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Task as a Context of Information Seeking: An Investigation of Daily Life Tasks on the Web

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This study examines how tasks influence information seeking behavior in the World Wide Web. There are three primary reasons for considering this issue: to understand the nature of people's information seeking tasks, to investigate the ways in which they attempt to execute tasks in their user-system interactions, and to facilitate the development and design of a system that serves people's task goals and supports their task-related information seeking behavior. Thirty students with backgrounds in library and information science participated in this study in a laboratory setting. Three different types of tasks were assigned. Significant differences were found in searching behavior on the Web among task types. Furthermore, the relationship of searching behavior with task difficulty, prior knowledge, and searchers' demographic characteristics varied by task types. The results suggest that information systems should be structured in ways that support users' tasks. Future study should focus on such issues and then propose how information systems and services can be tailored to the task in context.

Introduction

A mother-to-be anticipating the birth of her son is scanning boys' names in a baby name book. A man doing a project on Hawaii this summer is looking for some ideas on what to do on a Hawaiian vacation, where to go, the best beaches and sites to see. A woman believes that she has a high risk of breast cancer, as her sister had it four years ago. Her chest is sore to the touch and now she is browsing a WebMD site to see the symptoms of breast cancer. All these individuals participate in the process of information seeking in their day-to-day lives. Human information seeking behavior aspires to complete a task through information acquirement; so, in a sense, information seeking behaviors are embedded in real-life tasks in disparate domains.

It has been assumed that information seeking is context-dependent. It is generally agreed that the user's information need is prompted by a situation arising in daily living (Kuhlthau & Vakkari 1999); thus, information seeking is shaped and mediated by a situational context. Among many elements of context, task has been regarded as the essential element of context that affects information seeking behavior. Furthermore, task has been assumed to be unique to each physical setting in which each individual lives and works. As Solomon (2002, 240) said, "the task is a fundamental force that influences how and why people select sources, discover information in sources, evaluate information so discovered in relation to the task, and gain new insights related to the completion of the task."

Recently, much more attention has been paid to a task as the contextual factor which is significant to information seeking and retrieval studies (Järvelin & Wilson 2003; Järvelin & Ingwersen 2004; Kelly 2006; Vakkari 2003). And some stud-

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ies have focused on understanding the relationship between task characteristics and information seeking (Byström & Järvelin 1995; Vakkari 1999; Byström 2002). However, empirical findings of previous studies were concerned only with limited dimensions of a task and are therefore not comprehensive enough to fully describe a task as a user's context of information seeking.

Accordingly, the purpose of this study is to investigate how a task affects information seeking behavior, especially Web searching. The focus in this study is non-job-related daily life tasks that are embedded in everyday information seeking. More specifically, the research question driving this study is: Are there differences in Web searching behaviors for different kinds of tasks?

Literature Review

A user-centered approach in information need and seeking studies has focused on the individual in the context of a situation and assumed that users' information needs and information seeking depend on time, place, task at hand, device, and other factors that are given explicitly or implicitly in their environment or setting, that is, the context. In LIS studies, "context usually refers to any factors or variables that are seen to affect individuals' information seeking behavior" (Talja, Keso, & Pietiläinen 1999, 752).

The context, then, is not a single unified entity, but is composed of the elements of the situation or environment where users' information seeking occurs. The elements of context include physical and temporal features, searchers' social, informational, and emotional features as well as the task at hand. As such, Cool and Spink (2002, 605) stated that "information seeking, use, and evaluation take place within multidimensional contexts, which can be analyzed from multiple levels." This has long been recognized in a number of information behavior models that identified factors involved when people seek information. For instance, Wilson (1981, 552), in his early model presented the circumstances that give rise to information seeking behavior in terms of "the person performing a role in an environment." Dervin's (1983) sense-making placed heavy emphasis on the particular time-space of which an individual has to make sense. Taylor's (1991) IUE is another model that addressed information seeking within the context.

Among the various elements of context, the task has been discussed as a major component of the stimulus side of the context. It has been assumed that knowing a user's task at hand will help us understand the information need the task generates and therefore what the user wants. Thus, the task has long been used to convey a conceptualized information need, but also has been regarded as a higher level of construct that generates information seeking. It has been asserted that task needs to be taken into account and understood in the model of information behavior (Wilson 1981; Marchionini 1995; Ingwersen 1992; Saracevic 1997). The task has become the main contextual element in information seeking and retrieval studies (Järvelin & Ingwersen 2004; Kelly 2006; Freund & Toms 2005; Byström & Hansen 2005; Belkin & Cool 2005).

Further, it has been assumed that task characteristics may influence the ways a user approaches information seeking and retrieval activities (Belkin, Seeger, & Wersig 1983), and, as Vakkari (2003) pointed out, more attention has been paid to task characteristics as the exploratory factor in information seeking studies. Various approaches have been used to relate task characteristics and information seeking; one of the common features was to assign *two* task types (a factual task vs. a topical task) to see if different task conditions affect information seeking behaviors on the Web (Palmquist & Kim 2000; Schacter, Chung, & Dorr 1998; White & Iivonen 2001). A known item task and a subject task were tested in a similar way (Hsieh-Yee 1998). Many of those studies found that most of the subject task searches were successful, and dependence on task characteristics was also discovered in most of these cases. Sometimes as many task types as possible – e.g., decision search, background search, and fact search – were given to searchers in a task-oriented system evaluation approach (White, Jose, & Ruthven 2003).

Different task types have also been categorized according to domain, for example at the Text Retrieval Conference (TREC). In the TREC 2001 and 2002 interactive track, four tasks – medical, buying, travel, and project – were generated and tested (Hersh 2002; Hersh & Over 2001). The goal of TREC studies is to assess and compare different IR systems, and each evaluation involves different set of tasks. So the TREC studies observed the interaction of task and system tools/interfaces,

rather than the direct effect of the task domain on search behavior characteristics. Task domain was also shown to play a role in search behaviors in Toms and her colleagues' (2003) study. They examined Web searching behaviors in four task domains which had been used in TREC and reported that *participants* doing shopping tasks spent more time looking at the content of a Website but found it more difficult and less satisfying than other tasks.

Task complexity is another way to conceptualize the task as the exploratory factor. Several studies in this area considered the pre-determinability of task outcomes as a defining characteristic of the complexity of a task (Byström & Järvelin 1995; Vakkari 1999; Byström 2002). Another study considered the level of inferencing required to deduce the site's URL from the task description as the complexity of a task (Lazonder, Biemans, & Wopereis 2000). These studies assumed that complex tasks yield increased uncertainty about task inputs, search process, and outputs. In addition, the more complex a task becomes, the more necessary it is to engage in information seeking. Byström and Järvelin (1995) confirmed that as task complexity increases, searchers tend to use a greater number of sources and become more likely to turn to other people for information. All these studies explored how different kinds of task lead to differences in information seeking; however, most employed given generic tasks which did not consider aspects of searchers' contexts that had significant roles to play in shaping their tasks. Although task was the main focus, these studies did not explain its interaction with other elements of context.

Research Method

Experimental Approach

This study has taken the experimental approach that has become popular in information science and information retrieval. In experimental research, the investigator controls the conditions under study so that they may be varied to ascertain the impact of a particular variable. Many Web searching behavior studies have undertaken within experimental settings for this advantage: researchers can mandate the tasks in which a user engages and standardize the software across all participants.

Three different tasks were selected as independent variables in this study: a factual task, an interpretive task, and an exploratory task. The factual task is a closed task which has a definite answer, the interpretive task is a rather open-ended but goal-oriented task which requires a paragraph(s) or passage(s) for its answer, and the exploratory task is a vaguely structured as well as completely open-ended task, and its outcome is a collection of data. These are all hypothesized to have different effects on the nature of the information need, mental processes and levels of abstraction required for the needed information, and therefore on searching behavior.

In addition, tasks were placed in the context of a "simulated work task situation" (Borlund 2000) to ensure that the tasks were as close as possible to real world situations, especially users' daily life tasks. This scenario-oriented approach provides a context-specific situation description and therefore allows systematic investigation of how searchers behave to solve tasks in controlled settings. Task scenarios for the three task types were presented as follows:

- Factual task: You plan to visit San Francisco next week. One of your friends who has been there suggests that you visit the oldest seafood restaurant in town. You want to know the name of the restaurant.
- Interpretive task: Your cousin, a typical teenage girl, said that one of her friends had started to smoke. You fear your cousin might begin smoking in the near future and decide to educate her, so you have to find some information on what could happen if she starts smoking.
- Exploratory task: You have recently moved to Boston and you are interested in buying a home. You have heard that most homes built before 1978 have some lead paint, but that their paint status is often reported as "unknown." You think you should learn about lead paint and housing. The Web seems like a good place to locate this information.

Web searching behavior as a dependent variable was characterized using implicit measures that can be recorded without any intervention on the part of the user. Implicit measures were used to define task characteristics rather than to infer user interest in this study. Those measures are:

- Time spent: Minutes from the moment the subject opened the browser until the subject terminated the task, or the time limit to complete each task
- Pages viewed: the number of HTML pages viewed by the subject

Table 1. Searching behavior by three tasks.

	M	SD	F	Sig.	η^2
Time spent					
Factual task	8.53	5.44	0.98	0.38	0.02
Interpretive task	7.76	2.98			
Exploratory task	6.99	3.81			
Pages viewed					
Factual task	29.97	20.33	1.25	0.29	0.03
Interpretive task	28.93	17.14			
Exploratory task	23.24	14.32			
Pages saved					
Factual task	1.90	1.05	7.78	0.01	0.61
Interpretive task	5	4.46			
Exploratory task	3.93	3.15			
Search engine used					
Factual task	12.21	7.11	7.17	0.00	0.15
Interpretive task	6.03	5.47			
Exploratory task	7.45	6.81			
Query reformulations					
Factual task	4	3.68	2.55	0.08	0.06
Interpretive task	2.86	2.71			
Exploratory task	2.24	2.50			

- Pages saved: the number of HTML pages saved by the subject
- Search engine used: the number of search engine main and results pages viewed by the subject
- Query reformulations: the number of times queries are modified, enhanced, or expanded by the subject

Other variables were also considered which were assumed to have an indirect or direct effect on Web searching behavior, and were addressed through a task-by-task analysis. Participants' demographic characteristics were measured in terms of their age, gender, and undergraduate major. Other searcher-dependent task-related variables – pre-task difficulty, post-task difficulty, and prior knowledge were measured using a five point scale where 1=nothing and 5=quite a bit.

- Pre-task difficulty: How difficult this task will be?
- Post-task difficulty: How difficult was it to complete this task?
- Prior knowledge: How much do you know about the topic?

Procedure

An individual lab session was arranged for each participant. As each participant entered the lab, he or she was asked to sign the consent form and read the general instructions that provided a brief introduction to the study. Next, a background questionnaire was administered to collect each subject's demographic information. Subjects were then given a task and asked to save the pages that contained exact answers or *relevant information to complete each task.* Before they started searching, a pre-search questionnaire was presented to gauge their prior knowledge and pre-task difficulty. Search logs were captured while they were searching. After the task was completed, a post-search questionnaire was administered to subjects to articulate the reasoning for their post-task difficulty. Finally, a post-search interview was conducted to clarify and uncover each subject's reasoning for search behaviors.

The study used thirty graduate students with backgrounds in library and information science. It was assumed that graduate students with a library and information science background would be more motivated to learn about Web searching and were also more likely to be experienced searchers. Subjects were grouped by three demographics: age, gender, and undergraduate major. Of 30 participants, 22 were female (73%) and 8 were male (27%). The mean of the participants' ages was 32.7. Half of the participants (50%) were between 20 and 29. Ten participants (33%) were 30–39. Five (17%) were in the above-40 group. The

participants' undergraduate majors were diverse. 22 (73%) had art/humanities and social science majors but only 8 (27%) had science and engineering majors.

The total number of searches was 90 since each participant conducted 3 searches. Subjects averaged 496 seconds on each task. The average number of pages viewed and pages saved were 27.38 and 3.66 respectively. Across all three types of task, subjects visited search engines 8.56 times and executed 3.03 query reformulations while searching.

Searching behavior by task

Differences were compared among the mean of Web searching behavior measures with respect to different kinds of task. A series of analyses of variance (ANOVA) were conducted to determine if searching behavior differences exist among the three task types. The means and standard deviations for five searching-behavior variables with respect to task types are displayed in Table 1.

On average, participants tended to spend more time to complete the factual task than the other two tasks. This is because participants knew there was one right answer and kept searching until they found the right one. Several participants felt that "finding one specific answer is more challenging and stressful" (S008-T1). On the other hand, the mean number of time spent for the exploratory task is the lowest. This tells us that many participants did not actually learn on the Web. In addition, they were pressured for time to complete a task, and as subject 018 said, "There's lots of good information and references, and if I had more time, I would spend more time in reading it" (S018-T3). However, an ANOVA test indicated no significant differences among different kinds of task in total time spent.

The mean number of pages viewed averaged 29.97 for the factual task, 28.93 for the interpretive task, and 23.24 for the exploratory task. The factual task has the highest mean number of pages viewed. Subject 001 characterized the factual task as being "more hunting around than just reading information" (S001-T1). But the exploratory task has the lowest number of pages viewed as well as in total time spent.

This result occurs because most participants felt easily satisfied that they had completed the exploratory task, which does not have any specific goal. Once again, statistically significant differences were not obtained.

The number of pages saved averaged 1.90 on the factual task, 5 on the interpretive task, and 3.93 on the exploratory task. An ANOVA test indicated that there is a statistically significant difference in pages saved ($F=7.78$, $p<.01$) among the three tasks. The mean number of pages saved is the lowest in the case of the exploratory task, as it was in the number of pages viewed. This is because many participants stopped searching once they found a page that had a lot of links. For instance, subject 008 saved the page he found without reading it and explained the reason why he did: "I didn't read all these because I knew that it's reputable, it's government, it has lots of links and facts and stuff, it's clearly representative and easy to read" (S008-T3).

The mean number of search engines used was calculated for each task type. It was found that a task had a main effect on search engine used ($F=7.17$, $p<.01$). A post-hoc test revealed that the mean number of search engine used was significantly greater for the factual task and other two tasks. It is evident that searchers depend on search engines to a great extent to complete the factual task. Their typical search strategy was to start with typing specific keywords in a certain search engine. They then scrolled through the results, opened a page by clicking one of the results, scanned the page, and went back to the result page until they found the target information. In the case of the interpretive task, more than half of the students started their search for smoking from a known website, such as American Cancer Society (www.cancer.org) or American Lung Society (www.lungusa.org). This result confirmed Allen and Kim's (2001) finding that undergraduate students did more searches for the assigned factual task.

Likewise, the mean number of query reformulations is the highest in the case of the factual task, whereas the exploratory task has the lowest number of query reformulations. The difference in the number of query reformulations is only significant at the 0.1 level, so a T-test was conducted to see whether there was any difference in query reformulations between the factual task and the exploratory task. It was found that there is a significant difference in the mean number of query

Table 2. Searching behavior by searchers' demographic characteristics.

	Age		Undergraduate major	
	Under 30 years old	Over 30 years old	Art/Humanities/ Social science	Science/ Engineering
Time spent				
Factual task	8.76	8.32	8.51	8.62
Interpretive task	8.13	7.43	7.55	8.43
Exploratory task	7.24	6.75	6.30	9.14
Pages viewed				
Factual task	28.60	31.20	30.50	28.29
Interpretive task	27.00	30.73	28.64	29.86
Exploratory task	22.43	24.00	21.14	29.86
Pages saved				
Factual task	1.93	1.87	1.91	1.86
Interpretive task	4.86	5.40	5.27	4.71
Exploratory task	3.86	4.00	3.86	4.14
Search engine used				
Factual task	10.80	13.71	11.59	14.14
Interpretive task	6.93	5.64	6.05	6.00
Exploratory task	6.47	8.50	7.09	8.57
Query reformulations				
Factual task	4.57	3.47	3.45	5.71
Interpretive task	3.07	2.67	2.36	4.43
Exploratory task	2.22	2.27	1.86	3.75

reformulations between the two tasks ($t=4.52$, $p<.05$). This result implies that participants more focused on reformulating queries multiple times to complete the factual task. To find the name of the oldest seafood restaurant in San Francisco, most subjects tried different combinations of keywords or the exact sentence in the task scenario. This was often frustrating for the participants – "It took a couple of tries to get the right syntax to filter out restaurants from other cities" (S001-T1).

Searching behavior by searchers' demographic characteristics

The possible relationship between searching behavior and searchers' demographic characteristics was investigated through a task-by-task analysis. Participants were split into two groups based on age, gender, and undergraduate major: under 30 years vs. over 30 years, female vs. male, and art/humanities/social science majors vs. science/ engineering majors. Since the sample sizes for the two groups by gender and undergraduate major were unequal, Levene's test for homogeneity of variances was examined. Then a T-test was conducted to determine whether there is a significant difference in searching behavior between groups.

Overall, there were no differences in searching behavior between male and female searchers, so only the mean of searching behavior variables by age and undergraduate major groups was presented in Table 2. In general, it seems that the group under 30 years old spent more time, viewed fewer pages, and reformulated queries more often across all three tasks. People who majored in science and engineering tended to spend more time, made more frequent use of search engines, and reformulate queries more often across all three tasks.

Statistical analysis revealed a significant difference in pages viewed between searchers under 30 and searchers over 30 only in the case of the factual task ($t=4.91$, $p<.05$). Older searchers tended to view more pages than younger searchers, but this did not mean that they spent more time doing so. Significant undergraduate major group differ-

3. Correlation between perceived difficulty and searching behavior.

	Time spent	Pages viewed	Pages saved	Search engine used	Query reformulations
Pre-task difficulty					
Factual task	0.07	0.02	-0.07	0.07	0.19
Interpretive task	0.16	0.29	0.05	0.32	0.09
Exploratory task	0.26	0.49**	0.42*	0.34	0.59**
Post-task difficulty					
Factual task	0.66**	0.60**	-0.16	0.45*	0.39*
Interpretive task	0.13	-0.24	-0.34	-0.22	-0.20
Exploratory task	-0.10	-0.02	-0.35	-0.19	-0.23

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

ences were observed in several searching behavior variables: when conducting the factual task, searchers who majored in science/engineering tended to use search engines (t= 3.98, p<.01) and reformulate queries (t=11.27, p<.01) more often than searchers who majored in art/humanities/social sciences. Again, when conducting the exploratory task, the mean of query reformulations in science/engineering major group was significantly higher (t=4.59, p<.05).

Searching behavior by perceived difficulty and prior knowledge

The Pearson Coefficient of Correlation was used to explore the possible relationship between other task-related variables and searching behavior. The analysis found that prior knowledge is not an influential factor for searching behavior across all three tasks; perceived difficulty, however, led to differences in searching behavior for each task in some way. Table 3 presents the results for the correlation analysis by perceived difficulty. Overall, searching behavior for the interpretive task was random regardless of perceived difficulty.

Many participants mentioned that they were not clear about where to start and which search system to apply at the pre-task stage when they started searching for the exploratory task. Similar to Kuhlthau and Vakkari's (1991) "initiation" stage of information search process, several participants expressed feelings of uncertainty and apprehension, for instance, "I got a little frustrated over where to look for information first" (S018-T3), and "This one is annoying. I do not know where to go" (S019-T1). So only in the case of the exploratory task was pre-task difficulty significantly related with pages viewed (r=.49, p<.05), pages saved (r=.42, p<.05), and query reformulations (r=.59, p<.05). Participants who predicted that the assigned exploratory task would be difficult tended to view more pages, which resulted in more pages saved. In addition, this result indicates that participants who expected the exploratory task to be difficult sought information by reformulating queries multiple times. Overall, pre-task difficulty seems to be a good predictor for searching behavior only in the exploratory task; it had no effect on searching behavior for the other two tasks.

When participants completed the factual task, many experienced problems during the search process, such as accessing a certain site, navigating within a certain site, specifying a query, or searching a specific phrase or terms in a page. Surprisingly, some of the participants explicitly conveyed dissatisfaction with search results as a reason of difficulty. For instance, subject 022 actually did not spend much time to complete the factual task but said the task was difficult. She explained the reason for her difficulty as "I am not convinced that I got a right answer" (S022-T1). Hence, for the factual task, post-task difficulty was significantly related to time spent (r=.66, p<.05). In addition, post-task difficulty was positively related with pages viewed (r=.60, p<.05), search engines used (r=.45, p<.05), and query reformulations (r=.39, p<.01). So the more time spent, pages viewed, search engines used, and query reformulations executed to complete the factual task, the more difficult the participants deemed the task. Overall,

post-task difficulty seems to be a good indicator of searching behavior only in the case of the factual task.

Conclusions

This study examined Web searching behavior in relation to a user's task, and found significant differences in searching behavior according to different kinds of task. Three major findings emerged. First, different types of task lead to differences in searching behavior variables. Searchers tended to spend more time, view more pages, save fewer pages, use search engines more often, and modify their queries more frequently to complete the factual task. Searchers tended to spend less time, view fewer pages, save more pages, use search engines less often, and expand their queries infrequently to complete the exploratory task. Notably, the number of analytic searching behaviors searchers used in the factual task was significantly greater than the number of analytic searching behaviors employed in the other two tasks. In other words, searchers employed elaborated analytic searching strategies when they had to find one answer. This finding supports the earlier ones by Schacter, Chung, and Dorr (1998), in which children employed significantly more analytic search strategies on well-defined tasks as opposed to ill-defined tasks.

Second, in examining how searchers' demographic characteristics influence searching behavior, this study found that age explained more variances in searching behavior. Younger searchers tended to spend more time and view fewer pages than older searchers. Distinct disciplinary differences in information seeking behavior patterns were observed, too – science and engineering majors tended to engage in more analytic searching behavior. While previous studies observed significant behavioral gender differences (Large, Beheshti, & Rahman 2002; Roy & Chi 2003), gender had almost no impact on this study's searching behavior variables. Overall, the factual task and the exploratory task showed differences in searching behavior by searchers' ages and disciplines, but searching behavior in the case of the interpretive task was random regardless of the searchers' demographics.

Third, this study also considered prior knowledge and perceived difficulty as control variables that affect searching behavior, and found that perceived difficulty correlated significantly with pages viewed and query reformulations both in the case of the factual task and the exploratory task. Pre-task difficulty was a good predictor for searching behavior only in the case of the exploratory task, while post-task difficulty was a good indicator of searching behavior in the case of the factual task. Prior knowledge, however, was not an influential factor for performing daily life tasks in this study, even though prior knowledge has been regarded as an important factor in previous studies (Wildemuth 2004; Kelly & Cool 2002).

The study found that distinguishing characteristics within task types produce different levels and patterns in searching behavior on the Web, and that different tasks can therefore predict Web information seeking. This issue is considered with the hope of understanding the nature of people's information seeking tasks and the ways in which they attempt to perform tasks via their interactions with information systems. The present work went further by integrating characteristics of the searcher, the searcher's task, and other contextual factors with the interaction process between searcher and search system. By doing so, this study confirmed that information seeking takes place in a certain context determined by a user's task. In addition, it took a step toward a model of task-based information seeking explains the task's relationship to other variables.

This study also further considers task-oriented research as a way to facilitate the development and design of information systems structured to support tasks and behaviors. Information systems research becomes more relevant and applicable as it assesses how well existing tools support users in completing tasks on the Web and how they might be better supported. To do so, it is important to understand the types of tasks people perform on the Web; therefore, information systems should be structured in ways that support users' tasks, and future study should focus on such issues and then propose how information systems and services can be tailored to the task in context.

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