

Effects of Cognitive Style on Web Search and Navigation

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Abstract: This study examined how users with different cognitive styles locate information on a university Web site, a hypermedia-based information system. A hypermedia system is considered to be capable of accommodating cognitive style differences because of its multimodal attributes. Undergraduate students with different cognitive styles (field-dependence and field-independence) participated in the study. Findings suggest that the level of users' online search experience influenced effects of cognitive style on the search and navigational behavior. Only the field-dependent users with little or no online experience seemed to have difficulties in retrieving information on the Web.

Introduction

Hypermedia is one of the recently developed information technologies equipped with attractive interface and great capacity of improving access to information. By way of the World Wide Web (Web) and other networks, hypermedia has come to include remote databases and online resources (Ayersman, 1996). Naturally, the Web, with its attractive interface and capability of connecting to a variety of different resources, has become one of the most widely used information systems in the world.

Different from more traditional information systems (e.g. books), hypermedia is intentionally nonlinear (Nielsen, 1995). It presents a new information environment with which the user may not be familiar. Hypermedia 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 technology of the book and the narrative structure used by most authors. Users who have not developed skills of information-gathering in the nonlinear environment often report discomfort and experience difficulties in using hypermedia, such as "cognitive overload" and "disorientation" (Nielsen, 1995; Conklin, 1987).

Despite all these problems, early research suggests that hypermedia is promising as an information system (Gary and Shasha, 1989; Egan et al., 1989). Other studies evaluating the effectiveness of hypermedia, however, have not been uniformly successful in showing the advantage of hypermedia over other existing information systems (McKnight et al., 1990; Marchionini and Shneiderman, 1988). These inconsistent findings have led to a suspicion that there may be variables, other than system differences, influencing the effective use of hypermedia systems. To explore and identify factors influencing the effective use of hypermedia, a number of studies have been conducted. Results from the research suggest that characteristics of users and tasks may be major factors affecting the use of hypermedia systems (Qiu, 1993; Ford et al., 1994).

This study investigates how some of user variables influence the use of the Web as a hypermedia-based information system. The focus of the study is on the user's cognitive style, and its effects on the search behavior are examined in relation to the user's online search experience.

Background

A study analyzing usability studies of hypertext systems has revealed that four of the ten largest effects were due to users' individual differences (Nielsen, 1989). Among different kinds of individual differences, cognitive style, especially field-dependence/field-independence (FD/FI), is one of the most frequently studied factors in the research of learning on hypermedia systems (Liu & Reed, 1994; Leader & Klein, 1996). The FD individuals who tend to be easily dominated by salient cues are more likely to be distracted in hypermedia systems where information units are presented through a variety of different, attractive media forms. In fact,

several studies have shown that the FI individuals, less likely dominated by prominent stimuli, generally perform better than the FDs in finding information on hypermedia systems. The FIs tend to search information more efficiently and arrive at desired goals more quickly than the FDs (Ellis et al., 1993; Ford et al., 1994). Each group utilize a hypermedia learning environment differently although both of the groups have equivalent learning outcomes (Fitzgerald and Semrau, 1998).

Another kind of individual difference with a strong impact on the information-seeking process includes users' experience and expertise. Experience with online search and subject expertise have been found to influence the choice of search strategies and the search performance on information systems. Studies on linear information systems have revealed that online search experience, rather than subject expertise, plays the major role in determining the effective use of the systems (Hsieh-Yee, 1993). However, this finding is yet to be confirmed with hypermedia-based information systems.

The Study

Forty-eight volunteer students from a public university participated in this experiment. Their participation was financially compensated. All the participants were undergraduate students with different academic orientations. Fifty-four percent (n=26) of the participants were with soft science (social science, arts and humanities), and 46% (n=22) were with hard science (natural science and engineering) background. Half of the participants were male and the other half were female students.

The GEFT (Group Embedded Figures Test) and a questionnaire were used to determine the cognitive style and the level of online database search experience, respectively. Based on the results from the test (with scores ranging from 0 to 18) and questionnaire (with scores ranging from 0 to 4), participants were selected, and an individual lab session was arranged for each of the participants. Half of the participants were field-dependent (FD) and the other half were field-independent (FI): $Mean_{FD} = 8.25$, $Mean_{FI} = 15.96$. Also, half of them were novice and the other half were experienced online searchers; $Mean_{NOV} = 0.92$, $Mean_{EXP} = 2.96$. In the lab session, the participant was assigned search tasks for which he or she had to locate pertinent information within a university Web site. The Web browser used in the study was *Netscape 4.0*.

Independent variables for the study include users' cognitive style (field-dependent (FD) vs. field-independent (FI)) and online database search experience (experienced (EXP) vs. novice (NOV)). On the basis of their cognitive style and online experience, participants were evenly divided into four groups (FD-NOV; FD-EXP; FI-NOV; FI-EXP). Two dependent variables were adopted to measure search performance of the participants: the average time spent and the average number of nodes visited for the completion of a task. Additionally, the number of times each navigational tool chosen was counted to examine the user's search and navigational style.

The individual lab session started with a review of Web basics, designed to ensure that every participant was aware of the availability of different navigational/search tools and menus in the Web browser used and also general features of search engines. When the review was over, two search tasks were assigned to the participant. The same set of search tasks were used for all the participants. When the participant felt ready to start searching, he or she asked the researcher to start recording the search session. During the search session, all the screen displays consulted and keyboard/mouse inputs were recorded using *Lotus ScreenCam*. The participants were asked to make a bookmark of each Web page where he or she found relevant information.

Results

Average Length of Time Spent for the Completion of a Task

A two-way ANOVA was performed for the average length of time spent for the completion of a task. In this report, the level of significance was set at $p < .10$. The result indicated a significant main effect of cognitive style: $F_C(1,44) = 5.271$, $p < .03$. The FD individuals tended to spend more time than the FIs to find a piece of information: $Mean_{FD} = 130.3$ sec., $Mean_{FI} = 89.9$ sec. A significant main effect of online search experience was also found: $F_O(1,44) = 3.69$, $p < .07$. To find information on the Web, those with little or no online search experience spent more time than those with substantial online search experience: $Mean_{NOV} = 127$ sec., $Mean_{EXP} = 93.2$ sec. There was a significant interaction between the two independent variables: $F_{C \times O}(1,44) = 3.859$, $p < .06$. Figure 1 shows how the cognitive style and online search experience variables interacted with each other to influence the time spent for the completion of a task.

	df	F
Cognitive Style (C)	1	5.271*
Online Experience (O)	1	3.690*
C x O	1	3.859*
Within Groups	44	

* $p < .10$

Table 1. Analysis of Variance on the Average Time Spent for the Completion of a Task

For those with considerable online search experience, cognitive style seemed to have little impact: $Mean_{FD-EXP} = 96.1$, $Mean_{FI-EXP} = 90.3$. For those with little or no online experience, however, cognitive style seemed to play an important role in decreasing or increasing the length of time spent for the completion of a task. The FDs (FD-NOV) tended to spend longer time to retrieve information than the FIs (FI-NOV): $Mean_{FD-NOV} = 164.6$, $Mean_{FI-NOV} = 89.5$. Interestingly, the FDs with substantial online experience spent almost the same amount of time as the FIs (FI-NOV and FI-EXP) did for the completion of a task. It seems that, only among those with little online experience, cognitive style has an effect on the time spent for finding information.

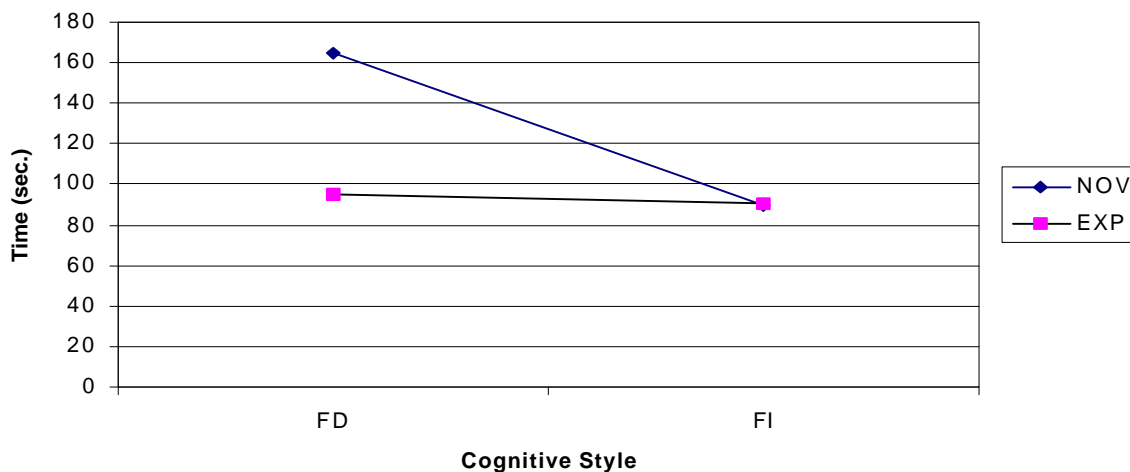


Figure 1. Average Time Spent for the Completion of a Task (sec.): Cognitive Style by Online Search Experience

Average Number of Nodes Visited for the Completion of a Task

A two-way ANOVA was performed for the average number of nodes visited for the completion of a task. At $p < .07$, a significant interaction between cognitive style and online experience was found: $F_{C \times O} (1,44) = 3.57$. As shown in Figure 2, the FI-NOV tended to visit a lower number of nodes than the FD-NOV: $Mean_{FI-NOV} = 7.3$, $Mean_{FD-NOV} = 11.7$. Among the experienced online searchers, on the other hand, little difference was found between the FIs and the FDs: $Mean_{FI-EXP} = 8.5$, $Mean_{FD-EXP} = 7.8$. The pattern was similar to what was found with the time spent for the completion of a task. No significant main effect was found, however. That is, no statistically significant difference existed between the numbers of nodes visited when the groups were compared on the participants' cognitive style or on the level of their online search experience.

	df	F
Cognitive Style (C)	1	2.029
Online Experience (O)	1	1.005
C x O	1	3.570*
Within Groups	44	

* $p < .10$

Table 2. Analysis of Variance on the Average Number of Nodes Visited for the Completion of a Task

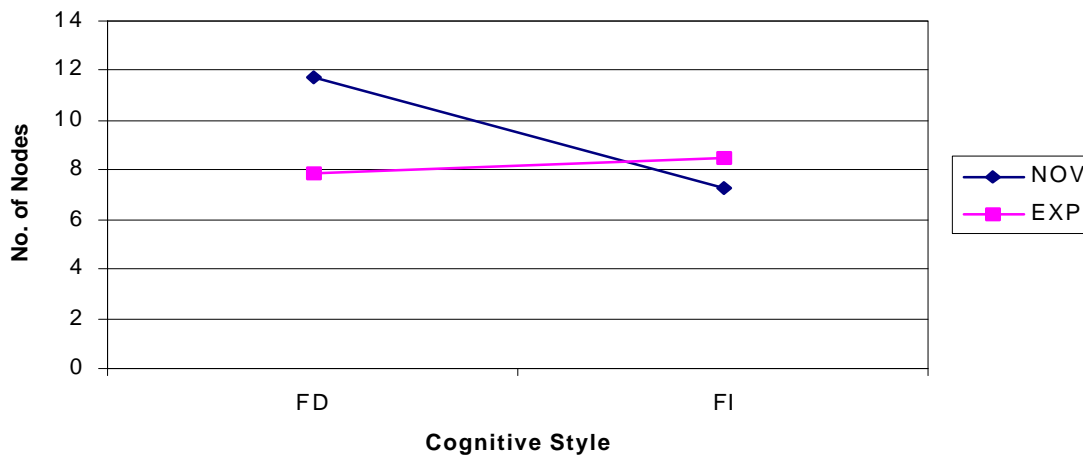


Figure 2. Average Number of Nodes Visited for the Completion of a Task: Cognitive Style by Online Experience

Use of Navigational Tools

In order to find whether differences in search performance were reflected in the navigational tools chosen, additional sets of two-way ANOVA were carried out using the number of times different navigational tools were used (such as embedded links, Back, Home, Go, History, search engines, etc.) as the dependent variable. Significant interactions were found for the use of embedded links and the Home button: for embedded links, $F_{C \times O}(1,44) = 5.002$, $p < .04$, and for the Home button, $F_{C \times O}(1,44) = 3.728$, $p < .07$. The pattern of interactions was similar to the one found with the time spent and the number of nodes visited for the completion of a task. The FDs with little or no search experience (FD-NOV) used embedded links and the Home button significantly more frequently than the rest.

In addition to the interaction effects found in the use of embedded links and Home button, a significant main effect of online experience was found in the use of jump tools: $F_O(1,44) = 6.568$, $p < .02$. Here, jump tools include Go, History, Location box used for an “active” jump. The result revealed that the experienced online searchers used jump tools more frequently than the novice searchers: $Mean_{EXP} = 0.60$, $Mean_{NOV} = 0.005$.

Discussion

Results from this study suggest that the level of users' online search experience influences the effect of cognitive style on the search performance. That is, among those who had little or no experience with online searches, the FI individuals tend to outperform the FDs. In order to complete a search task, the FIs spent less time and needed to visit fewer nodes than the FDs. However, the difference created by participants' cognitive style disappeared in those participants who had considerable online search experience. Among the experienced online searchers, no significant difference was found between the FDs and the FIs in terms of the time spent and the number of nodes visited for the completion of a task. This implies that difficulties that the FDs face in finding information on the Web may be overcome as the FDs gain experience and develop their search strategies while using online databases. Despite presentational and structural differences between traditional "linear" online database systems and the "non-linear" Web, skills required for using online databases seem to be transferred to the use of Web sources.

With regard to the choice of navigational tools, a similar interaction effect was observed. In the group of individuals with little or no online search experience, the FDs used embedded links more frequently than the FIs. The frequent usage of embedded links can be interpreted as a linear rather than a non-linear way of navigation. It is because other tools (such as Go, History list, or a typed URL) allow the user to jump to more temporally removed point whereas embedded links do not. Findings from the study implies that the FD-NOVs navigate the Web in a more linear mode than the rest. In fact, this might be the way in which we would expect the "typical" FD would navigate. The FDs prefer a well structured set of stimuli. As they tend to be passive in learning (Witkin et al., 1977), the FDs would not enjoy imposing a structure of their own. Thus, the FDs are more likely to navigate the Web in a linear mode. Previous studies on the use of hypermedia systems found that the FDs tended to explore a hypermedia system in a linear mode, following the sequence encouraged by the system (Liu & Reed, 1994). This finding is, however, only partly supported by our study. In our study, only the FDs with little or no online experience demonstrated the linear mode of navigation. The way in which the FDs with considerable online search experience navigated the Web was different from the way in which the FDs with little online experience did. The FDs with substantial online search experience had a navigational style, reflected in their use of tools, which was rather similar to the FIs'. Their search performance, reflected in the time spent and the number of nodes visited for the completion of a task, was also comparable to the FI's.

In this study, the FDs with little or no online experience tended to use Home button more frequently than the rest. The use of Home button can be viewed as one possible indication of the user's "getting lost," because the Home button is often used when people wish to start over, abandoning whatever they have been doing. Based on this interpretation, the result implies that the FD-NOVs get lost more often than the rest. It is known that the FDs tend to be easily distracted in a complex field by cues that may not be relevant to the goal (Witkin et al., 1977). Hence, the FDs are expected to become easily lost through the pursuit of more dominant but possibly irrelevant cues. Again, findings from our study supports the hypothesis only partially. Among the FDs, only those with little or no online experience tended to get lost more easily than the rest, including the FDs with substantial online search experience.

The FDs, especially those with little or no experience with online databases, seem to need special attention from interface designers and those who train Web users. Interface designers may want to incorporate devices that can help the FDs be 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 and functioning like a map, at the same time. Such a list should be readily available, rather than requiring the user to make an active search for it through several pull down menu listings (which is often found in "linear" online systems). This would be useful to the FD users because the list could be used as a map showing what has been visited and also provides an easy way to return to some temporally distant, previously visited sites. 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 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 be because the Web has inherited many interface features from the traditional linear online systems. It may also be that the knowledge and skills for using online databases are useful regardless of the system used. Obviously more research is called for to investigate these potential explanations.

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