novices adopted a more linear browsing approach to navigating the system.

With regard to the use of the Home button, an interaction between cognitive style and online experience was found again. In the Novice group, on the one hand, FDs used the Home button more frequently than FIs. In the Experienced group, on the other hand, both the FD and the FI groups rarely used Home. It seems that FDs with little or no online search experience tend to get disoriented easily, and that is why the Home button was used more often by the FD–Novices. With more online search experience, however, FDs seem to become able to overcome the problem of disorientation. It is noteworthy that FIs do not seem to experience this kind of problem at all regardless of the amount of their online search experience.

The result on the number of layers consecutively traversed indicated that the Experienced searchers usually traversed only one or two layers successively from a point of start. The Novice searchers, on the other hand, often traversed two or more layers consecutively. It seems that the Experienced searchers are aware of the fact that the risk of disorientation would increase as they traverse more layers in sequence without checking back where they have been. This inference is supported by an analysis of suggestions that participants made after completing their search. When participants were asked to provide suggestions on searching and navigating the WWW, 58% of Experienced searchers mentioned limiting the number of layers consecutively traversed as a strategy for an efficient navigation without disorientation. Among Novice searchers, on the other hand, only 12% of them made similar remarks. Obviously, the strategy of checking no more than two levels of depth was helpful in reducing the chance of getting lost or becoming disoriented.

To summarize findings of the study, online search experience affected navigational style, whereas cognitive style influenced search time. Experienced searchers traversed no more than two layers consecutively and tended to initiate jumps more frequently than Novices. FDs spent longer search time than FIs. In addition, there existed interactions between online experience and cognitive style. FDs with little or no online search experience navigated the WWW in a fairly linear mode, using embedded links frequently. They also tended to visit more nodes and used the Home button more frequently than the rest. It was apparent that as FDs gained more online search experience, their navigational style and search performance changed. The tendency to spend more search time, visit more nodes, become disoriented, and navigate linearly, observed among FD–Novices, disappeared among FD–Experienced individuals. FD–Experienced individuals' search performance and navigational style were comparable to FIs’.

In the next section, some implications of these findings are discussed in the light of different approaches to facilitating WWW searches: improving the WWW interface and user training programs.
6. IMPLICATIONS

The findings of this study may provide useful insights to those who design and develop the WWW and also those who train WWW users. First, WWW designers might want to think twice before adding fancy features to a page. What is the main purpose of the WWW page that is being created? If there is a main point on which the designer wants users to focus, he or she ought to make it conspicuous to everyone. It should also be noted that most users prefer finding information from the first screen of a page without scrolling down (Nielsen, 2000). The limited WWW space should be wisely used and not cluttered with any unnecessary links or attention-grabbing features. In addition, designers should remember that there are individuals who are less able to recognize and locate important information from its surrounding field, such as FDs. The designer should develop WWW pages to help all users find information easily and achieve their goals equally well, without penalizing those who actually need more support. To assist FDs, providing information with a salient and rather rigid structure would be one solution, whereas training them to recognize structures useful to given tasks would be another (Stanney & Salvendy, 1994, 1995).

WWW designers and developers also need to think about ways of preventing users from getting lost on the WWW. As previous studies suggested (Gay, Trumbull, & Mazur, 1991; Nielsen, 1995), providing a site map might be one possible solution. Leader and Klein (1996) found, however, that FIs, not FDs, could take advantage of a map to improve search performance on a hypermedia system. Further research is needed to find out whether providing a site map could actually reduce the chance of FDs getting lost. Another solution to the "getting lost" or disorientation problem is to limit the number of depths inherent to a WWW structure. Investigating the depth or breadth trade-off in content design of the WWW and its impact on the retrieval of information, Larson and Czerwinski (1998) discovered that more than two levels of depth significantly increased searching problems, regardless of the breadth. In general, limiting the levels of depth to one or two may effectively lessen the disorientation problem, although it might not always be desirable depending on the goal of the author and the user, and also the nature of the content (Dee-Lucas & Larkin, 1999).

For those who design WWW browsers, the message is clear: They should find ways to make nonlinear navigation easy for everyone. FDs with little or no online search experience navigated the WWW linearly, even when nonlinear jumps could be more efficient to complete the search task given. One of the ways to facilitate nonlinear jumps is to make jump tools more visible and easy to use. A history list, for example, can be used as a tool for jumping and should be placed in a location easy to spot. In the Netscape browser used in this study (Navigator 4.0), locating the history list required at least two steps: choosing Communicator and then History on a pull-down menu. In the case of its more recent version (e.g., Netscape Navigator 4.7), it is even more difficult to locate History, because it requires not just two but three steps. The History list should be located in a conspicuous place so that anyone can find it with little effort. Apparently, Microsoft Internet Explorer does a better job making History more visible.

Besides increasing the visibility, there is plenty of room for improvement in the interface of current History list designs. To make the History list more intuitive, its
text-based interface may need to be enhanced with graphics. For example, "Graphic History," developed by Ayers and Stasko (1995), presents titles, URLs, and miniature (thumbnail) images of the pages visited. The graphical layout is based on a two-dimensional tree, designed to provide spatial as well as temporal context. The images provide useful additions because they can help users review and recall what the pages visited were about, without checking out the actual pages. The way in which the History list is presented in the Graphic History may help users see where they are and have been, and also facilitate their jumps with more confidence about where to go. A combination of History lists and site maps would be another way of improving a History list (Cockburn & Jones, 1996). This kind of device can assist users to easily view not only their navigation path but also subspaces that can be accessed from each WWW site visited.

Finally, for those who train WWW users, some instructional considerations also emerge from this study. It was found that online search experience could help individuals with a limited ability of cognitive differentiation and restructuring recognize and adopt useful strategies to compensate or to overcome the limitation. Online experience may help such individuals develop strategies for effective and efficient WWW searches if not navigation. Although the exact reason is unclear at present, this study suggests some elements that should be taught to assist individuals to use the WWW well. Trainers may want to include in their teaching plan instructions on how to use traditional online database systems. After all, search engines currently available on the WWW share several features with linear online database systems. Like other online database systems, many WWW search engines encourage users to type in keywords, to utilize Boolean search logic, and so on. Most WWW browsers still have pull-down menus similar to those of online database systems. Exposing users to search basics for online database systems will be helpful for users to understand and to learn how to utilize search engines on the WWW as well as databases on a traditional online system. In addition, trainers may want to teach users effective ways of navigating and jumping around on the WWW without getting lost.

Based on the findings of the study, suggestions on WWW design and user training programs have been made, which may help all users, despite their individual differences, find information easily and equally well. As this study was focused on general search tasks, the suggestions that are provided here should be relevant to the case of information searches. For other kinds of tasks such as learning or decision making, however, the suggestions might need further elaboration. More research needs to be done to investigate a user's interaction with systems in the context of different tasks and to find whether tasks of different kinds require interface features and user skills other than those useful for search tasks.

REFERENCES


