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IDENTIFYING THE IMPACT OF DOMAIN KNOWLEDGE AND COGNITIVE STYLE ON WEB-BASED INFORMATION SEARCH BEHAVIOR

YOUNG PARK

JOHN B. BLACK

Columbia University

ABSTRACT

Although information searching in hypermedia environments has become a new important problem solving capability, there is not much known about what types of individual characteristics constitute a successful information search behavior. This study mainly investigated which of the 2 factors, 1) natural characteristics (cognitive style), and 2) acquired knowledge (domain knowledge) had a stronger influence on search behavior, and what types of impact these had on search activities. To examine search behavior, the search outcome precision, the searching time, the number of URL nodes, and the number of keywords were analyzed and the demographic backgrounds including the searching experience and gender were also measured to discover any correlation with the major variables. The study findings suggest that domain knowledge was not associated with any other search activities but affected only the search precision. Cognitive style meanwhile did not affect search precision but interacted with the searching experience and this interaction affected the total length of searching time. Finally, there was no correlation found between 2 variables: domain knowledge and cognitive style.

INTRODUCTION

The Internet has experienced a strong social penetration. The university campus is located at the forefront of social change, progressively using the Internet for communication, recreation and file sharing, and the first to hook up with regular broadband Internet access. Internet use first became widespread on college campuses in the 1990s, and in many ways the Internet is a direct outcome of university-based research. In a broad sense, studying college students' Internet habits can yield insights into means of future online learning and teaching, and studying specifically their information search behavior can add new knowledge into the entire picture.

Today's college students were born at the time when the personal computer was introduced to the public. According to Pew Internet and American Life survey results (2002), three-quarters (74%) of college students used the Internet 4 or more hours per week; about one-fifth (19%) used it 12 or more hours per week while only 14% spent more than 12 hours for studying. More specifically related to this study, nearly three-quarters (73%) of college students said that they used the Internet more than the library, while only 9% said that they used the library more than the Internet for information searching.

To do homework, in the old times, students had to go to a library to search for references but nowadays they take a seat in front of a computer and start to surf the Internet instead. That is, Information Communication Technology (ICT) allows learners to access much more information than ever before and the learners' information search offers more than simply a piece of the information. A learner's information search behavior could be also seen as one's indicator of learning achievement or a specific content understanding (Grace-Martin & Gay, 2001; Roy & Chi, 2003).

As information searching is central, it may be infertile to capitalize on its values without full understanding of how individual variance actually influences searching. Content-based Web searches typically return a virtual mountain of information, resulting in the "information overload" problem (Lielson, 1995). How to find the material most relevant to an individual's need without being overwhelmed by irrelevant information requires search expertise.

Accordingly, it is critical to know what constitutes a successful information search capability, and how it is eventually correlated with sustaining the learning process. To understand what constitutes information search capability, this study concentrated on the impact of individual differences in relation to 2 factors—1) natural characteristics (cognitive style) and 2) acquired knowledge (domain knowledge)—both of which would most likely have a strong influence on search behavior and, if they did, in what ways would they be correlated to each other. The aim of this research was thus to characterize Information Search Behavior (ISB)[1] and ultimately to identify ISB's roles for learning achievement.

FRAMEWORKS OF THE RESEARCH

A number of researchers have theorized that information search capability in hypermedia environments maximizes potential benefits to learning (Ford & Chen,

[1] It is the purposive seking for information. It consists of all the interactions with the system like human computer interaction (for example, use of the mouse and click-on links) or at the intellectual level's interaction, which also invovles mental acts, such as judging the relevance of data or information retrieved.

2000; Jonassen, 1992; Liu & Reed, 1994). Several empirical studies have included measures of cognitive styles and have examined their relationship to student information search outcomes in hypermedia environments (Kim, 2002; Leader & Klein, 1996; Palmquist & Kim, 2000; Rodriguez, 2001). Riding and Douglas investigated the effect of text-plus-text vs. text-plus-picture computer presentation conditions, and students' cognitive styles on learning performance. They found that verbal-imagery cognitive style and presentation con- dition interacted in their effect on overall learning performance. Kim's study proposed that field-independence and logical reasoning ability gave rise to the primary process predicting search outcome. The results of Kim's study also emphasized the importance of considering cognitive variables as important predictors to information search process and outcome; additionally, measures of the search process appeared to play a mediating role between cognitive variables and search outcome. Palmquist and Kim's study indicated that cognitive style (field dependence vs. field independence) and search experience interacted in their effect on the search performance. Rodriguez's study meanwhile found no significant difference between a person's cognitive style by using the intuition and sensing dimensions of the Keirsey Temperament Sorter and different mode of Web-based instructional design. To date, the impact of cognitive style on search outcome or learning performance appeared to vary relying on the different conditions.

The key to the effective use of information systems should be the ability to orchestrate cognitive processes, and this ability is closely related to cognitive style. Cognitive styles play an important role especially in the development of hypermedia-based learning because they refer to learners' information processing habits, representing individual learners' typical modes of perceiving, thinking, remembering, and problem solving (Messick, 1976). Also, as previous research indicates that students with different cognitive styles show different learning preferences and require different navigational support in hypermedia systems (e.g., Chen & Macredie, 2002; Ford & Chen, 2000; Palmquist & Kim, 2000). One can thus conjecture that learning performance can ultimately benefit from full understanding of cognitive style in information search behavior.

Among the total of 16 studies[2] for investigating cognitive style's relation to search behavior in hypermedia environments, fifteen studies chose the particular dimension of cognitive style, field dependence/independence while the other one chose verbal-imagery/holistic-analytic.

According to Miller's (1987) suggestion, most cognitive styles are "subordinate to, and reflect, a broad super-ordinate stylistic difference" (p, 253), which represents a long established distinction between contrasting modes of thought: analysis vs. intuition. This specific dimension of cognitive style, however, has hardly been paid attention in a field.

[2] The studies were selected following criteria: 1) appeared in one of databases, Eric, Psycinfo, and Proquest; 2) published since 1990; and 3) had keywords of cognitive style, information search behavior, and hypermedia.

According to Carland (1982) and Allinson and Hayes (1997), intuitive approaches to information processing tend to rely on holistic impressions, random methods of exploring, and impulsive synthesis while Ornstein (1977) also refers that analytic approaches involve viewing in sequence the individual parts, favor a structured approach to problem solving, and depend on systematic methods of investigation. This study hypothesized that there should be more than one cognitive style affecting information search and that this cognitive style, analysis vs. intuition, should influence information search activities. So far, many of research studies in this focus have been interested in field dependence/independence but hardly in analysis vs. intuition.

In the meantime, domain knowledge has been known as one of the major factors affecting information search behavior in hypermedia environments. A domain is a body of information, which includes entities and relationships. The user's previous knowledge about the domain is known to have an impact on the outcome of the information-seeking characteristics as well as on the strategies being used during the process (Borgman, 1989; Marchionini, Dwiggins, Katz, & Lin, 1993). Domain knowledge is a powerful factor in selecting a search system and focusing a search, as is information-seeking expertise with a variety of systems (Marchionini et al., 1993). However, the authors' concern was that it has been still insufficient to examine the multi-dimensioned relationships of domain knowledge with other factors, as Zhang and Chignell (2001) argued as well. That is, the authors' hypothesis was that impact of domain knowledge may be entwined with other factors in affecting search behavior and its interrelationships with other search behaviors have not been explored fully.

RESEARCH QUESTIONS

Therefore, the study focused on the impacts of two major individual characteristics relating to searching the Web, that is, domain knowledge (major) as a representative of obtained knowledge through training and secondly, cognitive style as a representative of natural characteristics.

1. In which ways, if any, does domain knowledge influence Web searching behaviors (activities) and search task score?
2. In which ways, if any, do cognitive style differences influence Web searching behaviors and search task score?
3. How do the two sets of variables (cognitive style difference and domain knowledge) interact with each other to determine Web searching behaviors (activities) and task score? In which ways, if any, do they interact with other learner background factors such as search experience?

METHODS

Participants

A total of 61 first year graduate students participated in the study. Thirty-one participants were recruited from the field of psychology while the other 30 participants were recruited from the field of biology to assess the main effect of domain knowledge. The psychology major participants were grouped as the psychology group while the biology major participants were grouped as the biology group. The subjects consisted of 19 male students and 42 females recruited from several private colleges in New York, New Jersey, and Massachusetts. In terms of ethnicity, 61 students included 19 Asians, 1 African American, and 41 Caucasians. Their economic background was not a key criteria for recruiting but instead collected the years of computer and Web surfing experience that background information was sufficient for this study.

Design

Using largely the quantitative research design, the main independent variables were cognitive style and domain knowledge while the dependent variables were the search task score that indicated search outcome, the total length of searching time, the number of Web-nodes visited, and the number of keywords typed. The years of Web surfing experience, weekly Web surfing hours, gender, and the level of interest toward a participant's own major, and the level of interest toward Web surfing were chosen as the demographic variables (see Table 1).

Treatments

To conduct the study, a participant was asked to search for answers using six open-ended questions: three psychology-based questions and three biology-based ones. The questions were "known-item" type questions. The operational definition of "known-item" search is requiring the searcher to find a piece of information that is known to exist and to give a specific answer to the question given. The question topics were drawn from a pool of GRE Subject Test questions which were the characteristics of all DNA viruses, the characteristic of an adolescent's primary developmental tasks, anaphases of mitosis, a characteristic of a theory that Mischel suggested, a type of a natural selection theory, and bystander effect. Selecting the topics from GRE tests endeavored the treatment to increase a possible degree of content validity. The question format was then re-designed to fit the study.

Domain

Note that for the treatments, two disciplines, psychology and biology, were selected. The chief reason for choosing these two majors was concerned with the

Table 1. Description of Variables Used in the Study

Individual difference	Cognitive Style	The CSI score indicating if one is analytical or intuitive split up by the mean point 41
	Domain (=Major)	Psychology vs. Biology
	Web Searching Experience (Years and hours per week)	Hours: The average hour that a participant spends on Web surfing per week Years: The total number of years that a participant has experience with Web surfing.
	Gender	Female vs. Male
Search behavior	Search Outcome	The search task score that is the level of task answers' outcome accuracy. On a scale of 1 to 7, each question was graded. Since the task consisted of six questions, the perfect score would be 42
	The Number of Web links visited	The number of nodes (URL links) clicked for the completion of search questions
	The number of Keywords typed	The number of keywords used for the search of the task
	Searching Time to finish the task	The length of time spent on retrieving information and answering the search questions

research operational point of view. As they were prevalent disciplines in any colleges, recruiting participants was expected to be easier.

And the second reason was based on the different nature of the disciplines. As Borgman et al. (1995) proposed engineering or science-oriented disciplines outperformed social sciences and humanities in search performance, people from different disciplines showed to have differing styles of information seeking in terms of task score and time and set different priorities on the use of specific information sources. The study results were accordingly anticipated to show different searching characteristics between social science majors and natural science majors.

Cognitive Style Index (CSI)

This paper-pencil test was developed by Allinson and Hayes (1996). It aims to measure how much one is analytical or intuitive. It consists of a total of 38 trichotomously scored items (true; uncertain; false) and its theoretical maximum score is 76 and the theoretical minimum is 0. The higher the score, the more analytical a person's style; the lower the score the more intuitive the person is. Test-retest reliability has ranges from .78 to .90 (Allinson & Hayes) Construct validity has previously been demonstrated through maximum likelihood factor analysis and correlational studies (for more, see Allinson & Hayes).

On the basis of 32 former research studies having employed the CSI test over the last 8 years since 1996, the mean of 41 was used to categorize if one is intuitive or analytical. The CSI test does not provide any point to determine if one is an absolute analytics or intuitivist but simply helps us understand a participant's relative tendency. The study however chose the dimensionality to be rather bipolar, using a meta-analysis of other studies, in order to stress their impacts on search activities and outcome.

Procedure

On average, the experiment was conducted in a single session on an individual basis. Each session lasted on average of an hour and 20 minutes. At the beginning of the session, each participant was given a psychological test, the CSI, for 15 minutes to identify participants' cognitive styles. And then a brief demographic questionnaire followed. To ensure participants' confidentiality, they were asked at the beginning to draw a number from a box and to put the number on each page. These numbers were later used as a discreet coding system.

During the experiment, the participants were not limited to any Web search engines but were restricted to use only Netscape Navigator version 6 or higher for a Web browser for greater control. Also their Web searching activities were monitored using commercial Web monitoring software. It recorded all the URLs of the Web pages visited and the duration of each visit as seen in Figure 1. Finally, the brief interview followed for about 10 minutes even though the study could not conduct an interview with all participants but only 64% due to unwillingness or personal time constraints. The nature of the interview was self-evaluating and descriptive utilized in an attempt to confirm the studies' findings. The interview not only served to screen what answers the participants knew already but also elicit what factors affected generating a keyword, one of the very important search activities. The interview could reveal a participant's decision-making process on bringing up a new keyword to search targeted information. All comments by participants were also recorded, using a tape recorder, and then transcribed.

Task Scoring and Search Questions

The search task score indicated the level of task answers' outcome accuracy. On a scale of 1 to 7, each question was graded. Since the task consisted of 6 questions, the perfect score would be 42. To make the study results more valid, the answer sheets were reviewed by two people: the researcher and the other reviewer who

Site
http://www.advocatesforyouth.org/publications/pccbasics/form_transparency/developmental.htm
http://tm.wc.ask.com/development/teens_stages.shtml
http://www.childdevelopmentinfo.com/development/teens_stages.shtml
http://web.ask.com/links?q=developmental+tasks+and+adolescents&u=http%3a%2f%2ftm.wc.ask.com%2fr%3ft%3
http://www.childdevelopmentinfo.com/development/piaget.shtml
http://web.ask.com/top?q=developmental+tasks+and+adolescents&s=a&optout=&cleanImg=
http://www.childdevelopmentinfo.com/development/erickson.shtml
http://search.atomz.com/search/?sp-q=developmental+tasks&search.x=0&search.y=0&sp-a=000604b7-sp00000001
http://www.childdevelopmentinfo.com/development/erickson.shtml
http://www.childdevelopmentinfo.com/development/teens_stages.shtml
http://tm.wc.ask.com/wgbh/evolution
http://www.pbs.org/wgbh/evolution
http://www.pbs.org/wgbh/evolution/darwin/index.html
http://www.pbs.org/wgbh/evolution/darwin/origin/index.html
http://www.pbs.org/wgbh/evolution/educators/index.html
http://www.pbs.org/wgbh/evolution/educators/lessons/index.html
http://web.ask.com/top?q=natural+selection+theory&s=a&optout=&cleanImg=
http://tm.wc.ask.com/faqs/origin.html
http://www.talkorigins.org/faqs/origin.html

Figure 1. Example of a data log frame.

was a biologist. Since the researcher herself was not an expert in biology, the biologist's advice on grading the answers was critical. As the questions were open-ended, before beginning to grade them, the appropriate words/concepts that needed to be included in an answer sheet were discussed between the two reviewers. Any discrepancy made during the grading was discussed until the two reviewers reached an agreement.

RESULTS

Preliminary Analysis

In investigating any key impacts of domain and cognitive style on search behaviors and their relationships with demographic backgrounds, in summary, first, as seen in Table 2, any variation grounded by the domain was examined. The biology group's CSI score (47.4) was higher than the psychology group's CSI (41.8), which meant that biology group participants tended to be more analytical and that the psychology group's CSI average (41.8) was rather neutral close to CSI norm (41.0). The two major groups hardly had any difference on the total length of search time (48.0 minutes for bio group vs. 47.3 minutes for psychology group) and the total number of nodes clicked (72.5 for bio group vs. 73.7 for psychology group) but the biology group participants used a higher number of keywords (18.2)

Table 2. Descriptive Statistics for Two Domain Groups

		Psychology group (n = 30)	Biology group (n = 30)	Psychology group vs. Biology group p-value
Task score	*M*	26.3823	30.5843	.002
	SD	4.632	5.623	
Cognitive style	*M*	41.7667	47.3667	0.72
	SD	10.743	12.837	
Length of search time	*M*	47.3367	47.9935	.882
	SD	18.846	15.368	
Number of nodes	*M*	73.6667	72.5000	.911
	SD	40.186	40.059	
Number of keywords	*M*	13.4667	18.1613	.075
	SD	10.689	9.539	
Weekly Web surfing hours	*M*	11.3500	7.0645	.021
	SD	7.904	6.086	
Years of Web surfing exp.	*M*	7.5172	6.3067	.025
	SD	1.478	2.437	

than the psychology group participants did (13.5). The biology group spent considerably less time surfing the Web per week (7.1 hours) than the psychology group did (11.4 hours) and two major groups' Web surfing experience was 6.3 years and 7.5 hours for the biology group and the psychology group, respectively.

All variations were then re-measured based on CSI's perspective: Analysts vs. Intuitivist. Overall, Analysts spent more time to finish the task (49.7 minutes for Analysts vs. 45.5 minutes for Intuitivists), clicked more hyper-nodes (79.4 nodes for Analysts vs. 65.7 nodes for Intuitivists), and used a higher number of keywords (17.9 times for Analysts vs. 13.3 times for Intuitivists). However, Analysts spent less time online per week (8.6 hours) than Intuitivists did although Analysts' Web surfing experience (7.2 years) was a bit higher than Intuitivists' Web surfing years (6.5 years).

As Table 2 shows, first, domain was a predictor of the task score ($p = .002$). Domain was also related to participants Web searching experience: the weekly Web surfing hours and the years of Web experience ($p = .021$, $p = .025$). And cognitive style appeared to predict the number of keywords ($p = .052$) even if it was not statistically significant. The more concentrated analysis of data upon research questions is described in Table 3.

Table 3. Descriptive Statistics for Two Cognitive Style Groups

		Analytic (n = 38)	Intuitivist (n = 22)	Analytic vs. Intuitivist p-value
Search Score	*M*	28.1422	29.4101	.558
	SD	5.889	5.030	
Length of search time	*M*	49.7438	45.5036	.421
	SD	19.416	14.148	
Number of nodes	*M*	79.3538	65.7153	.416
	SD	47.935	28.269	
Number of keywords	*M*	17.9063	13.3214	.052
	SD	10.023	10.406	
Weekly Web surfing hours	*M*	8.5469	10.0357	.497
	SD	6.787	7.991	
Years of Web surfing exp.	*M*	7.1774	6.4704	.038
	SD	2.043	2.083	

Major Findings

Impacts of Domain Knowledge on Search Activities

According to interview results, each major group's participants found the non-major search questions relatively more uncomfortable to seek the right answer, which seemed to be rational (refer to quotes below).

A biology major participant said, "Biology questions were looking for general facts and figures. But, psychology questions were looking for inferences or theories, so psychology questions were more difficult."

On the other hand, "For biology questions, I don't know what the words mean. So hard to find what would be good keywords, also difficult to verify which ones would be the right answers," said a psychology major participant.

Therefore, interview results would suggest that the mean score of two major groups would be identical.

A domain however showed a strong impact on task score. As can be seen in Table 4, the biology group attained the higher task score across all search questions than the psychology group ($F(1, 58) = 11.716$, $p = .0011$).

To understand it, each major group was examined independently using a within-subject experimental design method. Within each domain group, the difference between the two major sets of search questions was assessed using *t*-test (paired). None of the factors were affected by the domain of search questions except for the number of nodes. Both groups, the psychology group and the biology group clicked a significantly larger number of URL nodes for the biology questions than the psychology questions. The psychology group clicked about 26.9 hyper-nodes for psychology questions and about 46.8 hyper-nodes for biology questions ($t = -4.144$, $p = .0003$) while the biology group clicked about 29.9 hyper-nodes for psychology questions and about 45.1 hyper-nodes for biology questions ($t = -2.950$, $p = .0064$).

That is, the biology questions required a larger number of Web-site visits to browse and complete the given questions.

Second, as expected, the level of domain knowledge that a participant possessed had a significant impact on the search task score. The psychology group appeared to attain a marginally higher task score on psychology questions, even if not significant statistically ($F(1, 58) = 3.553$, $p = .0644$) while the biology group attained a significantly higher task score than the psychology group on biology questions ($F(1, 58) = 33.634$, $p < .0001$). See Table 5.

Moreover, matching the domain of search questions with the major of participants appeared to increase a task score. The result suggested that participants' prior knowledge of their own major had a strong impact on searching for the target information of their domain.

Table 4. Total Task Score Affected by Domain Groups

Total task score	Psychology group ($n = 30$)	Biology group ($n = 30$)	Psychology group vs. Biology group *p*-value
M	25.733	30.767	< .0011
SD	5.765	5.624	

Table 5. Each Domain Task Score Affected by Domain Groups

Each domain task score		Psychology group ($n = 30$)	Biology group ($n = 30$)	Psychology group vs. Biology group *p*-value
Psychology	*M*	14.867	13.400	.0644
	SD	3.170	2.848	
Biology	*M*	10.833	15.767	< .0001
	SD	3.323	3.266	

Next, interestingly, the score of psychology questions was predicted by a joint significance of domain and the weekly Web surfing hours (F (3, 59) = 3.038, p = .0364). This indicates that the psychology major participants who were more frequent Web surfers completed the answers better on their major (psychology) questions. (See Table 6 and Figure 2).

However, this was not a strong indicator for the biology questions in that the weekly Web surfing hours did not influence a biology group's biology task score (F(3, 59) = 1.232, p = .2810); major was the main contributor affecting biology questions' score (F(3, 59) = 23.267, p < .0001).

Namely, the score of the psychology questions was strongly influenced not only by the participants' domain but also by their weekly Web searching hours in that the weekly Web searching hours acted as a moderating variable. But the participants' domain was a single factor affecting the score of the biology questions.

Note that the weekly Web surfing hours was in fact only factor showing variance between two major groups. The difference was so significant (F(1, 59) = 5.735, p = .0199) that the psychology group spent hours on the Web approximately 62.9% higher than the biology group did (on average, 11.4 hours for the psychology group and 7.0 hours for the bio group). Given this result, one can assume once the hours of Web surfing experience reach a certain level, it may help a participant's search for the target information in her or his domain. However, less than a certain amount of Web surfing experience (shorter surfing hours) or a participant's search in an unfamiliar domain (a participant's non-major search questions) may not appear to affect his or her search outcome. The minimum amount of Web surfing experience to make such a variation visible however has not been identified by this study but should be further addressed.

It is quite consistent with previous findings in that search experience has a correlation with search outcome (Fenichel, 1980; Marchionini et al., 1993). Fenichel and Marchionini et al. concluded that more experienced Web surfers would be more familiar with necessary search strategies and would have already

Table 6. Factors Predicting Each Domain Search Question's Score

	Psychology questions' score		Biology questions' score	
Factors	*SD* coefficient	*p*-value	*SD* coefficient	*p*-value
Domain (Major)	–.210	.2615	–.727	< .0001
Weekly Web surfing hours	–.059	.7552	–.100	.5230
Major weekly Web surfing hours	.534	.0303	.222	.2810

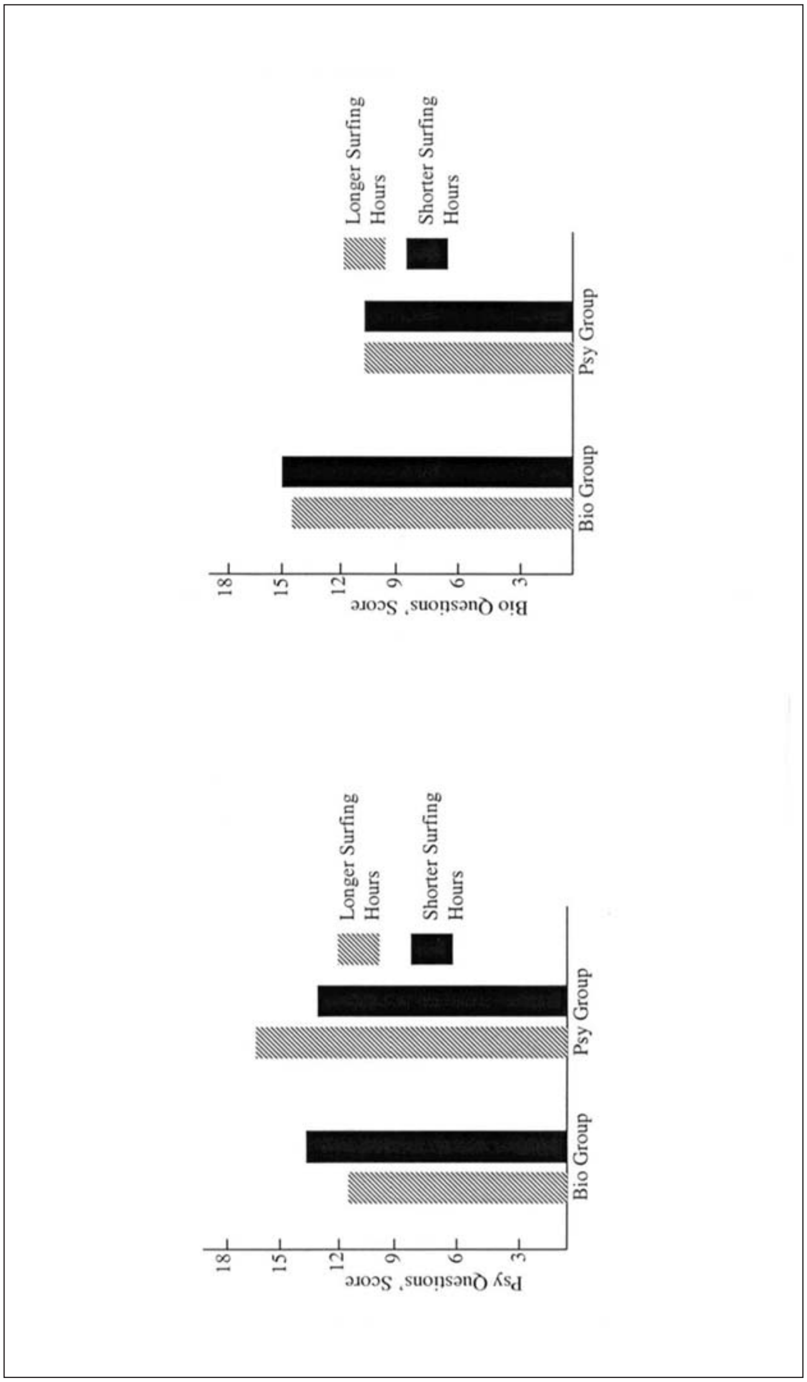

Figure 2. Different interactions of domain and Web surfing hours in two domain search questions scores.

developed a certain schema of how to search for information. Their points look to bolster the finding of this study.

Impacts of Cognitive Style on Search Activities

Cognitive style did not affect the overall task score ($F(1, 58) = .521$, $p = .4735$), the searching time ($p = .422$), and the number of nodes ($p = .416$). It yet appeared to affect the number of keyword ($F(1, 58) = 3.946$, $p = .052$).

Particularly, regardless of each participant's domain, Analytics used a significantly larger number of keywords to search for the given search task than Intuitivists did (17.9 trial number of keywords for Analytics vs. 13.3 trial number of keywords for Intuitivists; Analytics used 29% higher number of keywords on the basis of the mean 15.9). Analytical participants seemed to continue to put different keywords and review hits' short descriptions returned by a search engine before clicking any links and visiting their Web sites until they believed that they found the most accurate keywords pointing out the target answers. Meanwhile Intuitive participants tried to put relatively fewer keywords than Analytical participants. Moreover while no other demographic factors had a considerable interaction with cognitive style, the weekly Web surfing hours appeared to interact with cognitive style producing an interesting affect to the search time ($F(3, 59) = 3.294$, $p = .075$).

To be exact, Analytics spent more time completing the search task when they were generally less frequent Web surfers while Intuitivists with the same condition spent less time to finish the search task. In other words, for more-frequent Web surfers, their search time was less influenced by their cognitive style: whether they were Intuitivists or Analytics (45.6 minutes for Analyst vs. 46.9 minutes for Intuitivist) and the opposite was the case that for less frequent Web surfers, their search time was more influenced by their cognitive style (52.8 minutes for Analyst vs. 44.3 minutes for Intuitivist). As seen in Table 7, the mean difference of search time between two cognitive style holders was 8.5 minutes (17.8%) and 1.3 minutes (2.8%) for less-frequent Web surfers and more frequent Web surfers respectively.

In fact, adding another factor, the years of Web surfing experience to the same relationship increased the statistical significance of the model ($F(4, 57) = 2.924$,

Table 7. Impacts of Cognitive Style and the Weekly Web Surfing Hours on Searching Time

Searching time	Analyst & longer surfing hours (n = 14)	Analyst & shorter surfing hours (n = 17)	Intuitivist & longer surfing hours (n = 13)	Intuitivist & shorter surfing hours (n = 15)
M	45.644	52.753	46.922	44.273
SD	20.679	18.873	11.061	6.664

p = .0296). As the weekly Web surfing hours and the years of Web surfing experience basically indicated the same factor, *Web surfing experience*, one can say that *Web surfing experience* interacted with cognitive style and their interaction was an indicator anticipating the search time ($F(4, 57) = 10.229$, $p = .0027$).

Another finding adds an interest to the above results that the task score is related to search time ($F(1, 59) = 5.233$, $p = .026$), pointing out that the longer search time is, the lower the task score is. For those who took a longer time to finish the given task were thus expected to show a lower search score. It was assumed that those who were not sure of verifying the correct answers actually spent more time to search for the answers.

Hence, analytical participants doing heavy Web surfing took less time to finish the task and were anticipated to show a higher task score. On the conflict, intuitive participants doing heavy Web surfing took more time to finish the task and were expected to have a lower task score.

Finally, measuring the impact of the interaction between cognitive style and domain knowledge on the search behaviors, conflicted with a hypothesis, this interaction did not influence the search task score ($F(3, 59) = .005$, $p = .944$). It did not also predict any search activities: the length of searching time ($F(3, 58) = .411$, $p = .524$), the number of nodes ($F(3, 57) = .247$, $p = .621$), or the number of keywords ($F(3, 58) = .010$, $p = .921$).

Descriptive Analysis of Interview Data

As mentioned earlier, the interview had not only a monitoring purpose but also asked an important question on techniques to extract the right keywords in seeking the targeted information.

The qualitative data analysis process, although the total amount of data was not much, was guided by a codifying procedure that Strauss and Corbin suggested (1990). In accordance with the procedures, a code was developed and open coding methods such as microanalysis were applied. Specifically, this technique required: 1) reviewing the transcripts a few times; 2) creating a set of codes that clearly reflect the major ideas; 3) applying those codes systematically to a set of texts; 4) creating a unit-of-analysis-by-variable matrix from the texts and codes; and 5) analyzing that matrix statistically. The last two procedures, 4) and 5), were hardly utilized in that the amount of narrative data was relatively small. The essence of this analysis of qualitative data was to discover a single factor, either a need or a property that causes a specific search characteristic, *generating a keyword*. This step in the analysis was to see whether similarities and/or differences could be detected in the responses of all respondents.

Overall, the familiarity with the domain knowledge affected their choice of an appropriate keyword (32 participants out of the total of 50) because they sensed their non-major/discipline having more complicated characteristics, which had them find more difficult to select appropriate keywords and to search for answers.

Their sense of familiarity to a specific domain however did not appear to have a direct relationship with the keyword-pick-up-techniques that they used in this study.

As Figure 3 shows, a total of 4 techniques in generating a keyword were discovered; looking for an overarching concept (32), combining several specific concepts (21), referring to hits' description summary (7), and adding new keywords based on prior knowledge (6). The first two codes were largely used either for their major or non-major questions while the third code was used mainly when participants encountered non-major and/or unfamiliar search questions and the last code was mainly used when participants faced their major questions but were not successful to find the right answers in a few attempts. No participants used the last technique for their non-major search questions. Not surprisingly, participants were not persistent using only a single technique but used different techniques for keywords depending on the types of search questions.

DISCUSSION

Overall, the biology group's task score was higher than the score of psychology group in spite of the psychology group's overall greater Web surfing experience.

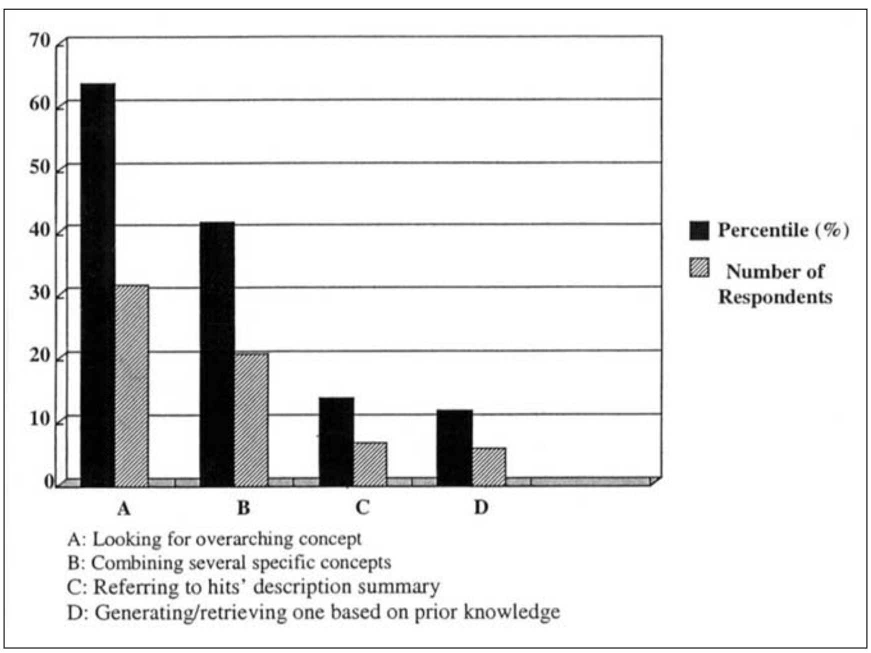

Figure 3. Graph showing the number of techniques used for generating keywords.

Moreover, no matter which major group a participant belonged to, they visited a larger number of Web sites to complete the biology questions. This result might be explained by the nature of biology, which includes more technical terms and has a facts-oriented knowledge structure. It could also have been each group's attitude toward participating in the study experiment that might have caused the different results. Most of the psychology group participants were required to join the study to fulfill their course requirement while the biology group participants were mostly volunteers. Hence, biology group participants were more serious in performing a study experiment and more interested in the nature of the study. Or, biology group participants might be simply more efficient in Web-searching. Another feasible reason could be that science major participants might be superior in general on information searching to other social science majors as Borgman (1989) suggested. The characteristics of a discipline that are the results of a participant's self-selection, training, socialization by the discipline, and/or a combination of these might cause such discrepancy.

Cognitive style, meanwhile, did not contribute to searching task score. This is consistent with Kim and Allen's study (2002) where field dependence/field independence was employed. Their findings showed that there was no significant main effect of cognitive ability on search outcome. In this study, cognitive style, however, demonstrated a moderate impact on certain search behavior; that is, the number of keywords used. Analytics used a larger number of keywords to complete a given task than Intuitivists did.

Cognitive style also showed an interesting interaction with the Web surfing experience (weekly Web surfing hours and years of Web surfing experience) on the total length of search time to finish the task. Namely, Analytics who were less experienced Web surfers took a longer time to finish the search task than Analytics who were more experienced Web surfers while the opposite was true for Intuitivists. Intuitivists who were more experienced Web surfers in fact took a longer time to finish the search task than Intuitivists who were less experienced Web surfers.

The finding for Analytics sounds logical. As discussed already, searching experience allows individuals to be more familiar with necessary searching strategies and to build a certain schema of how to search for information. Consequently, in terms of making decisions of when to go to the next search question, the experienced surfers may realize quicker that they may not be able to find more accurate information even if more time is given. This may result in shorter total searching time for experienced Web surfers.

The finding for Intuitivist, however, does not look logical at first glance. As Intuitivists rely on holistic impressions and random methods of exploring, their intuitive manner may be able to expedite judging the relevance of information in a limited short time. This argument is supported by the interesting study that entrepreneurs in a business world scored significantly higher on the intuitive scale of the Myers-Briggs Type Indicator (MBTI; Myers, 1962). Notwithstanding the contingencies suggested by Miner (1997) and Olson (1985), given the nature of entrepreneurial activity with high levels of uncertainty, few precedents, a lack of hard data, and often the need to make decisions under time pressure, their study proposed that the entrepreneurs either developed intuitive characteristics or were born as Intuitivists to become successful entrepreneurs.

Although it is beyond the scope of the study to analyze what happened here, a preliminary interpretation on the finding that less experienced intuitive Web surfer spent less time on searching is that they were fully affected by their natural intuition only. Yet, as they become more experienced Web surfers, the schema and strategies built for the Web surfing might interfere with the surfers' intuitive nature which results in longer searching time. This however should be further addressed.

Even if cognitive style is revealed to relate efficiency such as the searching time, since the searching time is not related to the search outcome, it is insufficient to argue that cognitive style may be a moderator as to whether one will arrive at a correct answer.

Finally, two major factors, domain and cognitive style, did not show any significant interactive impact on searching task score and activities contradicting with the initial hypothesis.

The study had certain issues to be addressed for the findings. To generalize the findings, first the study should be extended to other domains such as physics and/or language literature in order to confirm the impact of domain knowledge. It is also strongly recommended that future studies may involve including other characteristics of participants or different dimensions of cognitive styles.

NEXT STEPS AND CONCLUSION

Generally, considering information search behavior, search time is taken into account when measuring efficiency. For this purpose, in a broader sense, cognitive style may be an important factor for an efficiency-related issue. To answer the question, "what strategies do they employ to ascertain that the information provided is valid as individuals are becoming more reply on the Internet for searching information?" cognitive style might play a key role. In this study, the majority of participants merely depended on the origins where the information was provided; they showed higher trust for educational institutes (.edu or .org) rather than companies (.com). However, their natural cognitive style might have been compounded with this judgment somehow. This conjecture could be a new inquiry to lead the next study.

Or, to deeply delve into a cognitive style's impact on various factors, John and Boucouvalas (2002) studied the relationship between multimedia tasks and user cognitive styles using the other type of measuring test (Riding, 1991). They conducted the experiment that measured whether the same cognitive style would govern the perception of information when listening to or viewing information presented by a multimedia computer. The conclusion of the experiment was that there are differences in outcome when information is presented visually or using audio. It will be interesting to explore if the analogous results will be found when the information being perceived and searched includes a visual form.

Smith and Renzulli (1984) argue that congruence of style and a learning method can have an effect upon learning motivation and "investment" in the learning material. Equally important, matching can help eliminate barriers to learning that arise when educators fail to address the affective response that various teaching modalities elicit from students. Hayes and Allinson (1998) reviewed 19 studies that investigated the interaction effect of cognitive style and the learning style orientation[3] of learning activities on learning outcomes. They found that in 12 of them there was some support for the proposition that matching style and method contributes to improved learning performance. This led them to conclude that cognitive style may be a potent characteristic of learning that needs to be taken into account when developing conceptual frameworks for the design of development activities.

The findings of this study engaged with cognitive style and domain knowledge then may suggest how a Web-based learning environment can be more user-oriented and more learning process-matched.

APPENDIX A: TASK QUESTIONS

Please, search the Web to answer the following questions. Bookmark the Web pages showing their answers under the given subject number and then fill in answers here too.

Subject No.:

1. Which phenomenon is taking place during anaphase of mitosis in an animal cell?
2. In contrast to trait theories of personality, which factors have been focused on in a theory that Walter Mischel has suggested?
3. Define the characteristic of all viruses with DNA genomes.
4. Define the characteristic of adolescent's primary developmental tasks.
5. A severe winter storm kills many chickadees. An investigation comparing the body size of dead birds with that of survivors reveals that the dead birds included mainly the largest and smallest members of the population. What type of a natural selection theory does this winter storm exemplify?
6. When a crowed in a public setting witnessed an accident, nobody acted to help the victim. The people in the crowd failed to act because of diffusion of responsibility, desire to conform to others who are not helping. What effect defines this psychological tendency?

[3] Note that cognitive styles are more related to theoretical or academic research while learning styles are more related to practical applications (Liu & Ginther, 1999).

APPENDIX B: CORRELATION TABLE

		Task score	Time	Node	Keyword	Major	CSI	Hour	Year	Gender
Task Score	Pearson Cor.	1	–.285*	–.074	.042.	–.397**	.077	–.070	–.036	–.149
	Sig. (2-tailed)	—	.026	.574	.750	.002	.558	.591	.787	.251
	N	*61*	*61*	*60*	*61*	*61*	*60*	*61*	*59*	*61*
Time	Pearson Cor.	–.285*	1	.430**	.302*	–.019	.106	–.021	–.041	.080
	Sig. (2-tailed)	.026	—	.001	.018	.882	.421	.873	.757	.541
	N	*61*	*61*	*60*	*61*	*61*	*60*	*61*	*59*	*61*
Node	Pearson Cor.	–.074	.430**	1	.474**	.015	.108	–.090	.128	.047
	Sig. (2-tailed)	.574	.001	—	.000	.911	.416	.495	.338	.723
	N	*60*	*60*	*60*	*60*	*60*	*59*	*60*	*58*	*60*
Keyword	Pearson Cor.	.042	.302*	.474**	1	–.229	.252	.175	–.208	–.136
	Sig. (2-tailed)	.750	.018	.000	—	.075	.052	.178	.114	.297
	N	*61*	*61*	*60*	*61*	*61*	*60*	*61*	*59*	*61*
Major	Pearson Cor.	–.397**	–.019	.015	–.229	1	–.234	.296*	.292*	.117
	Sig. (2-tailed)	.002	.882	.911	.075	—	.072	.021	.025	.368
	N	*61*	*61*	*60*	*61*	*61*	*60*	*61*	*59*	*61*

CSI	Pearson Cor.	.077	.106	.108	.252	–.234	1	–.089	.273*	–.028
	Sig. (2-tailed)	.558	.421	.416	.052	.072	—	.497	.038	.832
	N	*60*	*60*	*59*	*60*	*60*	*60*	*60*	*58*	*60*
Hour	Pearson Cor.	–.070	–.021	–.090	.175	.296*	–.089	1	–.064	–.006
	Sig. (2-tailed)	.591	.873	.495	.178	.021	.497	—	.632	.962
	N	*61*	*61*	*60*	*61*	*61*	*60*	*61*	*59*	*61*
Year	Pearson Cor.	–.036	–.041	.128	–.208	.292*	.273*	–.064	1	.208
	Sig. (2-tailed)	.787	.757	.338	.114	.025	.038	.632	—	.114
	N	*59*	*59*	*58*	*59*	*59*	*58*	*59*	*59*	*59*
Gender	Pearson Cor.	–.149	.080	.047	–.136	.117	–.028	–.006	.208	1
	Sig. (2-tailed)	.251	.541	.723	.297	.368	.832	.962	.114	—
	N	*61*	*61*	*60*	*61*	*61*	*60*	*61*	*59*	*61*
Major Interest	Pearson Cor.	.011	–.063	.044	–.090	.058	–.212	–.111	.141	–.088
	Sig. (2-tailed)	.934	.633	.741	.496	.659	.106	.400	.288	.502
	N	*60*	*60*	*59*	*60*	*60*	*59*	*60*	*59*	*60*

*Correlation is significant at the 0.05 level (2-tailed).
**Correlation is significant at the 0.01 level (2-tailed).

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Direct reprint requests to:

Young Park
45 Concord Ave., #35
Somerville, MA 02143
e-mail: yp85@tcalumni.columbia.edu