VERS, TASKS AND THE WEB: THEIR IMPACT ON THE INFORMATION SEEKING BEHAVIOR

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Abstract: This study investigated how cognitive style and online database search experience influence users' search performance on two tasks carried out on a large university Web site. Search performance was measured both by the time spent and by the number of nodes visited for the completion of a task. The users' choice of navigational tools was also examined. Forty-eight undergraduate students participated in the study. Based on their cognitive style (field-dependent and independent) and their online database search experience (novice and experienced), the participants were divided into four groups. Each participant was asked to search for information on the Web in order to complete two search tasks (factual and topical searches). All online search navigation decisions and nodes visited were recorded in real time. Results indicates that the difference in performance created by a participant’s cognitive style was almost erased in those participants who had considerable online database experience. This kind of interaction between cognitive style and online database search experience was also observed in the choice of navigational tools. Based on findings, suggestions for Web training and the development of some navigational tools were made.

1. INTRODUCTION

As computer technologies advance, information systems have been developed and evolved for improving the retrieval of information. Hypermedia is one of information technologies, equipped with attractive interface and great capacity of improving access to information. Information in a hypermedia system can be presented in a variety of different forms, such as text, images, sounds, and even videos. Hypermedia can also provide different organizational structures for information and access in ways that can accommodate the user’s interest and need. With the development of network technologies, hypermedia has come to include remote databases and online resources accessible by way of the World-Wide Web (Web) and other networks using Web browsers (Ref.1). Allowing flexible presentation of and limitless access to information, the Web is probably the most important application of hypermedia and also the most widely used information system.

According to Marchionini (Ref. 2, 3), information-seeking depends on the interaction between several factors. The factors include the characteristics of the information seeker, search task, search system (the source of information and strategies for access), domain (fields of knowledge), setting (the situation and physical context for information-seeking), and search outcomes (the feedback from the system). Among these factors, Marchionini places the information seeker at the center, and believes that a successful system will allow the seeker to exploit these other factors as the information seeking progresses.
Each information-seeker possesses unique mental models, experiences, abilities, and preferences. These individual differences among information-seekers seem to play an important role in determining whether the seeker can effectively use an information system or not. In a group of thirty individuals, Egan (Ref. 4) reports, performance differences between users on the order of 20:1 is not uncommon for some computer based tasks. Nielsen (Ref. 5) also argues that the users’ individual characteristics and their tasks are the most important issues for usability of hypermedia. An analysis of ninety-two published comparisons of usability of hypertext systems found that four of the ten largest effects in these studies were due to individual differences among users and that two were due to task differences (Ref. 6).

This study investigates some of the seemingly important factors affecting the information-seeking behavior of users on hypermedia based systems, using the World Wide Web as a current popular information intense choice. Factors such as task type, users’ online database search experience and cognitive style are considered together with the relationships and effects these factors exert on the information search behavior. The study examines the effects of the three selected factors not only by measuring the effectiveness of search performance but also by analyzing search and navigational options chosen.

2. BACKGROUND

Among different kinds of individual differences, cognitive style\(^1\), 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/independence on the structure of the prevailing visual field (Ref. 7). This tendency is believed to be transferred to, and affect the individual’s cognitive and personality orientations as well. The FDs tend to be dominated by salient cues and perceive stimuli more holistically. On the other hand, the FIs are less dominated by the most obvious or salient cues, and perceive stimuli more analytically by imposing their own structure (Ref. 8). In hypermedia systems where information units are presented through a variety of different media and in a loose structure, FD individuals are more likely to be distracted. 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, less likely dominated by salient cues, generally perform better than FDs on hypermedia information systems. The former tend to search information more correctly and efficiently and arrive at desired goals more quickly than the latter (Ref. 9,10).

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 on the choice of search strategies and the search performances on hypermedia. The more computer experience individuals have, the more analytical searching strategies they use (Ref. 11). And expertise in subject areas and expertise in online searching are found to have similarly positive effects on the search performance (Ref. 12). Other studies have shown, however, that among different kinds of experiences and expertise, online search experience plays the major role in determining the effective use of systems (Ref. 13,14).

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Besides user factors, task types also seem to be one of the important factors affecting the search behavior on hypermedia. Campagnoni and Erlich (Ref. 15) found that a search for specific factual information leads users to adopt analytical searching strategies whereas a search for general information leads to browsing. Similar results were also yielded in other studies (Ref. 16,17).

This study examines how task type and users' online database search experience and cognitive style variables influence the information search performance and the use of navigational tools on the Web, a hypermedia-based information system.

3. THE STUDY

Independent Variables

Independent variables used in the study include users' cognitive style (field-dependent (FD) vs. field-independent (FI)), online database search experience (experienced (EXP) vs. novice (NOV)), and the type of search tasks (factual (FACT) vs. topical (TOPIC) information search tasks). On the basis of their cognitive style and online experience, participants were evenly divided into four groups: (1) FD-NOV, (2) FD-EXP, (3) FI-NOV, and (4) FI-EXP. All the participants were assigned the same set of two search tasks: one is factual information search task and the other is topical information search task.

Dependent Variables

Two dependent variables were adopted to measure search performance of the participants: the average length of time spent and the average number of nodes visited for the completion of a task. In addition, the number of times each search/navigational tool chosen was counted to examine the user's search/navigational style. These tools include Back, Forward, and Home buttons, Jump tools (comprising Location window, Go, and History), embedded links and search engines.

Procedure

Forty-eight undergraduate students from a university participated in this research. Their participation was on a voluntary basis, and was financially compensated. To determine the cognitive style and the level of online database search experience, the GEFT (Group Embedded Figures Test) and a questionnaire were administered. Based on the results from the test and questionnaire, participants were selected, and an individual lab session was arranged for each of the participant.

In a lab environment, the participant was assigned two search tasks of different types: factual information search task and topical information search task. The participants were instructed to find information on the Web to answer questions given, and to make a bookmark of each Web page where they could find answers to those questions. In the factual information search task, there existed a Web page providing the correct answer to the question given, and the participants were asked to continue their search until they located the Web page and to make a bookmark of it. In the topical information search task, the participants were told to make bookmarks of more
than one Web page that they found relevant to the topic given. The order of tasks was alternated in order to eliminate any order effect. The search environment was limited to a university Web. 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 a software program. When the participant completed the search tasks, he or she asked the researcher to stop the recording.

4. Results

Search Performance: Time Spent for the Completion of a Task

ANOVA (Analysis of variance) was performed for the average length of time spent for the completion of a task. The result indicated a significant main effect for cognitive style: $F_{Cog} (1,44) = 6.38, p < .02$. In both search tasks, the FD (Field-Dependent) individuals tended to spend more time than the FIIs (Field-Independents) (See Table 1). At $p < .02$, a significant main effect of online search experience was also found: $F_{Ord} (1,44) = 6.32$. In both search tasks, those with little or no online search experience (NOVICE) tended to spend more time than those with substantial online search experience (EXPERIENCED), in order to complete search tasks (See Table 1).

<table>
<thead>
<tr>
<th>Task Type</th>
<th>Factual</th>
<th>Topical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive style</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FD</td>
<td>154.58 (156.9)</td>
<td>125.95 (86.3)</td>
</tr>
<tr>
<td>FI</td>
<td>86.92 (74.0)</td>
<td>91.39 (42.3)</td>
</tr>
<tr>
<td>Online search experience</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NOVICE</td>
<td>162.21 (162.0)</td>
<td>118.07 (70.4)</td>
</tr>
<tr>
<td>EXPERIENCED</td>
<td>79.29 (51.3)</td>
<td>99.27 (68.6)</td>
</tr>
</tbody>
</table>

Table 1. Time spent for the completion of a task (sec.): Means and standard deviation

A significant interaction between the two independent variables was found: $F_{Cog \times Ord} (1,44) = 5.791, p < .03$. For the FIs, online database search experience seemed to have little impact on the time spent for the completion of a task: $Mean_{FI-NOVICE} = 90.2, Mean_{FI-EXPERIENCED} = 88.1$. For the FDs, however, online experience seemed to play an important role in decreasing the length of time spent for the completion of a task. That is, the FDs who had little or no experience with online database searching (FD-NOVICE) tended to spend longer time to retrieve information than the FDs who had considerable experience with online database searching (FD-EXPERIENCED): $Mean_{FD-NOVICE} =$
190.0, Mean FD-EXPERIENCED = 90.5. Power of all the significant effects presented here was approximately 0.7.

It is interesting to note that the FD-EXPERIENCED spent almost the same amount of time as the FIs did for completing a task. The results suggest that online search experience contributes to reducing the length of time spent for the completion of a task among the FDs whereas the experience had little impact on the length of time that the FIs spent for the completion of a task.

Search Performance: Number of Nodes Visited for the Completion of a Task

At p < .05, a significant interaction between cognitive style and online experience was found: $F_{Cogn \times \text{On}} (1,44) = 4.21$. The FD-EXPERIENCED tended to visit a lower number of nodes than the FD-NOVICE: Mean FD-EXPERIENCED = 7.4, Mean FD-NOVICE = 13.1. 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 = 7.4, Mean FI-EXPERIENCED = 7.5. The pattern of the interaction was similar to what was found with the time spent for the completion of a task.

At p < .05, a significant interaction was found between online experience and task type: $F_{\text{On} \times \text{Task}} (1,44) = 4.09$. In TOPIC, both of the NOVICE and EXPERIENCED visited almost the same number of nodes: Mean NOVICE/Topic = 9.0, Mean EXPERIENCED/Topic = 8.9. In FACT, however, the NOVICE visited a significantly higher number of nodes than the EXPERIENCED: Mean NOVICE/FACT = 11.5, Mean EXPERIENCED/FACT = 5.96.

No significant main effect was found at p < .05, however. That is, no statistically significant difference existed between the numbers of nodes visited when the groups were compared on the participants’ cognitive style, on the level of their online database search experience, or the type of search tasks. Power of all the significant interaction effects presented here was approximately 0.5.

<table>
<thead>
<tr>
<th>Task Type</th>
<th>Factual</th>
<th>Topical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive style</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FD</td>
<td>10.75 (11.3)</td>
<td>9.78 (6.8)</td>
</tr>
<tr>
<td>FI</td>
<td>6.70 (3.5)</td>
<td>8.26 (3.7)</td>
</tr>
<tr>
<td>Online search experience</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NOVICE</td>
<td>11.50 (11.3)</td>
<td>9.06 (5.3)</td>
</tr>
<tr>
<td>EXPERIENCED</td>
<td>5.95 (2.4)</td>
<td>8.98 (5.7)</td>
</tr>
</tbody>
</table>

Table 2. Number of nodes visited for the completion of a task (f): Means and standard deviation
Navigational Style: Use of Search/Navigational Tools

To assess whether differences in search performance would be reflected in the search/navigational tools chosen, additional sets of ANOVA were carried out, using the number of times different search/navigational tools used (such as embedded links, Back, Home, Go, History, etc.) as dependent variables.

Embedded links

For the use of embedded links, two two-way interactions were found to be significant. A significant interaction was found between cognitive style and online experience: $F_{Cog \times Oml} (1,44) = 6.78, p < .02$. For the FIs, online database search experience seemed to have little impact on the use of embedded links for the completion of a task: $Mean_{FI-NOVICE} = 4.4$, $Mean_{FI-EXPERIENCED} = 4.4$. For the FDs, however, online experience seemed to play an important role in decreasing the number of times embedded links used for the completion of a task. Among the FDs, those with little or no online search experience tended to use embedded links more frequently than the experienced online searchers: $Mean_{FD-NOVICE} = 7.6$, $Mean_{FD-EXPERIENCED} = 4.2$.

Another significant interaction was found between online experience and task type: $F_{Oml \times Task} (1,44) = 6.16, p < .02$. In the TOPIC, online database search experience seemed to have little impact on the use of embedded links for the completion of a task: $Mean_{NOVICE/TOPIC} = 4.6$, $Mean_{EXPERIENCED/TOPIC} = 4.3$. In the FACT, however, online experience seemed to play an important role in decreasing the number of times embedded links used for the completion of a task. The NOVICE tended to use embedded links more frequently than the experienced online searchers: $Mean_{NOVICE/FACT} = 7.4$, $Mean_{EXPERIENCED/FACT} = 4.2$.

Jump tools

The frequency of intentional jumps was measured based on the number of times that a participant used tools for jumping, such as Go, History, and Location window. At $p < .01$, a significant interaction between online search experience and task type was found: $F_{Oml \times Task} (1,44) = 9.71$. In the FACT, there was no significant difference between the NOVICE and the EXPERIENCED. In the TOPIC, on the other hand, the EXPERIENCED used jump tools more frequently than the NOVICE.

Home button

For the use of Home button, a significant interaction was found between cognitive style and online search experience: $F_{Cog \times Oml} (1,44) = 4.54, p < .04$. The pattern of interactions was similar to the one found with other performance variables. For the FIs, online database search experience seemed to have little impact on the use of Home button: $Mean_{FI-NOVICE} = 0.03$, $Mean_{FI-EXPERIENCED} = 0.05$. For the FDs, however, online experience seemed to play an important role in decreasing the number of times Home button was used: $Mean_{FD-NOVICE} = 0.25$, $Mean_{FD-EXPERIENCED} = 0.02$. The FD-NOVICE used Home button significantly more frequently than the rest.
5. DISCUSSION AND CONCLUSIONS

Results suggest that the level of users’ online database search experience influence the effect of cognitive style on the search performance. That is, among those who had little or no experience with online database search, FI individuals outperformed FD individuals. In order to complete a task, the FDs spent longer time and needed to visit a higher number of nodes than the FIs. There was an indication, however, that the difference in performance created by participants’ cognitive style was almost erased in those participants who had considerable online database search experience. Among the experienced online searchers, no significant difference was found between the FDs and the FIs in terms of the length of time spent and the number of nodes visited for the completion of a task.

One of implications from this fining is that a training program for improving the use of online databases could be beneficial and may lead to effective and efficient searches on the Web. Despite presentational and structural differences between online databases on linear systems and information sources on the Web – a “non-linear” system, it seems that skills required for using online databases can be transferred to and useful for the Web search. It also seems that difficulties and problems users may face (partly due to their cognitive style) in searching the Web could be reduced as the users gain experience and develop their search strategies through training for the effective use of online databases.

A similar interaction effect between cognitive style and online database search experience was observed in the choice of navigational tools. Although no difference was found between the FDs and the FIs among the experienced searchers, in the group of novice searchers, the FDs used embedded links and the Home button more frequently than the FIs. The frequent use of embedded links can be interpreted as a “linear” rather than a non-linear way of navigation. The use of the Home button can be viewed as one possible indication of “getting lost.” When we assume this interpretation, results on the use of embedded links and Home button seem to indicate that the FD-NOVICEs tend to navigate the Web in a more linear mode and that they get lost more frequently than the rest. The way in which the FD-NOVICE used tools reflects the characteristics of the “typical” FDs who tend to be easily distracted and prefer not to impose a structure of their own. It should be noted, however, that the way in which the FD-EXPERIENCED navigated the Web was different from the FD-NOVICE’s way of navigation. The FD-EXPERIENCED searchers had a navigational style, which was rather similar to the FIs.’ And 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.

Another interesting finding is that the level of users’ online database search experience influences the effect of task types on the search performance and the use of navigational tools. The EXPERIENCED visited a lower number of nodes to complete the factual information search task (FACT) than the NOVICE although no significant difference between the two was found in the topical information search task (TOPIC). This was reflected in the use of embedded links as well. An interaction between users’ online database search experience and task type was also found in the use of intentional jumps, although the pattern of the interaction is different from
those found in the number of nodes visited and the number of times embedded links chosen. For the TOPIC, individuals with online search experience tended to use jump tools more frequently than the novices. As the TOPIC requires finding information spread out in different locations, tools allowing a jump from one location to another seem particularly useful. But interestingly, only those who had considerable search experience in online database systems – linear systems – tended to navigate the Web in a non-linear mode. All of these results are different from those of previous studies. Previous research (Ref. 18) found that users tend to adopt more analytical search strategies in factual/specific information search tasks and browsing strategies in topical/general information search tasks. Before comparing the findings, however, it should be noted that, in this study, the participants performed the search in their university Web site which they might have been familiar with before the search began. It is possible that most of the participants felt that they knew the search environment well enough to locate information for the FACT by browsing. The topical information search task, on the other hand, was broader than the FACT. Thus, most of the participants including even those who knew their search environment well might have decided to rely on search engines to find information in different locations. The average numbers of times that a search engine was used for the FACT and the TOPIC support this speculation: Mean \text{FACT} = .45, Mean \text{TOPIC} = .82. Besides the characteristics of search tasks, this special condition might also have influenced the results. Further study is called for in order to measure the effect of task types more accurately by systematically controlling external factors.

Although it is difficult to find the exact cause resulting the interaction effects between online search experience and tasks, it seems obvious that those with online search experiences tend to find information more efficiently by following fewer links and by navigating the Web in a non-linear mode. To facilitate the information search and navigation on the Web, the Web designers might want to make jump tools more readily available and easier to use. In addition, they might need to be more selective when adding embedded links to the Web pages if they want to prevent any unnecessary layer traversals of the user.

Essentially, this study provides some evidence that it is possible to improve individuals' search performance on the Web, particularly the performance of FD individuals, a group with a cognitive style that is less well served by the Web's visual complexity and higher navigational choice. It seems that the FDs, especially those with little or no experience with online databases, need special attention from those who train Web users. 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.

6. NOTES

1. An individual characteristic and consistent manner of processing and organizing what he or she sees and thinks about. (The Encyclopedic Dictionary of Psychology, 1983)
2. A task of this type requires the searcher to find a piece of factual information for an item known to exist, which provides a specific answer to the question given.

3. A task of this type requires the searcher to find more than one piece of information related to the topic given and regarded useful to the searcher.

7. REFERENCES


