Cognitive Style and On-Line Database Search Experience as Predictors of Web Search Performance

Ruth A. Palmquist  
Graduate School of Library and Information Science, University of Texas, SZB 546, D7000, Austin, TX 78712.  
E-mail: palmquis@uts.cc.utexas.edu

Kyung-Sun Kim  
School of Information Science and Learning Technologies, University of Missouri, 20 Rothwell Gym, Columbia, MO 65211.  
E-mail: kimk@missouri.edu

This study sought to investigate the effects of cognitive style (field dependent and field independent) and on-line database search experience (novice and experienced) on the World Wide Web (WWW) search performance of undergraduate college students (n = 48). It also attempted to find user factors that could be used to predict search efficiency. Search performance, the dependent variable, was defined in two ways: (1) time required for retrieving a relevant information item, and (2) the number of nodes traversed for retrieving a relevant information item. The search tasks required were carried out on a University Web site, and included a factual task and a topical search task of interest to the participant. Results indicated that while cognitive style (FD/FI) significantly influenced the search performance of novice searchers, the influence was greatly reduced in those searchers who had on-line database search experience. Based on the findings, suggestions for possible changes to the design of the current Web interface and to user training programs are provided.

Introduction

The current popularity of the World Wide Web (Web)—probably the most widely used hypermedia system—is a strong testament to the efficacy of visual/spatial interface design. The speed of its adoption by and appeal to a wide variety of new users from around the globe certainly must largely be due to the visual appeal and comfort users feel in manipulating and navigating its realm, primarily through visual icons and readily identified interface features. The past decades of command-driven information systems clearly seem to mark another era. Nevertheless, even those more traditional command-driven services like Dialog and Lexis-Nexis are quickly putting out their shingles on the Web. There should be little to surprise us in the popularity of this more graphically rich information environment, however. We are inherently spatial creatures, and interface designers, recognizing this important skill, have been able to design for such an ability, allowing our visual/spatial skills to matter rather more than our ability to remember literal commands.

Even prior to the popularity of the Web, a number of hypermedia researchers (e.g., Conklin, 1987; Marchionini & Shneiderman, 1988; Nielsen, 1989) were able to identify the major difficulties that users might have in a hyperlinked information environment. Although such an environment is intended to be ideal for browsing and communicating associated ideas, it has been found to be potentially disorienting, and to provide a heavier cognitive load for the user than that associated with a more traditional, linear information arrangement.

Although cognitive theorists have yet to agree on the actual mechanisms by which the brain processes visual/spatial data (De Vega, Inton-Peterson, Johnson–Laird, Denis, & Marschark, 1996), there is interest in the hypermedia research community in the importance of examining user’s information processing skills as they are affected by spatial complexity. A study of users’ information seeking on the Web can be viewed as a study of the ability to successfully interpret the complex spatial elements on the screen display. How well does the user manipulate the features of the Web browser to follow the appropriate clues that will advance his effort toward the information that he seeks? What are the human factors affecting an efficient use of the Web?

This study pursues the general aim of understanding how individuals with different characteristics use and interact with the Web. More specifically, the questions of importance are as follows: (1) what are the effects of the users’ cognitive style and on-line database search experience on their search performance? and (2) among several user factors, which one(s) contribute to the efficiency of the user’s...
search performance? In addition, the effects of cognitive style and on-line experience on the navigational decisions made using various browser tools were also examined. The following section provides some background on the main factors examined: cognitive style, and user experience.

**Background**

Information seeking as a spatial navigation issue in a computer-produced search environment existed well before the advent of the Web. Both McGill (1976) and Brookes (1980) argued that information retrieval could be greatly improved if it could be moved from the largely mathematical realm toward a process occurring in an “information space.” Essentially, both argued that the process of information seeking involved intensely cognitive events that were played out for the user in a landscape-like environment of visual elements called an “information space.” The advent of the Web brought just such a visual “information space” to reality, and provided such a space to a much more diverse audience of users.

With the wider audience comes a more diverse set of individual differences with which to contend. As a one-size-fits-all approach to designing information systems seems less likely successful with heterogeneous user groups (Allen, 1996), individual difference has received more attention, and has been recognized as a crucial aspect of study for understanding users and developing more usable systems (Egan, 1988; Nielsen, 1993). Dillon and Watson (1996) provide a review of the human factors literature, with an emphasis on applications for user-centered design. The human factors of interest to this study include a cognitive style that has a long established history and experience, which critically contributes to the formation of knowledge.

**Human Factor: Cognitive Style**

Work in psychology during the 1940s and 1950s suggested that when processing information for the purpose of problem solving or learning, humans exhibited preferred modes or strategies that could be detected as distinctive or characteristic methods of performing. Further, these styles, often called cognitive styles (Goldstein & Blackman, 1978), were believed to be fairly static over an individual’s lifetime and instruments were developed to detect these prevailing styles and assess them in relation to a variety of educational considerations, particularly educational concerns for student achievement and academic skill preference.

Sternberg (1997a) compares the ebb and flow of cognitive styles research to the fashion dictates of our times, but essentially declares that cognitive style research is alive and well, and has relevance for today’s issues. He highlights the work of Witkin (Witkin, 1964; Witkin, Dyk, Faterson, Goodenough, & Karp, 1962), and describes their effort to develop a useful measure of cognitive style. The work of Witkin and his colleagues has several interpretations, but the cognitive style that their work suggested is often simply called field dependence or independence. This interpretation has some detractors (McKenna, 1983), who argue that it is more a measurement of spatial ability than a true cognitive style differentiation. Sternberg (1997b), however, feels that this distinction does not detract from its value and long history in assessing human problem-solving style, and that it may be particularly valuable in visually complex realms. An abbreviated history of field dependence—indifference is provided here, but those who wish to fully explore the evolution of this cognitive style and its measure are referred to Witkin and Goodenough (1981).

Witkin and his colleagues began their studies in the late 1940s to determine how it is that humans can perceive their orientation with respect to “upright” as quickly and accurately as they do. They were surprised to find that their experimental subjects varied greatly when asked to ignore the visual context of a lighted rod in relation to the position of their bodies’ orientation in a darkened room. With a special apparatus, Witkin was able to move a seated subject up to 40 degrees off of true vertical. Although some recognized that their orientation was not truly vertical, others were consistently unable to detect the shift as long as the lighted rod appeared to have an angle equal to their own, making it seem that they were aligned with the rod in a vertical orientation. The consistency of their findings, across a variety of tasks, suggested that people have preferred ways of integrating the diverse sources of information available to them the information for locating a true vertical orientation, for example. Their work examined these individual differences in the information processing of spatial figures. Essentially, their theoretical belief was that the individual difference found could be explained by subjects’ reliance on either the field (external context) or on the body position (internal context) for their perception of vertical.

These studies are well explained in Witkin and Goodenough (1981), and eventually led to the development of an instrument, the Embedded Figures Test (EFT), which effectively determines one’s ability to disembed simple geometric shapes from more complex geometric backgrounds. This ability to disembed shapes from the background was found to be tied to problem-solving styles. Field independent individuals were more prone to act upon a problem’s stimulus material, changing its structure or imposing their own internally held structure upon it, and field-dependent individuals were more prone to leave stimulus material “as is,” adopting more of an observer role. The finding that the field-independent (FI) individual would impose structure on a complex field, and therefore, was more likely to experience it as organized, whereas a field-dependent (FD) person would not, was supported by many of Witkin’s studies using both perceptual and problem-solving tasks.

This polar construct of FI/FD has been attractive to the hypermedia community for a variety of reasons. First, it has been tested extensively over a wide range of situations, and has been acknowledged for its ability to detect an individuals’ global vs. analytic search behavior (Wood, Ford, &
Miller, 1996). Second, it provides an easy to administer measure of a person’s ability to be dependent or independent of the organization of a complex visual field. The EFT is available in a group-administered version, the Group Embedded Figure Test (GEFT), which is a simple, standardized, paper-and-pencil test that takes only about 15 minutes to complete. The test consists of 18 complex figures. For each figure, the test taker has to find a simple figure that is embedded in a complex figure in a way that obscures the simple figure. In scoring the test, the test taker is shown the simple shape by looking at the back cover of the test booklet. The subject is told that the simple shape will appear in the same size and orientation as the sample on the back cover. The test taker then turns back to the complex figure within the test booklet and must trace the outline that discloses the simpler shape. To be given a correct score for the effort, the lines traced may not stray beyond those appropriate. A high score indicates a cognitive style of field independence (FI), while a low score reflects the cognitive style of field dependence (FD). The reliability of the test is 0.82 for both male and female undergraduates.

Witkin did not originally conceive the test as a measure of cognitive style, but rather a test of perceptual, analytical ability. He found over a large number of trials that a high score on the EFT was well correlated with achievement in abstract, analytical areas like math, science, and, more recently, in computer-related subjects. Field dependents, on the other hand, were more skilled as global thinkers and were better users of external, interpersonal, or socially based skills. This distinction between analytic and global perception when applied to one’s ability to structure a problem, led to the notion of articulation. A person who experiences stimuli in an “articulated” fashion, can comprehend items as discrete from their background when the field is organized, and can also impose structure on a field when the field has little inherent structure. Therefore, he is disposed in both cases to perceive a complex visual field as relatively organized. The person with a “global” field orientation, on the other hand, experiences fused complex field, and is likely to overlook a needed cue because he is distracted by unimportant, but more dominant, visual cues. For users of hypermedia environments like the Web, this distinction has been thought to be an important factor in users’ ability to find the important visual cues to select appropriate links in the pursuit of an information goal.

As an example of others who have used the FI/FD as a measure, Korthauer and Koubek (1994) investigated the effects of FD and FI on users’ search performance on a hypertext system. They found that the FI’s search outcome was significantly more accurate than the FD’s, which was also supported by Ellis, Ford, and Wood’s study (1993). Liu and Reed (1994) conducted a study to investigate whether hypermedia-assisted instruction can improve vocabulary learning. Although cognitive style did not influence the learning outcome, a significant relationship was found between the participants’ cognitive style and their use of a hypermedia system. The FIIs explored the hypermedia system in a nonlinear mode, whereas the FDs navigated in a more linear mode, following the provided sequence of the system. This result seemed to be supported by Leader and Klein (1996). In a study examining the effects of cognitive style and search tools on search performance on a hypermedia system, Leader and Klein found that the FIIs outperformed the FDs in search tests, especially when the system was equipped with tools that facilitated nonlinear navigation and analytical searches.

**Human Factor: User’s Experience**

Those who work with human–computer interaction (HCI) and usability testing have found that users’ performance on computer-based systems can be greatly affected by the users’ previous experience and knowledge (Dumas and Redish, 1993; Egan, 1988; Nielsen, 1995). This experience and knowledge can generally be defined in one of two ways: the knowledge of the search topic or domain, and the knowledge of the system used.

Although it can easily be expected that the domain expert would outperform the novice with little knowledge of the domain, Egan (1988) points out that domain-specific knowledge begins to predict performance only after users have acquired some experience with the system used. In a study on factors affecting search performance on an on-line database system, Jacob and Fusani (1992) found that system knowledge and computer experience were those critically influencing search performance.

When a search task is involved, it seems that search experience becomes another important factor affecting the use of the search system. Comparing search performance between experienced and novice searchers, Fenichel (1981) found that users’ search experience influenced search performance. Using a hypertext system, Marchionini, Lin, and Dwiggins (1990) attempted to compare the effects of users’ search experience and subject expertise on information search outcomes. Both subject experts and search experts outperformed the novices, and no difference on search outcomes was found between the two expert groups. In a study comparing the effects of users’ search experience and subject expertise on the use of online database systems, however, Hsieh-Yee (1993) concluded that the users’ search experience affected their use of search strategies and played a more important role than did their subject knowledge.

**The Study**

**Participants**

Forty-eight individuals participated in this study. All of the participants were undergraduate students, recruited from the University of Texas at Austin. For their participation, monetary compensation was offered. Based on their cognitive style (FD/FI) and on-line searching experience, participants were selected from a pool of over a hundred students.
This filtering process was necessary to achieve a balanced sample (see Appendix 1).

The age of the participants ranged from 17 to 43 (mean = 21.9, SD = 4.4). Half of the participants (n = 24) were male, and the other half were female. With regard to their academic background, the participants were from various fields of study. Fifty-four percent of the participants (n = 26) were from the soft sciences (social sciences, arts, and humanities) and 46% (n = 22) were from hard sciences (natural science and engineering). Twelve percent of the participants (n = 6) were freshmen, and 15% (n = 7), 25% (n = 12), and 48% (n = 23) were sophomores, juniors, and seniors, respectively.

Equipment

The computer used for the study was an IBM personal computer (PC), equipped with a standard keyboard and mouse required for user input. Two speakers were also attached to the PC to permit the delivery of audio information to the user. As a Web browser, Netscape Navigator 4.0 was used. LOTUS ScreenCam'97 was used to record screen displays in real time so as to capture users' navigation decisions. These decisions might involve either browser tools or embedded links provided within the Web content viewed.

Data Collection

To identify subjects' cognitive style, the Group Embedded Figures Test (GEFT) was administered, along with an additional questionnaire used to collect background on search experience and other demographic information (gender, age, grade level, disciplinary background, etc.). The information gathered through these two instruments was used to identify and select participants for this study.

For each of the participants selected, an individual lab session was arranged. The lab session started with a brief review of the Web basics, which was designed to ensure that every participant was aware of the availability of different tools and options in both the Web browser and the site's search engine. Once the review was completed, two search tasks were given to the participant. The tasks were developed to be factual and topical in nature (see Appendix 2). These two types of search tasks were adopted because they are similar to "typical" information tasks frequently studied in the field of library and information science (Lai & Waugh, 1995; Marchionini, 1989; Matthews, Lawrence, & Ferguson, 1983; Qiu, 1993).

The factual search task was to find information on general requirements for applying for graduate study at the University. There existed a specific piece of target information, and the participant was required to continue searching until he or she located the target information. The participant was asked to make a bookmark of the Web page containing the target information once they found it. The researcher was on site to verify the relevance of information retrieved by the participant. The other search task was more topical in nature—to find information helpful to the participant's future career plans. As the participant was allowed to search for information related to the career of his or her interest, the relevance of the retrieved information was judged subjectively by the participant. Bookmarks were made of the pages that the participant felt were useful, thus overtly signaling that those pages were judged relevant. The two search tasks, factual and topical, were alternated between participants to avoid any order effects, but each participant was required to complete both tasks.

The participant began each search task from the same location, the homepage of the University of Texas' Web site. By limiting the search tasks to the University's Web site, some of the variance was reduced and the "noise" of intrusive advertisements was eliminated. Using the University Web site also lessened the likelihood of excessive connection delays and gave the students an environment in which they could pursue search tasks of likely interest.

For each individual's search session, all the screen displays consulted and keyboard/mouse inputs were recorded. When the participant felt ready to start searching, he or she asked the researcher to start recording the search session. The recording of the search session ended when the participant indicated completion.

Independent Variables

There were two independent variables of interest in this study: (1) cognitive style, and (2) on-line database search experience. Each of the variables was defined dichotomously.

Cognitive Style

The participant's cognitive style was determined by the scores from Group Embedded Figure Test (GEFT; Oltman, Raskin, & Witkin, 1971). Decisions about the FI and FD distinctions were made on the basis of the norms provided in the GEFT Manual (Witkin et al., 1971). Half of the participants (n = 24) were FIs (mean = 8.25, SD = 2.63), and the other half (n = 24) were FDs (mean = 15.96, SD = 1.99).

On-Line Database Search Experience

A questionnaire was used to collect each participant's experience with online databases. Four questions were used for this purpose: (1) Have you ever used any online databases (indexes, abstracts, full text databases) available in the university libraries or any other places? (2) How long have you been using online databases? (3) How long have you been using online databases? (4) Could you name any of the online databases that you have used before? Participants who answered "No" to the first question got a score of zero, and were classified as "NOVICE." For those who answered "Yes" to the first question, their answers to the second and
third questions were weighted and averaged to determine their degree of experience searching on-line databases. For example, those who reported using on-line databases daily, for more than 2 years and could actually name the database(s) used received the highest score (four points). Those using on-line databases once every few months and for less than 6 months received a low score (one point). To improve the validity of these questions, a short interview by the researcher was used to establish the participant’s understanding of what was meant by on-line databases. Participants were screened until half (n = 24) could be identified as NOVICE (mean = 0.92, SD = 0.95), and half were EXPERIENCED (mean = 2.96, SD = 0.46).

Dependent Measures

Two dependent variables were adopted to measure the user’s search performance: (1) AVTIME, and (2) AVNODES.

AVTIME

AVTIME was the average length of time spent on retrieving a piece of information. It was calculated by dividing the total length of time that a participant spent for the completion of search tasks by the number of bookmarks that he or she made during the search session. This measurement could be interpreted as “search speed.” It should be noted, however, that AVTIME can be affected not only by search ability but also by the reading speed of the participant.

AVNODES

AVNODES was the average number of nodes visited for retrieving a piece of information. It was calculated by dividing the total number of nodes visited for the completion of search tasks by the number of bookmarks made. AVNODES could be regarded as a measurement of “search efficiency,” because it reflects the participant’s ability to move effectively between links in a number of search steps needed to find the relevant information desired.

Results

Two-way ANOVAs were performed to determine the effects of cognitive style and on-line search experience on the search performance measures—AVTIME and AVNODES. In addition, a multiple regression was performed to predict the contribution of different user variables to search performance. User characteristics adopted as predictor variables included age, gender, grade level, academic background, computer experience, and Web experience, in addition to cognitive style and on-line search experience. AVNODES for the factual information search task was used as the criterion variable because it was considered a better measure of performance; it was less influenced by other factors than was the variable of AVTIME. AVTIME could be affected by reading speed as well as by the users’ search skill, so AVNODES seemed to better reflect only search ability. The AVNODES for the factual task was used because, for the factual search task, the relevance of the retrieved information could be more objectively evaluated and controlled. This minimized the problem of relevancy issues involved in the topical search task used in the study.

ANOVA Results on AVTIME

A two-way ANOVA was performed for AVTIME, and the result indicated a significant main effect for cognitive style: $F_{\text{Cog}} (1, 44) = 5.271, p = 0.027$. The length of time that the FDS spent for retrieving a piece of information was significantly different from the length of time FIs spent. That is, the FDS tended to spend more time than the FIs: Mean$_{\text{FD}} = 130.3$ seconds, and the Mean$_{\text{FI}} = 89.9$ seconds (see Table 1). The effect size index $f$ was 0.35, which falls between medium ($f = 0.25$) and large ($f = 0.40$) effect size, using Cohen (1977).

If the level of significance is raised to $p < 0.10$, not only is the main effect of cognitive style significant, but also the main effect of online search experience: $F_{\text{Onl}} (1, 44) = 3.69, p = 0.061$. There was also a significant interaction between the two independent variables: $F_{\text{Cog} \times \text{Onl}} (1, 44) = 3.859, p = 0.056$. Their effect sizes are in the medium range: $f_{\text{Cog} \times \text{Onl}} = 0.29, f_{\text{Cog} \times \text{Onl}} = 0.30$.

Figure 1 shows how the cognitive style and on-line search experience variables interacted with each other, influencing AVTIME. For the FIs, on-line experience seemed to have little impact on AVTIME: Mean$_{\text{FI-NOVICE}} = 89.5$, Mean$_{\text{FI-EXPERIENCED}} = 90.3$. For the FDS, however, online experience seemed to play an important role on decreasing

![FIG. 1. AVTIME (seconds): cognitive style by on-line experience.](image-url)
AVTIME. The FDs who had little experience with online database searching (FD-NOVICE) tended to spend longer time to retrieve a piece of information than did the FD-EXPERIENCED: Mean_{FD-NOVICE} = 164.6, Mean_{FD-EXPERIENCED} = 96.1. It is interesting to note that the FD-EXPERIENCED reduced the AVTIME measure to almost that of the FIs. On-line search experience seems to contribute to reducing AVTIME among the FDs, whereas the experience had little impact on the AVTIME performance of the FIs.

ANOVA Results on AVNODES

A two-way ANOVA was performed for AVNODES. At $p < 0.05$, no significant main effect or interaction was found. At $p < 0.10$, however, the interaction between cognitive style and on-line experience was significant: $F_{Cog \times Onl}(1, 44) = 3.57, p = 0.065$. As shown in Figure 2, the FDs with a high level of on-line search experience (FD-EXPERIENCED) tended to visit a lower number of nodes than those with little or no online search experience (FD-NOVICE): mean_{FD-NOVICE} = 11.7, mean_{FD-EXPERIENCED} = 7.8. In the FI group, on the other hand, little difference was found between the novices (FI-NOVICE) and the experienced (FI-EXPERIENCED): mean_{FI-NOVICE} = 7.3, Mean_{FI-EXPERIENCED} = 8.5. This pattern is similar to what was found with AVTIME. The effect size index $f$ was equal to 0.28, which was in the medium range.

No main effect was found to be significant at $p < 0.05$; no statistically significant difference existed between the AVNODES values when the groups were compared on the participants’ cognitive style or on the level of their on-line database search experience. Table 2 is given as an indication of the descriptive characteristics for these variables.

Multiple Regression Results

To assess the value of the user factor(s) that may be used to predict the efficiency of a Web search, a step-down multiple regression was performed. For this regression, user variables such as academic background, age, cognitive style, gender, grade level (Freshman/Sophomore/Junior/Senior), computer experience, on-line search experience, and Web experience were used as predictor variables. Among the predictors, academic background (Hard/Soft), cognitive style (FD/FI), gender (F/M), on-line experience (EXPERIENCED/NOVICE), computer experience (Computer Experienced/Computer Novice), and Web experience (Web Experienced/Web Novice) were all dichotomously defined variables. As the criterion variable, AVNODES for the factual search task (rather than the topical task) was used. In the factual information search task, participants were allowed to stop searching only after having found and bookmarked the target information. The accuracy of the target information could be objectively judged. Thus, it can be said that all the completed searches in the factual task were “successful” ones, although the length of time spent or the number of steps followed to complete the task varied depending on participants. For the topical information search task, on the other hand, the participants were allowed to find and bookmark information they found relevant. Here, the relevance of the retrieved information was judged subjectively by the participants. As no objective criteria or measures were adopted for controlling the relevance of the retrieved information, it seems unwarranted to assume that all the topical search results were “evenly” relevant and successful. To avoid these relevancy issues related to the topical information search task, only the AVNODES for the factual information search task was used as a measurement of search efficiency. Table 3 summarizes the result of the multiple regression.

<table>
<thead>
<tr>
<th>Variable</th>
<th>$B$</th>
<th>SE. $B$</th>
<th>$\beta$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Online experience</td>
<td>-5.703</td>
<td>2.341</td>
<td>-.336</td>
</tr>
<tr>
<td>Cognitive style</td>
<td>-4.526</td>
<td>2.414</td>
<td>-.267</td>
</tr>
<tr>
<td>Gender</td>
<td>2.120</td>
<td>2.341</td>
<td>.125</td>
</tr>
<tr>
<td>Web experience</td>
<td>3.871</td>
<td>5.024</td>
<td>.110</td>
</tr>
<tr>
<td>Step 6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Online experience</td>
<td>-5.542</td>
<td>2.320</td>
<td>-.327</td>
</tr>
<tr>
<td>Cognitive style</td>
<td>-4.042</td>
<td>2.320</td>
<td>-.238</td>
</tr>
<tr>
<td>Gender</td>
<td>1.958</td>
<td>.320</td>
<td>.115</td>
</tr>
<tr>
<td>Step 7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Online experience</td>
<td>-5.542</td>
<td>2.313</td>
<td>-.327*</td>
</tr>
<tr>
<td>Cognitive style</td>
<td>-4.042</td>
<td>2.313</td>
<td>-.238</td>
</tr>
</tbody>
</table>

Note. $R^2 = 0.177$ for step 6 ($p < 0.05$); $R^2 = 0.163$ for step 7 ($p < 0.05$).

*p < 0.05.
The regression result in Table 3 shows that there was a significant measure of relationship when some of the user factors—particularly cognitive style, gender, and on-line experience—were used to predict the AVNODES value. These three variables could account for 17.7% of the variance: \( r^2 = 0.177, p = 0.034 \). When the gender variable was removed, 16.3% of variance could be predicted by cognitive style and online experience variables: \( r^2 = 0.163, p = 0.018 \). This relationship was mainly attributed to on-line database search experience which had a significant negative relationship with AVNODES: \( \beta = -0.327 \) and \( p = 0.021 \). When coded, the EXPERIENCED was coded “1” and the NOVICE “0.” Participants with much experience in searching online databases (EXPERIENCED) tended to complete a task by following a lower number of nodes/steps than those with little experience (NOVICE), as reflected in the significant negative relationship between on-line experience and AVNODES. Following the online search experience variable, cognitive style was the second most useful user variable for predicting search efficiency: \( \beta = -0.238, p = 0.087 \). The relationship between cognitive style and AVNODES was again a negative one. That is, the FIs (coded “1”) tended to visit a smaller number of nodes than did the FDs (coded “0”) when retrieving a piece of information. It is interesting to note that the contributions of gender and Web experience on the AVNODES measure were larger than other user variables, although not significant.

**Discussion and Conclusion**

With regard to search performance, measured by both the average length of time spent and the average number of nodes visited for retrieving a piece of information, a consistent interaction between cognitive style and on-line experience was found. That is, among the online search EXPERIENCED individuals, both the FDs and the FIs retrieved a piece of information after spending almost the same length of time to do so, and after visiting almost the same number of nodes. Among the NOVICEs, however, the FDs needed to spend a longer time and to visit more nodes than did the FIs. It is somewhat surprising to find that the FDs—whom we thought could be easily distracted, and thus were expected to need more time to find target information than the FIs—could complete a search task almost as quickly as the FIs when the FDs had substantial experience with on-line databases (FD-EXPERIENCED). This implies that on-line search experience may help the FDs to overcome the spatial complexities of hypermedia information architecture.

To assess whether differences in search performance would be reflected in the search/navigational tools chosen, an additional set of two-way ANOVAs were carried out using the average number of times different navigational/search tools (such as embedded links, Back, Home, Go, History, etc.) were used as the dependent variable. Significant interactions of the same pattern were found for use of embedded links and for use of the Home button: for embedded links, \( F_{Cog \times Onl} (1, 44) = 5.002, p < 0.04 \), and for the Home button, \( F_{Cog \times Onl} (1, 44) = 3.728, p < 0.07 \). The FD-NOVICEs used embedded links and the Home button significantly more frequently than the rest.

Frequent usage of embedded links can be interpreted as a “passive” way of navigation because it indicates that the user navigates the Web simply by following sets of links provided by the Web authors. The use of embedded links can also be viewed as a “linear” rather than nonlinear way of navigation because other tools (such as Go, History list, or a typed URL) allow the user to jump to some more temporally removed point, whereas embedded links do not. The Home button is often used when people wish to start over, essentially stopping whatever they have been doing. Therefore, the use of the Home button can be seen as one possible indication of “getting lost.”

When we assume this interpretation, results on the tool use seem to indicate that the FD-NOVICEs navigate the Web in a more passive, linear mode (use of embedded links), and also that they get lost more frequently (use of the Home button) than the rest. This might be the way in which we would expect the “typical” FDs to navigate. FDs prefer a well-structured set of stimuli, and do not enjoy imposing a structure of their own. Also, they are easily distracted in a complex field by cues that may not be relevant to the goal. So the FDs are expected to prefer a navigational style that follows links prescribed by the web page author or to become easily lost through the pursuit of more dominant but irrelevant cues. It should be noted, however, that the way in which the FD-EXPERIENCED navigated the Web was different from the way in which the FD-NOVICE did. The FD-EXPERIENCED searched in a navigational style, reflected in their use of tools, which was rather similar to the FI’s and their search performance, reflected in AVTIME and AVNODES, was also comparable to the FI’s.

It seems that the FDs, especially those with little or no experience with on-line databases, might need special attention from the interface designers and those who train Web users. Interface designers may want to incorporate devices that can help the FDs become better oriented and less likely to get lost. Providing a graphical map of their search progress would be an example, and several studies have found it to be effective in terms of resolving the problem of disorientation (Chen & Rada, 1996). With the browser interface, it might also be helpful to provide a visible history list, showing all sites the user has visited but also one that functions like a map. If such a list were readily available, rather than requiring the user to make an active search for it through several pull down menu listings, the FD users might have the benefit of both a map of what has been visited and an easy way to return to some temporally distant, previously visited sites. Also, if sets of resources, retrieved from a keyword search could be arranged in some structued way, FDs should prefer such structured presentations. Some Web engines have already begun to provide such structures in the form of general categories listed on the “gateway” screen or presenting the user with file folders.
in which the retrieved results are organized. Although there already exist studies investigating the interaction between some cognitive abilities and different ways of presenting information (Allen, 1994, 1998), more study is needed to examine the interaction between cognitive styles (such as FD/FI) and the design features, particularly in hypermedia environments.

When designing Web pages, the Web designer might also have to consider the goal of the Web pages in relation to the user characteristics. For example, if the goal of a Web page is to encourage a particular behavior (e.g., analytical/keyword searches) over another (e.g., browsing), then the Web designer might want to adopt a simple interface with a few links providing information essential for conducting analytic searches only. Any unnecessary, attention-grabbing links would only hamper effective use or undercut the designer’s intent, especially among the FDs.

Web search trainers might examine the finding that online database search experience was particularly beneficial to FD users. The exact reason is not clear, however. It may be because the tasks used in this study were similar to the tasks involved in using an online database. It could be that the heavily text-based design of both the Web and online databases appear the same to the user even though they may have very different features and intents. It may also be that the knowledge and skills for using online databases are useful regardless of the system used. Obviously more research is needed to find support of these potential explanations.

It is noteworthy that a highly significant main effect of cognitive style was found on AVTIME, but not on AVNOD. The field-dependent individuals (FD) simply needed a longer time than the field-independent individuals (FI) to complete search tasks. Unlike other traditional “linear” information systems, hypermedia systems can offer many different navigational options and attractive features. In 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 within a seemingly large number of choices. The FDs who tend to be easily distracted by salient cues that are not necessarily pertinent to the given task are likely to have difficulties concentrating on whatever they need. Because of this tendency, the FDs are more likely to spend extra time following unnecessary links, or to spend more time assessing a wide variety of stimuli that are attractive, or to find those that lead toward, not away from, the desired goal. It is likely that this is why the FDs needed more time to complete a task than the FI did.

Essentially, this study provides some evidence that it is possible to improve individuals’ search performance on the Web, particularly the performance of field dependent individuals (FDs), a group with a cognitive style that is less well served by the Web’s visual complexity and higher navigational choice. These visual complexity and choices are essentially the defining features of hypertext and the impact of this new information “architecture” has only begun to find a research base in library and information science. Several disciplines potentially contribute to an understanding of this interplay of cognition and hypertext, and it will doubtlessly take such interdisciplinarity to cope with the complexities that must be examined. Whether one asserts that the designer must ensure to make hypermedia systems adjustable to provide for the individual differences in the broader user community or encourages the trainer to develop new abilities and skills in the user, what seems to be in agreement is the need for a user-centered focus.

Appendix 1: Research Design

<table>
<thead>
<tr>
<th></th>
<th>Cog. Style</th>
<th>NOVICE</th>
<th>EXPERIENCED</th>
</tr>
</thead>
<tbody>
<tr>
<td>FD</td>
<td>n = 12</td>
<td></td>
<td>n = 12</td>
</tr>
<tr>
<td>FI</td>
<td>n = 12</td>
<td></td>
<td>n = 12</td>
</tr>
</tbody>
</table>

Appendix 2: Search Tasks

Factual Information Search Task

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

Topical Information Search Task

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: (1) What kind of jobs is available and/or suitable for a person with a background like yours? (2) Where can you find information on the jobs? (3) Is there any career service available on campus? (4) Is there any job fair on campus? (5) What are you supposed to do for interviews—before, during, and after interviews? (6) How should you prepare your resume (curriculum vitae) and/or other documents? (7) Are there any people who are currently employed and want to share their experience? and many others. When you located a useful resource, make a bookmark of it. And go on for the next. Find three to five Web resources that you think useful and bookmark them.

References


