EFFECTS OF INDIVIDUAL DIFFERENCES AND TASK ENVIRONMENTS ON USERS' INTERACTIONS WITH WEB RESOURCES

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Abstract

This study was conducted to extract more detailed knowledge of how individual differences affect Web search behavior and performance in different task environments. Participants performed a search task finding the answers from the Web. Four independent variables were manipulated in the study: (1) cognitive style, (2) time availability, (3) knowledge type, and (4) problem structure. Two types of measurements were used as dependent variables: (1) search performance measurements including accuracy, search time, and number of pages visited, and (2) search/navigation changes as a search behavior measurement. Results of this study indicated that both task-related factors and different cognitive styles affected search performance and behavior. Training programs designed to improve Web search performance and support users' search behavior must be supplemented with training focused on the nature of the information for which the user is searching in terms of its availability, distribution, and quality in certain fields.

Introduction

Society has become more and more dependent upon "information ecologies" for survival, and the World Wide Web (WWW) has gained popularity as an information ecology. Information ecologies[10] like the WWW are comprised of the content, structure, distributions, technologies, and people who are using information for knowledge work. Unfortunately, these Web characteristics bring many challenges to users who are seeking information on the Web. Many of these users are students in educational settings. Educational environments in both K-12 and higher education are relying on the Web as a tool for students' information seeking, which now provides more credible information. According to the National Center for Educational Statistics (2000), 60% of public school teachers reported using computers and the Internet for classroom instruction. Of those, 25% of elementary school teachers and 41% of secondary school teachers required students to conduct research using the Internet. Statistics also show that searching on the Web differs in frequency in high poverty schools compared to low poverty schools, with less search activities occurring in high poverty schools[27].

There is a strong need to focus on information behavior to design more effective information tools, so that all students can have access to credible and quality information resources. Information behavior reflects the way individuals approach and handle information, and consists of the search, use, modification, storage, and application of information used by individuals.[10] Information seeking is a subset of information behavior. Since Web resources are organized in a nonlinear and non-hierarchical way, users tend to have difficulty when searching for information on the Web [36]. Some users prefer to start their searches from known sites [18];[35] with different browsing styles[28]. Others tend to use a specific search engine [16], while searching for information in a small area[7].

To explain Web users' diverse behaviors, studies on the interaction of users with Web resources have identified many variables. For

example, some researchers maintain that different user characteristics may be important factors because the Web must serve heterogeneous user groups in terms of gender, cognitive style, educational background, class, ethnicity, and computer literacy [28];[30]. Task environments have also been shown to affect users' information seeking on the Web, such as the type of questions and search tools used (e.g., [34];[39]. However, few studies have attempted to investigate the effects of both individual differences and task environments on Web users' search performance and behavior. In addition, while there have been many studies on users' search performance and behavior in hypermedia environments, much study is still needed on users' interactions with Web resources[36].

The main objective of this study was to empirically describe and analyze the factors that influence Web search performance and behavior, both internal (such as cognitive styles) and external (such as time availability). Knowledge of search performance and behavior can provide important guidelines for the design of customization protocols and effective interventions when in classroom settings, or when developing training programs. Ultimately, this information should support the design of more usable Web sites. As a consequence of the increasing need to understand diverse users' search behaviors, this study was conducted to see how individual differences such as cognitive style affect Web search behavior and performance in task environments that varied on the basis of problem structure, time availability, and type of knowledge required. For brevity, the variables selected for this study and the rationale for each are summarized in Table 1.

Based on previous studies, the following hypotheses were tested:

1. Users' cognitive styles will have an effect on different levels of information searching performance and behavior.
2. Different task environments will have an effect on users' information searching performance and behavior. And more specifically,
   2.1. Problem structure will have an effect on different levels of information searching performance and behavior.
   2.2. Time availability will have an effect on different levels of information searching performance and behavior.
   2.3. Types of knowledge required for information seeking will have an effect on different levels of information searching performance and behavior.

Method

Participants

Twenty-four participants were recruited from the Industrial and Systems Engineering (ISE) undergraduate student population at Virginia Polytechnic Institute and State University (VT) via posted flyers. Participants were given monetary compensation for their participation. There were 9 female and 15 male participants whose mean age was 21 years (*SD* = 1.5 years). Participants' mean years of computer use were 8.7 years (*SD* = 2.7 years). All participants used computers daily. Most of the participants were seniors (70.8%, *n* = 17) and 16.7% (*n* = 4) were sophomores, while 12.5% (*n* = 3) were juniors.

Experimental Materials and Questionnaires

Prior to the experiment, the Group Embedded Figures Test (GEFT; [41]) was administered to screen participants for further participation in the study. The GEFT measures field dependence and independence, which reflect an individual's tendency to process information on the basis of figure versus ground (contextual field).

Participants performed the experimental tasks using a Pentium computer, equipped with a standard keyboard, mouse, and 17" super VGA monitor. Internet Explorer (IE) 6.0 running in Windows XP was used as a Web browser.

Table 1: Overview of Internal and External Variables

Factor Type	Variable	Description/Rationale	Source
Internal	Cognitive Style	Cognitive style has significant impacts on Web search behaviors. Field Dependent seekers organize perceptions using the overall surrounding field, while Field Independent seekers organize perceptions in discrete parts.	Ellis, Ford, & Wood; 1993; Kim, 2001; Leader & Klein, 1996; Liu & Reed; Messick, 1976; Palmquist & Kim, 2000; Witkin & Goodenough, 1981; Witkin, Oltman, Raskin, & Karp, 1971
External	Problem Structures	Structures of search problems may affect the way students find information and select strategies to find information. Question type influences students' choices of a search strategy.	Hawk & Wang, 1999; Lazonder,Biemans, & Wopereis, 2000; Taylor, 1986; Vakkari, 1999; Wang et al., 2000; White & Iivonen, 2001;
	Time	Time availability affects the search behavior and motivation of consumers. Time pressure is a stressor that may lead to cognitive tunneling and less effective search behavior.	Baddeley, 1972; Beatty & Smith, 1987; Dirkin, 1983; Laroche, Saad, Cleveland, & Browne, 2000; Weltman, Smith, & Egstrom, 1971.)
	Knowledge Type	Prior knowledge of a domain and Web search experience are associated with more effective search behavior.	Bates, 1987; Fidel 1991; Holscher & Strube, 2000: Hsieh-Yee, 1998)

To capture participants' various behaviors during a Web-browsing session, two data-collection tools were used – TechSmith Camtasia and WebMonitor. TechSmith Camtasia was used to record screen displays in real time. WebMonitor, developed specifically for this study, was used to record browser action, requested URL, the cumulative time elapsed since the IE 6.0 was launched, and the differential time elapsed since the previous recorded event, respectively.

Independent Variables

There were four independent variables manipulated in the study: (1) cognitive style (field dependent versus field independent), (2) time availability (self-paced versus timed), (3) knowledge type (domain-specific versus general), and (4) problem structure (open/predictable versus open/unpredictable versus closed/predictable versus closed/ unpredictable). Cognitive style was a between-subjects variable while time availability, knowledge type, and problem structure were within-subjects variables. A 2 (cognitive style) x 2 (time availability) x 2 (knowledge type) x 4 (problem structure) mixed factor design was used.

Cognitive style: The mean score (M = 14.58, SD = 3.56) of the GEFT was used to assign participants to an FI cognitive style or an FD cognitive style. Half of the participants (n = 12) were FDs (M = 11.75, SD = 2.96), and the other half (n = 12) were FIs (M = 17.42, SD = 0.51). Thirty-two participants were screened in order to identify 12 FDs and 12 FIs. The difference between the two groups maintained internal validity as indicated by the significant difference between the mean scores on the GEFT, $t(22) = 6.54$, $p < 0.0001$.

Time availability: The time availability condition was manipulated as a 2-level within-subjects condition (i.e., timed vs. self-paced). A 2-minute time limit was used in the timed condition. The 2-minute time period was selected on the basis of data from a pilot study. In the self-paced condition, there were no externally imposed time limits.

Knowledge type: The knowledge type condition was manipulated as a 2-level within-subjects condition: domain-specific knowledge and general knowledge. Search questions about industrial engineering were used for the domain-specific knowledge condition (e.g., What is the meaning of the Theory of Constraints?). General knowledge questions were also selected making sure there was no overlap with ISE subject matter. An example of a general knowledge question was: What are some guidelines for the type of wine to serve with various dishes?

Problem structure: The problem structure condition was manipulated as a 4-level within-subjects condition by combining two characteristics borrowed from the study of White & Iivonen[39]: the specificity of the potential answer (closed/open) and source predictability (predictable/unpredictable). Since White & Iivonen's study[39] did not provide specific definitions of those two dimensions, this study operationalized closed/open and predictable/unpredictable using information from the White and Iivonen study and other information related to problem structures.

The closed/open dimension consists of questions that are dependent upon the specificity of the potential answer, and the number of possible responses. Closed questions yield a specific answer or list of correct answers. Open questions produce any possible number of correct answers. For closed questions, since there is usually one specific answer that is correct, users had to search for the specific information on a site and read carefully within a page. For example, two of the questions were phrased as follows: "Who was the winner for the 1992 Olympic Equestrian Three Day Event (individual)?" and "What are the colors of the flag of Mauritius?" There is only one first place winner and the flag is definite. On the other hand, open questions have several possible answers that could all be correct. This type of question only requires a general scanning of paragraphs or lists, but does not require very specific examination of text. For example, questions like "What is Biscayne National Park known for?" and "What is the name of a French film made prior to 1985?" are open questions in nature, because there are several park features that could be correct answers and there are many French films made before 1985.

The predictable/unpredictable dimension refers to the extent to which the source for the information can be predicted. For predictable questions, one has to go to a specific company or organization's Web site to get the information, such as "Who was the winner for the 1992 Olympic Equestrian Three Day Event (individual)?" and "What is Biscayne National Park known for?" To find answers, users must go to the National Parks web site and the Olympic homepage. For unpredictable questions, one can go just about anywhere to get the information. For instance, users may find films from several different web sites, such as the homepage of a collector of French films or movie library. Searchers may also find the flag on a number of web sites.

Table 2: Sample questions of four types of questions

		Source Predictability	
		Predictable	Unpredictable
Answer Specificity	Closed	Who was the winner for the 1992 Olympic Equestrian Three Day Event (individual)?	What are the colors of the flag of Mauritius?
	Open	What is Biscayne National Park known for?	What is the name of a French film made prior to 1985?

By combining these two dimensions, four types of questions were developed. Table 2 contains sample questions embedded within the 2 x 2 matrix. There were 32 questions grouped by the category, each of which had 8 questions.

Dependent Variables

To investigate the effects of individual differences and task environments on users' Web search, this study used several dependent measures, which can be categorized into two types of variables: search performance and behavior. Search performance measurements included accuracy, search time, and number of pages visited. The amount of search/navigation changes was used as search behavior measurement.

Search Performance Measurements

Accuracy: The accuracy variable refers to the participants' failure or success of getting the correct answer to a question.

Search time: This variable was measured as the time the participant spent to find the correct answer to one question (unit: second).

Number of pages visited: This variable was expressed as the number of Web pages that the participant visited to find the correct answer to one question.

Search Behavior Measurement

Search/navigation changes: The search behavior measurement was expressed as changes in search/navigation strategy, measured as the amount of changes in the use of different search/navigation tools. The search/navigational tools included every possible search/navigation tool in the Web browser (i.e., IE 6.0), such as embedded links, backward/forward buttons, home button, search engines, and the location window to type URLs.

The search/navigation changes variable was measured as the total number of changes, in which 1 was assigned if a participant used a different search/navigation tool from the previous movement, and 0 was assigned if the participant used the same tool from the previous movement. A smaller value indicates that the participants tended to keep using the same search/navigational tools that they used in the previous move. Table 3 shows how the search/navigation changes variable was calculated.

Procedures

After the GEFT was scored, participants were contacted and scheduled to return to the laboratory for the experimental session. After informed consent was acquired, participants were given written instructions for the task and asked to provide their initial search strategy to

Table 3: Example of the Search/Navigation Changes

Movement	Start	1st	2nd	3rd	4th	5th	Amount of changes
Pages visited for question A	VT Homepage	Type URL (www.google.com)	Type search terms in the search box	Click the link	Click the link	Click the link	
Changes	0	1	2	3	3	3	3
Pages visited for question B	VT Homepage	Type URL (www.google.com)	Type search terms in the search box	Click the link	Press the back button	Click the link	
Changes	0	1	2	3	4	5	5

locate the answer of the question presented to them. Participants then performed a short computer training exercise designed to familiarize them with the search task, and were asked to find the answers from the Web using the Web browser (i.e., IE 6.0). Thirty-two search questions were presented. The default page in the Web browser was set for Virginia Tech's homepage (www.vt.edu). At the end of the experiment, participants completed a demographic questionnaire and were debriefed.

Results

Four-way analyses of variance (ANOVAs) were performed to determine the effects of cognitive style and task characteristics (time availability, knowledge type, and problem structure) on search performance and search behavior measures. Since there were no data for questions not answered correctly (e.g., search time and number of pages visited), the PROC GLM procedure of SAS (Version 8.0) was used to accommodate unbalanced, missing values.

Search Performance Analyses

To investigate participants' performance in their Web-based information search, three dependent measures were employed. These measures, called here performance parameters, include accuracy, search time, and number of pages visited. Table 4 shows significant effects for search performance parameters across different experimental conditions.

Accuracy: The overall accuracy (24 participants x 32 questions) in the present study was 75.22%. An ANOVA was then conducted using the independent variables named previously. The main effect of knowledge type was significant, $F(1, 22) = 30.60$, $p < 0.0001$. That is, participants were more accurate for the general knowledge questions (i.e., non-ISE questions) than for the domain-specific knowledge questions (i.e., ISE-related questions), with success rates of 83.6% for the general knowledge questions and 67.5% for the domain-specific knowledge questions. The main effect of time availability was also

Table 4: Significant Effects for Performance Parameters

Parameter	Effect	F-Value	p-value
Accuracy	Knowledge type	$F_{1,22} = 30.60$	< .0001
	Time availability	$F_{1,22} = 7.46$	.0122
	Problem structure x Knowledge type	$F_{3,66} = 4.22$	.0086
	Problem structure x Time availability	$F_{3,66} = 21.76$	<.0001
Number of pages visited	Cognitive style	$F_{1,22} = 7.91$	.0101
	Knowledge type	$F_{1,22} = 6.56$	.0178
	Time availability	$F_{1,22} = 13.33$	0.0014
Search time	Cognitive style	$F_{1,22} = 6.78$	.0162
	Knowledge type	$F_{1,22} = 4.54$	.0445
	Time availability	$F_{1,22} = 40.84$	< .0001
	Problem structure x knowledge type	$F_{3,66} = 3.85$	.0137
	Problem structure x Time availability	$F_{3,66} = 3.39$	.0236
	Knowledge type x Time availability	$F_{1,22} = 7.09$	.0150

significant, $F(1, 22) = 7.46$, $p = 0.0122$, showing that participants were significantly more accurate under the self-paced condition (79.7%) than the timed condition (71.4%). No significant main effects for cognitive style and problem structure were found. There was a significant interaction effect between problem structure and knowledge type, $F(3, 66) = 4.22$, $p = 0.0086$ (Figure 1).

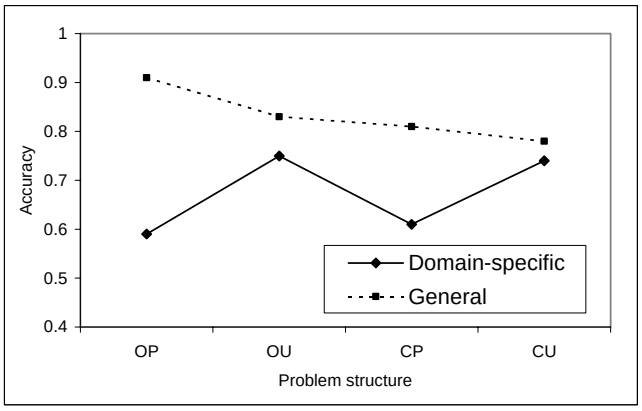

FIGURE 1 Interaction effect between problem structure and knowledge type for search accuracy. OP = open/predictable problem structures; OU = open/unpredictable problem structures; CP = closed/predictable problem structures; CU = closed/unpredictable problem structures.

Post hoc analyses were conducted to interpret the pattern of the means. The results indicated that the participants were more accurate for the general knowledge questions (91.7%) than for the domain-specific knowledge questions (59.4%) in the Open/Predictable problem structure conditions, $F(1, 94) = 22.42$, $p < .0001$. The participants were also more accurate for the general knowledge questions (81.3%) than for the domain-specific knowledge questions (61.5%) in the Closed/Predictable problem structure conditions. There was also a significant interaction effect between problem structure and time availability, $F(3, 66) = 21.76$, $p < 0.0001$ (Figure 2).

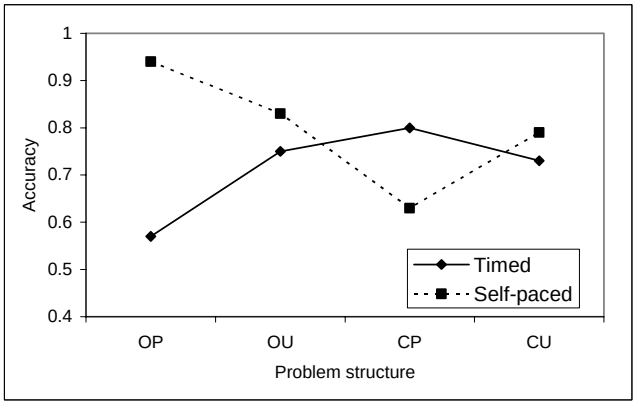

FIGURE 2 Interaction effect between problem structure and time availability for search accuracy. OP = open/predictable problem structures; OU = open/unpredictable problem structures; CP = closed/predictable problem structures; CU = closed/unpredictable problem structures.

Post hoc analyses indicated that when performing the Open/Predictable problem structure searches, the participants were more accurate under the self-paced condition (93.8%) than under the timed condition (57.3%), $F(1, 94) = 30.58$, $p < .0001$. However, the participants were more accurate for the Closed/Predictable problem structure searches under the timed condition (75.9%) than under the self-paced condition (64.3%), $F(1, 94) = 7.35$, $p = .0080$. No other significant interaction effects were found.

Number of pages visited: A significant main effect of cognitive style was found, $F(1, 22) = 7.91$, $p = 0.0101$. That is, the FD ($M = 7.1$ pages; $SD = 3.7$) visited more pages than did the FI ($M = 5.8$ pages; $SD = 2.4$). A significant main effect was also found on knowledge type, $F(1, 22) = 6.56$, p = .0178. In general, the participants visited significantly more pages for the ISE-related questions ($M = 6.9$ pages, $SD = 3.6$) than for the non-ISE questions ($M = 6.1$ pages, $SD = 2.6$). As expected, a significant main effect of time availability was found, $F(1, 22) = 13.33$, $p = .0014$. The participants visited more pages when they were not rushed for time ($M = 6.9$ pages, $SD = 3.8$) than when they were under time pressure ($M = 5.9$ pages, $SD = 2.1$). However, the problem structure condition did not show statistically significant differences in the number of pages participants visited. No interactions were significant at $p < 0.05$.

Search time: A four-way ANOVA was performed for search time, and the results demonstrated a significant main effect of cognitive style, $F(1, 22) = 6.78$, $p = .0162$; knowledge type, $F(1, 22) = 4.54$, $p = .0445$; and time availability, $F(1, 22) = 40.84$, $p < .0001$. Search time to locate a correct answer was significantly longer for the FD ($M = 73.8$ seconds, $SD = 46.3$) than for the FI ($M = 59.9$ seconds, $SD = 33.8$). The participants also spent more time in finding an answer for domain-specific knowledge questions ($M = 71.1$ seconds, $SD = 45.2$) than for general knowledge questions ($M = 62.5$ seconds, $SD = 36.1$). As expected, the length of time was significantly different between time pressure ($M = 55.1$ seconds, $SD = 24.9$) and no time pressure ($M = 77.1$ seconds, $SD = 49.1$).

Table 4 also shows significant interaction effects of problem structure and knowledge type, $F(3, 66) = 3.85$, $p = .0137$; problem structure and time availability, $F(3, 66) = 3.39$, $p = .0236$; and knowledge type and time availability, $F(1, 22) = 7.09$, $p = .015$. As seen in Figure 3, search time differences were particularly pronounced between general and domain specific knowledge for open predictable problem structures, with search times significantly faster for general knowledge searches compared to domain specific searches in the open predictable problem structure conditions, $F(1, 80) = 24.93$, $p < .0001$.

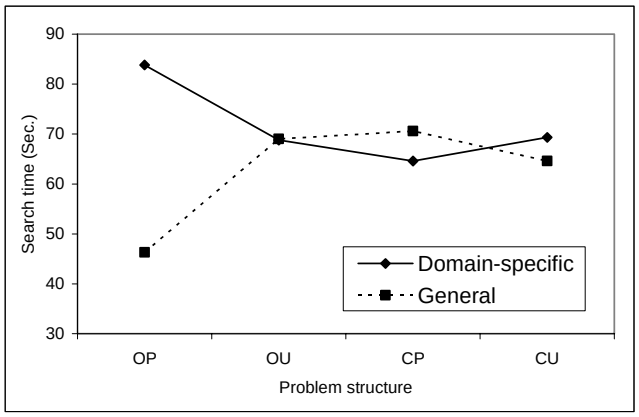

FIGURE 3 Interaction between the problem structure and knowledge type for the search time. OP = open/predictable problem structures; OU = open/unpredictable problem structures; CP = closed/predictable problem structures; CU = closed/unpredictable problem structures.

There were also interaction effects of problem structure by time availability on search time, as seen in Figure 4. In Open/Predictable questions, search times did not differ significantly on the basis of time pressure. However, the participants spent more time under no time pressure than under time pressure for Open/Unpredictable questions, $F(1, 94) = 20.94$, $p < .0001$; Closed/Predictable questions, $F(1,$

94) = 4.38, p = .0393; and Closed/Unpredictable questions, $F(1, 94) = 17.15$, $p < .0001$.

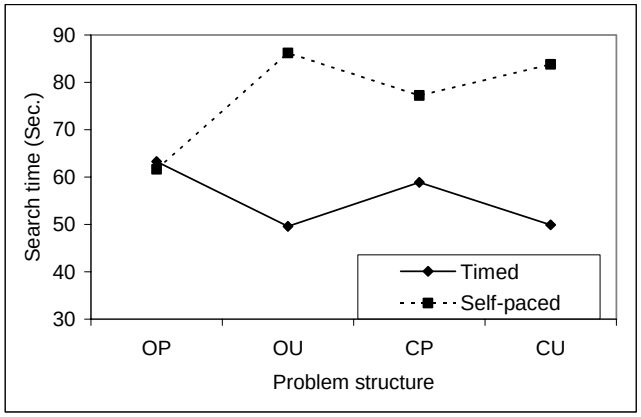

FIGURE 4 Interaction effect between knowledge type and time availability for the search time. OP = open/predictable problem structures; OU = open/unpredictable problem structures; CP = closed/predictable problem structures; CU = closed/unpredictable problem structures.

A significant interaction occurred between knowledge type and time availability. Figure 5 illustrates how the time availability and knowledge type variables interacted with each other, influencing search time. Under time pressure, there was no difference in search time between the domain-specific knowledge questions and general knowledge questions. However, in the self-paced condition, the participants spent a longer time searching answers to the domain-specific knowledge questions than to the general knowledge questions, $F(1, 178) = 6.52$, p = .0115.

Search Behavior Analyses

To investigate participants' search behavior in their Web-based information seeking, thesearch/navigation change was measured.

Search/navigation change: As seen in Table 4, a 2 x 2 x 2 x 4 ANOVA indicated a significant main effect of cognitive style, $F(1, 22) = 7.14$, p = 0.0139; knowledge type, $F(1, 22) = 9.78$, p = .0049; and time availability, $F(1, 22) = 16.15$, p = .0006.

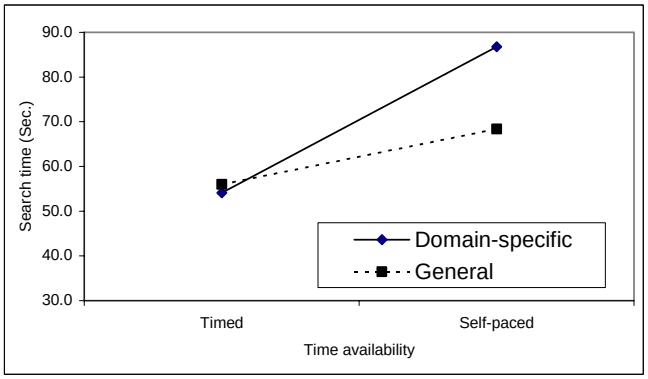

FIGURE 5 Interaction effect between knowledge type and time availability for search time. OP = open/predictable problem structures; OU = open/unpredictable problem structures; CP = closed/predictable problem structures; CU = closed/unpredictable problem structures.

In general, the FD (M = 6.6, SD = 4.2) changed the use of different search navigation tools more frequently than did the FI (M = 5.4, SD = 2.9). The participants tended to use different search navigation tools more frequently for ISE-related questions (M = 6.5, SD = 4.2) than for non-ISE questions (M = 5.5, SD = 3.0). Under timed conditions (M = 5.3, SD = 2.5), the participants tended to keep using the same navigation/search tools they used in the previous move, while they tended to use different navigation/search tools under the self-paced condition (M = 6.6, SD = 4.3). No other main and interaction effects were found.

Discussion

The present study began by suggesting that a deeper understanding of users' interactions with Web resources is needed to effectively support users' information seeking on the Web. To do this, individual's cognitive style and several task characteristics such as time availability, problem structure, and knowledge type, were investigated to see how they contribute to Web users' search performance and behavior.

Search Performance on the Web: Overall, results indicated both individuals' cognitive

style and task-related factors affected participants' Web search performance, measured by accuracy, number of pages visited, and search time. First, the FDs visited a higher number of pages and spent a longer time to find relevant information than the FIs, in particular, on domain-specific knowledge questions (i.e., ISE-related questions). This result is consistent with previous findings that in the task of successfully locating relevant information, FI individuals performed significantly better than FD individuals[20];[23].

The participants also showed better performance in finding correct answers to the general knowledge questions rather than to the ISE-related questions. It is possible that answers to domain-specific questions were more difficult because there is less domain-specific information available on the Web[3]. More searches by students may center ongeneral knowledge, while library databases are more oftern used for domain-specific knowledge. To find information on domain-specific knowledge, therefore, participants might have to naviage more pages while spending alonger time than they did for general questions.

The effect of time pressure on participants' web search performance was also demonstrated in this study. That is, when participants were under time pressure, they found fewer correct answers than when they could search at their own pace. Under time pressure, participants tended to navigate a smaller number of pages, while staying a shorter time in one page. This result is consistent with Moore & Lehman's study[26] that showed that people who are rushed for time tended to put forth less effort for searching than those who are not under time pressure.

This study found no main effect of problem structure on search performance, but there were interaction effects of problem structure by knowledge type and problem structure by time availability on search accuracy and search time. As seen in Figure 3, search times for domain-specific knowledge questions and general knowledge questions were different in open/closed questions, in which participants spent a longer time for domain-specific questions than for general questions. However, search time difference did not show in other dimensions. In open/predictable and closed/predictable questions, search times did not differ on the basis of time pressure. When participants found information for unpredictable questions regardless of open/closed nature of questions, however, they spent more time under no time pressure than under time pressure.

Search Behaviors on the Web: The results showed different user-Web interaction styles between the FD and FI in different task environments. First, the FDs used different navigation/search tools more frequently than the FIs. This finding is consistent with a number of studies showing that FD and FI individuals interact with hypermedia systems differently [23];[24]. The FD individuals might have to change their navigation/search strategies more frequently than their counterpart FIs because they are more easily distracted in hypermedia systems.

Participants also tended to use different search navigation tools more frequently for ISE-related questions (M = 6.6, SD = 4.2) than for non-ISE questions (M = 5.4, SD = 2.9). Note that a smaller value indicates the participants tended to keep using the same search/navigational tools that they used in the previous move. The participants might have had to use different search navigation tools more frequently as there is less domain-specific information available on the Web[3].

Under time pressure, participants tended to keep using the same navigation/search tools they used in the previous move. This result is consistent with what could have been predicted with performance models applied to other types of information searches (i.e., on displays, in text, system instructions). For example, when under time pressure while problem solving, individuals are more likely to display behaviors of perseveration, or repeating the same

unsuccessful behaviors (Reason, 1990). Repeated use of the same search strategy despite previous failures shows that perseveration also occurs in this operational context.

Conclusions

In conclusion, results of this study indicated that both task-related factors and different cognitive styles affected Web users' search performance and behavior. To effectively support users' interactions with Web resources in terms of training programs, classroom exercises, and usable Website designs, these factors should be considered.

The implications for training systems design are as follows:

1. Training designed to improve Web search performance must be focused on the nature of the information for which the user is searching in terms of its availability, distribution, and quality in certain fields.

2. Web searchers' behavioral patterns should be considered in the design of training programs. They tend to change their existing search strategy as they explore each page, and this behavioral pattern is mainly affected by cognitive styles and different task environments.

3. Time availability during Web search session is another factor to consider in training programs. Since time pressure consistently undermined search performance, it is important to determine ways to avoid time pressure when users are Web searching. This could include setting aside ample, uninterrupted time to allow searches. In addition, Libraries could allow times of day in which searchers could use as much time as needed to search for information (rather than deal with regulated 30 minute limits). Libraries could also provide waiting areas so that those waiting to use a computer are not in the visual path of the computer users. This would minimize a "sense" of time pressure. Gentle warnings (on-screen pop-ups for example) could be used to alert users to approaching time limits.

These results have a number of important implications for teachers who use computers and the Internet as tools for student research assignments and problem solving. The sample used in this study consisted of university students who used computers every day, and therefore, were familiar with searching the Web. When considering novices or young learners, teachers should recognize the potential impacts of cognitive style. In the context of this study, Field Dependent students tended to use several different navigation search tools compared to Field Independent students. Whether this search behavior leads to better or worse search performance could not be fully determined, but teachers should at least consider the role of cognitive style in successful outcomes from search behaviors. To enhance student's search self-efficacy, it is important to determine the extent of success that each student experiences because of a tendency to use a variety of search strategies or tendencies to use very few search strategies. Students can then be counseled to expand or limit their search strategies based upon the type of problem.

The influence of time pressure must also be noted. Classroom use of computers and the Internet is constrained by the daily schedule, providing small amounts of time for students to search for information. Given the real-world time constraints, teachers must be aware of the potential for time limitations to undermine search performance. To counteract the potential deleterious effects of time limits, teachers should spend more time designing problems requiring Internet searches that can be quickly represented and framed by students[14]. Problems that are open, ambiguous, or ill-structured may not be the most beneficial to student learning, if they must be solved within

the time-limited environments of the library, computer lab, or classroom.

Decrements due to time pressure are also important from a digital divide perspective. Students who use computers and the Internet from home, usually have the benefit of unlimited time to search for information. However, through its yearly survey of computer and Internet usage nationwide, the Department of Commerce[9] statistics indicate that, although increasing, home ownership of computers and Internet connections by ethnic minorities still lags behind that of majority group members, with only 23% percent of African-American and Latino citizens having computers in their homes. It is well known that public use computer labs constrain the amount of time users can spend at a given computer workstation. Consequently, students are consistently completing research assignments and problem solving activities given as homework in a time-limited context, which can undermine work quality and further increase disparities in educational achievement.

The results of this research also have implications for the design aspects of Websites. Web designers need to design Web pages with multiple users in mind, rather than focusing on one specific type of Web searcher. For example, individuals displaying global search behavior (field dependent) react differently from those with analytic search behavior (field independent). Both field dependent and independent searchers may be distracted by complicated search demands and information dense pages, but the nature of the distractions may differ. Field dependent individuals may use a global and generalized cognitive map to search for information. But when pages are viewed, field dependent users may have difficulty confirming the presence of a target and, in turn, difficulty confirming the accuracy of the global or generalized map. Without confirmation of the accuracy of a strategy, users will get lost in the search. Field independent users may maintain a specific cognitive map during the search, but may be overwhelmed by the amount of details embedded within a web site and may not be able to integrate the bits and pieces into a total awareness of their search activities.

In summary, this study was designed to extract more detailed knowledge of individual differences and external factors on web search behavior. Further studies are needed to confirm the effects of cognitive styles and task-related factors on Web users' diverse behaviors and performance.

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